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INTERNATIONAL SYMPOSIUM ON ADVANCED RADIO TECHNOLOGIES

INSTITUTE FOR TELECOMMUNICATION SCIENCES

# ISART 2012 Proceedings

## *Developing Forward Thinking Rules and Processes to Fully Exploit Spectrum Resources:* Case Study 2—Exploring Approaches for Real-Time Federal Spectrum Sharing

**July 25-26, 2012**
**Boulder, Colorado**

*special publication*

U.S. DEPARTMENT OF COMMERCE • National Telecommunications and Information Administration

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September 2014

## DISCLAIMER

Certain products, technologies, and corporations are mentioned in this report to describe aspects of the different current or potential future approaches for real-time federal spectrum sharing. The mention of such entities should not be construed as any endorsement, approval, recommendation, prediction of success, or that they are in any way superior to or more noteworthy than similar entities that were not mentioned.

## PREFACE

ISART 2012 was the thirteenth in a (more or less) annual series of symposia hosted by ITS. Since the first ISART in 1998, the conference has evolved from having a purely technical focus based on presentations of papers to providing a neutral forum where business experts, technologists, and government regulators can share their points of view, debate issues, and engage in a holistic and expansive exploration of the future use of existing and emerging radio technologies. Under the new format a greater proportion of the material was derived from slide presentations. Accordingly, the mechanics of maintaining a record of the events has evolved over time.

Speaker slides have always been published. In 2003, a call for papers was issued and Proceedings were published. In 2010, there was no formal call for papers, although some were submitted. For the first time in 2010, ISART was made publicly available as a real-time live videocast. Consequently, rather than publishing formal proceedings, the organizers experimented with publishing, in electronic form only, the videocast record of the conference, the slides, and any papers submitted by presenters. Feedback on this method of preserving a record of the event was decidedly mixed, but a clear preference for a written record emerged. The 2011 proceedings are an edited version of an informal transcript of the conference, a best effort to summarize information presented and articulated at the conference which speakers were invited to review.

Between 2010 and 2012, ITS was given more stringent directives about closed captioning of online published video. To accommodate those directives, all ITS published video was taken down for a period of time, and in 2012 a court reporter was engaged to keep a transcript of the conference. This allowed both the development of closed captioning for the video recording so it could be posted online and publication of the transcripts as proceedings.

This volume of proceedings is taken directly from the court reporter’s transcription of the conference. A best effort has been made to correct spellings of names and terms of art, but it is in no way an “edited” transcript.

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# ISART 2012 PROCEEDINGS

## Developing Forward Thinking Rules and Processes to Fully Exploit Spectrum Resources: Case Study 2—Exploring Approaches for Real-Time Federal Spectrum Sharing

The 13th Annual International Symposium on Advanced Radio Technologies, held in Boulder, Colorado, July 24–26, 2012, presented the second conference focused on *Developing Forward Thinking Rules and Processes to Fully Exploit Spectrum Resources.* Following on from the previous two ISARTs, ISART 2012 looked at *Case Study 2—Exploring Approaches for Real-Time Federal Spectrum Sharing*. Topics covered included The Federal Spectrum Ecosystem, Current Federal Efforts that Can Increase Spectrum Sharing, Institute for Telecommunication Sciences Spectrum Survey Activities, TV White Space Tutorial, Fresh Approaches to Spectrum Sharing, and Validating and Regulating New Sharing Schemes. The keynote speaker was Larry Strickling, Assistant Secretary of Commerce for Communications and Information, National Telecommunications and Information Administration. This volume of proceedings is taken directly from the court reporter's transcription of the conference. A best effort has been made to correct spellings of names and terms of art, but it is in no way an "edited" transcript.

Keywords: dynamic spectrum access (DSA), International Symposium on Advanced Radio Technologies (ISART), radio frequency assignment, radio spectrum management, spectrum sharing, spectrum surveys, TV white space

## 1. JULY 25, 2012

### 1.1 Eric Nelson: Welcome to ISART

#### 1.1.1 Introductory Remarks

Good morning, ladies and gentlemen. My name is Eric Nelson. I'm one of the division chiefs here for the Institute of Telecommunication Sciences. I'm co-chairing with Chriss Hammerschmidt. On behalf of NTIA, the Institute for Telecommunication Sciences, and our conference sponsor, the Office of Spectrum Management, we welcome you to the 13th Annual International Symposium on Advanced Radio Technologies. The title of this year's conference is, *Developing Forward Thinking Rules and Processes to Fully Exploit Spectrum Resources.* Our Case Study 2, following on from the last two ISARTs, will be exploring real-time federal spectrum sharing.

Before I cover the program, I want to provide a little bit of context for this week's sessions. We have a number of other meetings that have occurred this week. We've tried to provide a number of venues for people to get together to talk about the challenges of spectrum sharing. Yesterday Andrew Clay from the National Science Foundation hosted Wireless Spectrum R&D Senior Steering Group Workshop No. 3. Representatives from federal research agencies, private industry, and academia participated in that conference. The goal was to engage the federal government's research enterprise to take concrete steps to facilitate spectrum sharing, and to inform federal R&D interests. I caught the very end of the session. They were finishing up their SWAT analysis. It was a very lively discussion. And I think they were hitting on a number of key topics that need to be addressed.

Yesterday afternoon there was a Commerce Spectrum Management Advisory Committee meeting held over at the ITS building. CSMAC has recently launched five working groups to consider ways to facilitate implementation of commercial wireless broadband in the 1695 to 1710 and 1755 to 1850 megahertz bands. They're very actively participating in these working groups, some of them having upwards of 80 members. And there's a very aggressive schedule that they're already working hard at to meet.

Monday and Tuesday IEEE's working group, Policy Language and Policy Architectures for Managing Cognitive Radio for Dynamic Spectrum Access Applications held a meeting. Tomorrow in Session 3 Lynn Grante, who is chairperson of that group, will be providing background on IEEE standardization activities.

ISART is the fourth and final spectrum sharing related meeting of the week, and it gives us an opportunity to wrap up a lot of the thoughts that we have.

I'd like to move on to a little bit of housekeeping. I hope everyone had a chance to pick up their conference materials at the registration desk. The desk will be open until the afternoon break if you have any needs there. You should have all received a welcome packet. In the welcome packet we have the conference program, and the conference program has the agenda and the biographies in it. For the sake of time the introductions will be very brief during the presentations. So if you want to know a little bit more about any of the speakers just flip to the back of the conference program and there will be bios there. You also just received a welcome handout. It contains the key things people are already hard at, you know, getting connected to Wi-Fi and to the community portal. A number of people have already been making an effort to get connected to the portal. We haven't received all the presentations yet for the conference, so if you can hold off maybe until tomorrow afternoon, we hope to have everything up there. At some point what we may do is take them all, zip them all together into one big block of files to make them easier for you to download them.

We also have an ISART CD that came in your packet. The CD contains the ISART 2011 proceedings, and we ask you to take a look at that, the conference from last year. Very successful. Also a couple of years' worth of ITS Technical Progress Reports. We managed to get a copy—we actually held off on burning these until Friday afternoon so we could get a copy—of the PCAST Report. The PCAST Report will be mentioned several times here during the conference. You don't have to download it; you don't have to, you know, bog down Wi-Fi here getting a copy of the PCAST Report if you're interested in that. There's also background material: the President's memorandum, "Fast Track" Report, and other key background materials on the CD.

And, finally, we have a survey that we've provided. We ask that you take some time before the end of the conference to fill out the survey, and you can drop it off at the registration desk when you're done. The conference agenda is tight, so there is food provided, as you noticed this morning, your continental breakfast, mid-morning and afternoon refreshments, as well as lunch in the pavilion outside.

In terms of outreach, you know, we've made a couple of efforts to broaden the scope of the conference to reach out to as many people as possible. You may have noticed we have a live webcast that's running right now. This allows us to reach out to folks that maybe had travel restrictions, weren't able to make it to Boulder. Just want to mention to people, to speakers be aware that you are being webcast so you could have a potentially worldwide audience, so keep that in mind. Also let you know that there's at least one member of the press who mentioned that he would be participating via live webcast so keep that in mind when you crack your comments.

NTIA has a twitter account. I'm not really big on twitter but I have tried it out on my iPhone. We have announced the conference via twitter to increase the visibility of the conference. And so people out there in twitter land if you want to share your thoughts on the conference we will be monitoring that on occasion. We just ask that you use the hashtag ISART 2012 just to kind of keep all the comments together.

Finally we have a court reporter on hand who will be keeping a transcript of the conference. There's a couple of reasons for that. We will be producing proceedings from the conference. So we did it manually last year, and one of our after action items was to hire a court reporter for next year's. It also allows us to develop closed captioning for the recording so we can post it on our website.

### 1.1.2 Background

Let's change gears now and talk a little bit more about how we got to Case Study 2. This is ISART, the 13th annual ISART, which is a U.S. government sponsored conference hosted by ITS. The conference brings together the government, academia, and industry leaders for the purpose of forecasting the development and application of advanced radio technologies.

In the first ten years ISART was a primarily a science conference based on presentations of technical papers. While there were a few policy papers and roundtable discussions, the format was geared toward science and engineering, which is fitting to ITS' role as a research and engineering lab for NTIA.

In 2010 we adopted a new format though, and a new focus. We did an overview of spectrum sharing that year. The theme of that conference acknowledged the increasing difficulty with relocating existing federal incumbents to clear spectrum for auction by emphasizing the need for approaches to spectrum sharing. There were a number of different goals for the conference. Goal number one was multi stakeholder debates. We were trying to get, you know, legal and engineering and policy people all together. We also wanted multi-disciplinary deliberations.

Specific topics addressed two years ago were DSA technology and rules, measuring spectrum occupancy, interference protection criteria, spectrum management, sharing LMR bands, sharing radar bands, business context awareness, and research.

ISART 2010 required four days. And even then still left a lot of unanswered questions. There's a great deal of breadth in the conference, but not really the depth that you need to really delve into any particular solution space. It's clear we needed to focus next on an individual radio service and that was the goal, and to bring in experts from that radio service to dig in deeper into the specific comparability issues.

So ISART 2011 addressed a particular radio service. The first case study we handled last year was radar. Motivation for looking at radar was clear cut. Radar uses a lot of spectrum, 50 percent of the federal spectrum is radar. Radar spectrum is under constant pressure. Radar engineers are constantly trying to expand the capability of their radar systems within their existing allocations. And now more than ever they are working to coexist with other uses in their band.

Also there were recent reports of interference to terminal Doppler radars from DFS devices. The spectrum management community was still grappling with the appropriate corrective action. Notably, there was very little interaction really between the radar and the radio science communities.

This spawned the third goal for the conference, which was to bring together the radar community and the communications community that typically didn't go to conferences together, and get them thinking about how their different systems play with each other. That was Case Study 1, ISART 2011.

ISART 2012 could have moved on to the next largest radio service and, just in terms of spectrum use, just pick the next one. But a number of factors caused us to shift our emphasis. As the project leader for the spectrum sharing innovation and test bed we encountered a number of confounding problems with the technology that seemed to admit of a straightforward solution if you used some sort of database approach, for instance if you have a passive receiver that's a classic hidden node problem, and that's, you know, no sensor is going to be able to detect that, but a database entry is one solution to that.

Also the first TV white space device was sort of certified late last year, and a host of companies had committed to being database managers. This technology was gaining traction. And in a variety of contexts, we were hearing reports that the database driven approaches were the proverbial low hanging fruit. Actually heard that phrase used a couple of times. And that low hanging fruit would be the foundation for a new schema of spectrum management.

Finally Mike Cotton and I—and Mike was the chair of ISART last year—went on a fact-finding mission to find out what the state of play in spectrum sharing technologies was. We visited a number of government research labs, and found that there was a great deal of progress that had been made, but the new technologies' full potential would not be harnessed without revisiting some of the approaches to spectrum management. Most spectrum managers are radio scientists, and they're just now learning the potential, both good and bad, of software defined radio. For example, our colleagues at the FCC's OET informed us that a large percentage of the DFS devices that they encountered problems with have RF sections that span 00 megahertz and multiple services. Devices certified for one band were easily modified with firmware loads that permitted them to be retuned into the DFS band without the necessary detecting void requirements.

Modifying radio systems in the field to address interference problems is time consuming and costly. Radio engineers tried to figure all these things out up front to address potential problems in advance before systems are deployed. But now computer scientists have empowered radio systems with the ability to easily adapt, sometimes maybe too easily, not just with new modulations, but with new policies and new behaviors. So imagine if those DFS devices I just mentioned were connected to a policy database and contained time limited spectrum releases. New comparability rules could've been developed by the RF engineers. And ITS actually sent teams out to different field sites to work out comparability rules. Those rules might've loaded via a database solution out to the radios that were in the proximity of these terminal Doppler weather radios, you know, just suggesting an approach. Doing that might've solved a lot of the problems with a push of a new policy.

So this motivated the fourth goal of ISART in the topic of this conference to bring together the radio and computer science communities to learn a little bit more about how we each think, to address the feasibility of database approaches to real-time spectrum sharing with the federal government, and to learn more about each other's perspectives.

### 1.1.3 Agenda

I'd like to give a brief overview of the conference agenda. Session 1 is entitled "The Federal Spectrum Ecosystem." It will be moderated by Tom Kidd, who is the IRAC rep for the U.S. Navy. The goal of Session 1 is to describe the current spectrum management ecosystem, and to provide the context for later discussions during the conference. People sometimes, perhaps over-simplistically call for more spectrum sharing when in fact the federal government routinely shares spectrum with nongovernment entities. A number of illustrative cases will be explored in this session, and we'll see that none of them admits trivial solutions. Spectrum sharing advocates essentially want to expedite the planning process though, so it should be valuable to see just how the process presently works.

Session 2 [is entitled] "Current Federal Efforts that Can Increase Spectrum Sharing." It will be moderated by John Hunter. He is from NTIA's Office of Spectrum Management. Often not addressed in the media are the increasing spectrum demands of the federal agencies themselves. Session 2 will discuss activities within the federal government to promote dynamic management of, access to, and use of government spectrum. Also we will discuss NTIA's own spectrum management system, which will take a critical role in documenting federal spectrum management, or spectrum assignments. This will be detailed or was detailed in the PCAST Report.

We'll have a presentation on spectrum activity, spectrum survey activities at ITS. The temporal, spatial, and frequency characteristics of incumbent federal systems have to be understood to permit engineers to develop new sharing schemes, properly validate their operation, and establish system architectures and rules. ITS recently deployed its updated measurement system to San

Diego to conduct a comprehensive broadband spectrum survey, and we also did a specialized measurement of the high value band cited in the PCAST Report, 3550 to 3650 megahertz.

At the end of today we'll have a tutorial on TV white space. The phrase, "building upon the success of TV white space" has become a common refrain. We don't question the veracity of that claim, but it would be much more intellectually satisfying if we just knew exactly what that meant. So in the TV white space tutorial, three of the pioneers in this field will discuss the activities and lessons learned during the development of the white space's ruling, and also address the technical challenges that were overcome. It should permit us to envision how that technology might be extended to transform federal spectrum sharing.

Tomorrow we'll begin with Session 3, "Fresh Approaches to Spectrum Sharing," moderated by Preston Marshall. Session 3 will give us a more in-depth introduction to the recently released PCAST Report, and allow us to explore new developments in TV white space technology. We'll also be shown approaches under consideration by the White Space Alliance. Finally we'll learn about ongoing standardization efforts to clear the research on model based spectrum management and data exchange languages, two critical building blocks cited in the PCAST Report.

Session 4, "Validating and Regulating New Sharing Schemes," will be moderated by John Chapin from DARPA. In that session we'll consider what changes to existing regulatory processes might be considered to validate and regulate new sharing proposals and systems. New technology such as DSA present new challenges and exciting opportunities for regulators. Adaptable radio systems provide both unpredictable and abundant combinations of test data. There was a little bit of talk about that at the WSRD meeting yesterday. This panel will suggest optimal approaches to validating and regulating new systems.

We'll close out ISART at the end of the day tomorrow with a closing panel moderated by Pierre DeVries. Our closing panel will summarize the findings of the previous panels, and help to describe a roadmap of more dynamic spectrum sharing. The panel will give us an opportunity at the end of the week to capture findings not only from ISART but from the WSRD, IEEE, and CSMAC meetings. Also, the conference provided the first opportunity to engage in a dialogue on the specifics of the PCAST Report so we have a unique opportunity to provide feedback to that report's authors. Finally we'll ask if there are any other remaining issues that remain to be addressed that haven't been covered in CSMAC, WSRD, IEEE, and ISART and any doubts in that detail, and details that require more information and consider next steps.

As NTIA's research and engineering lab, we are counting on all of you to have a lively discussion and share your perspectives so we can gain a better understanding of how we can best service the spectrum policy and management community. So let's get started with the program. Assistant Secretary Strickling will be providing our keynote address.

### 1.1.4 Introduction of Keynote Speaker

Permit me to violate my own rule to say a few introductory remarks about Secretary Strickling. Soon after Larry Strickling was confirmed as the Assistant Secretary of NTIA he visited our management team out in Boulder. During our meeting he asked our management team about our perspective on spectrum management. And naturally the discussion eventually got around to the whole notion of reallocations. And our general consensus was that reallocations are going to be getting harder and harder, and that the opportunities are fleeting. Certainly we're seeing that in the formal report that our Office of Spectrum Management put out recently. The problem is that many systems that could be relocated are just too expensive to relocate in a lot of cases, and there's just basic fundamental physics. Some systems have to stay where they're at because of the physics of the band they're in. Dynamic spectrum sharing seems to hold promise, but it's in its infancy; it's not quite ready yet.

But it was clear to all of us though that Secretary Strickling was asking the right questions. He was already, you know, well up to speed on the various, the various issues, and was well informed; moreover, he is not content to just manage NTIA. Rather he is intent on being a change agent. I notice in the PCAST Report a reference to the interstate highway system. I'd always been of the understanding the interstate highway system was commissioned during the Eisenhower administration. But the report pointed out that the initial concept paper was commissioned by President Roosevelt as early as 1949. In much the same manner Secretary Strickling is initiating a change now which will impact spectrum management for decades to come. With that, I'd like to welcome Assistant Secretary Larry Strickling. (Applause.)

### 1.2 Larry Strickling: Keynote Address

MR. STRICKLING: Thank you, Eric, for that very kind introduction. But I most want to assure everyone this isn't just me. This effort and the great adventure we are about to embark on is really the product of a lot of people. It's a product of the folks at ITS, Eric and the team out here. It's also a product of Karl Nebbia, the Office of Spectrum Management at NTIA in Washington. It's the product of thinkers like Doug Sicker, who served us so ably as our chief technology officer in the last year, and is about to head back here to Boulder, as some of you know who joined us last evening at the bar down the street. It'll be the product of Peter Tenhula who just joined NTIA, who'll be stepping into a role as senior advisor on spectrum issues. It's the product of Tom Power, who is at the Office of Science and Technology Policy at the Whitehouse as Deputy Chief Technology Officer for Telecommunications, and is absentee Chief of Staff at NTIA. We won't let him forget that just so that he doesn't forget us.

So this is really an effort where, as we need to do in all contexts, we need to get the experts together, we need to work collaboratively, we need to come up with the solutions and really work to execute and implement them. So I appreciate the comments, but by no means is this something I would ever take credit for as something that I uniquely contributed to because I just didn't. But I am very pleased to host the 13$^{th}$—at NTIA excuse me, host the 13$^{th}$ annual International Symposium on Advanced Radio Technologies.

We come here at a very sad time. Obviously we're all aware of the events in Aurora over the weekend. It has a special resonance for us at NTIA because we've just been charged with the task by congress of standing up FirstNet, the organization that will be charged with developing a nationwide public safety broadband network for first responders. And all Congress gave us was 20 pages on how to pick the board, $7 billion, and 20 megahertz of spectrum and said, "You-all fill in the blanks," which we are trying to do. But as I read through the transcripts of this morning's paper communications between the first responders and the natural chaos and confusion that accompanies any of these tragic calamities such as what was experienced here I was really struck by the possibility, the opportunity that we have at NTIA and many of you will have who participate in this process of how to design, develop, and implement a nationwide public safety broadband network that will hopefully allow responses to future tragedies and disasters to be done as seamlessly and as promptly and as efficiently as they can.

We may wonder how these issues effect those of us hundreds of miles away and working in different areas, but in fact this is one that really should hit home for those of you in the spectrum world because this is an immense problem that we haven't solved in this nation for the last more than ten years, and now we have a terrific opportunity to do so. And I'm very pleased and proud that NTIA's going to take a major role in that. I'd also like to recognize our organizers for the conference. You've heard from Eric. And also his co-chair for this conference was Chriss Hammerschmidt from the ITS, folks here in Boulder. Chriss, are you here?

MS. HAMMERSCHMIDT: I'm right here.

MR. STRICKLING: Right here in front. Can we acknowledge Chriss and Eric here for a second? (Applause.)

MR. STRICKLING: I understand they had a little help from Mike Cotton, who was the chair of the previous two conferences. Thank you also, Mike. So while this conference occurs at something of a sad time and time for some reflection here in the Denver area, it also comes at a very propitious time. Just last Friday the President's Council on Science and Technology released an important report on spectrum sharing. And this report came on the heels of NTIA's study on the 1755 to 1850 band earlier this spring. So I'm particularly pleased that the President's panel of experts confirmed what we at NTIA have been saying for the past year, which is that we need to find a new way of making spectrum available for commercial broadband. And that new way has to embrace the sharing of spectrum between federal agencies and industry.

What I hope you'll take away from those two reports in this conference are the following three very important principles. First, spectrum sharing is now critical to solving and satisfying the nation's long-term needs for more spectrum for commercial broadband. Second, we're going to explore a variety of a sharing methods, and we should not constrain technology development by picking one solution or picking one solution too soon. And third, collaboration among all parties, but especially between federal agencies and industry is essential to coming up with a successful program of spectrum sharing.

Now, spectrum sharing, while it's certainly becoming a hot topic, is nothing new. It dates back 100 years to the Radio Law of 1912. I guess we're now two or three weeks away from the centennial of the Radio Law that was passed in August of 1912. But the Radio Law of 1912 was the first law enacted to regulate the operation of any apparatus for radio communication. And it specified certain regulations to be enforced by the Secretary of Commerce. Actually, back then he was the Secretary of Commerce and Labor. But I guess they decided at some point that that was too much for one person to do and split it off. But anyway, the Secretary of Commerce was directed to enforce regulations to prevent or minimize interference with communication between stations.

And one of the first regulations provided an explicit sharing mechanism granting priority for distress signals from ships. All stations were required to “give absolute priority to signals and radiograms relating to ships in distress; to cease all sending if they heard a distress signal, and except when engaged in answering and aiding a ship in distress to refrain from sending until all signals and radiograms related thereto are completed.” And that’s a quote. So while obviously my engineer—I’m sorry. While obviously rudimentary I guess my engineering friends would refer to this as the first listen before talk spectrum sharing protocol.

Another one of these original radio regulations mandated time based sharing by requiring a division of time that established a quiet period for certain private or commercial short transmitters during the first 15 minutes of each hour. Naval or military stations were granted exclusive use of those first 15 minutes of each hour to transmit their signals or radiograms. But this time sharing provision also included a geographic sharing component in that only, it only applied to important seaports, and all other places where naval or military and private and commercial shore operations operate in such close proximity that interference cannot be avoided by other means. And yes, every station was required to designate a certain definite wavelength as the normal sending or receiving wavelength of the station, which of course today we call frequency assignments.

So 100 years ago marked the start of the basic methods of sharing radio spectrum by exploiting the time, the space, and the frequency dimensions of the radiofrequencies. One hundred years later we now find ourselves moving toward a new but similar model of spectrum sharing exploiting the same properties and dimensions, but making use of modern technology to help do it as densely and as efficiently as possible.

Our challenge today, and I literally mean today and tomorrow at this conference, but also in the weeks and months to come, is come up with the framework within which to move forward on this important issue. Now, as the PCAST report concludes, the old method of clearing spectrum of federal users and then making it available for the exclusive use of commercial, commercial providers is not sustainable any longer. We have moved the easy systems and to continue the old method of spectrum reallocation costs too much and takes too long. The wireless broadband industry and its customers as well as our economy just cannot afford the cost and delay.

Moreover, over the years the critical missions performed by federal agencies have required radio systems of greater and greater complexity, and have increased the agencies’ need for spectrum. So the opportunities to find spectrum to which we can relocate federal systems are rapidly dwindling. So nowhere is this confluence of these factors better illustrated than in the 95 megahertz of spectrum located between 1755 and 1850. In terms of the federal use we have more than 20 agencies who, combined, have more than 3,000 assignments in this band. They include point to point microwave, covert law enforcement surveillance, and air combat training systems where the transmitters literally are embedded in the skin of the aircraft. Our study which was released this spring projected it would take at least ten years and $18 billion to do a complete relocation of these systems.

Now, granted these are preliminary numbers. But you can discount them however you want and I think you still come up with a conclusion that this is going to take too long and cost too much to do a complete relocation of these systems. The solution, as PCAST recommends, is for federal agencies and commercial users to share the spectrum. We're now moving forward to implement this idea where we can so we have our Commerce Spectrum Management Advisory Committee.

Many of you participate in and others of you joined the members of the committee yesterday at our meeting over at the ITS labs yesterday afternoon. So that group has already organized itself into five working groups consisting of industry and agency representatives. They're going to evaluate all of the different uses in the 1755 to 1850 band, and they're going to determine the fastest, most cost effective way we could move forward to allow for commercial use in that band.

Now, in some cases traditional relocation is likely going to be the recommendation. Point to point microwave is a good example of that. It's a pretty straightforward system to relocate. We have spectrum to which we can move those systems. In other cases like the satellite Earth stations we'll probably be looking at defining geographic exclusion zones to protect the Earth stations yet allow commercial entry in large parts of the country which aren't affected by such zones. Now as a result of our work we're going to add a third option to the discussion, and that's the possibility that industry and agencies can both use spectrum in the same geographic area through use of today's technologies that will allow for the more efficient use of the spectrum.

These working groups are now up and running. And we're looking forward to hopefully receiving recommendations from these groups at the beginning of next year. As I said at the outset, good collaboration between public and private entries will be key to reaching a successful outcome here. And if we can prove out the model in the discussions in this band it will be important to maintain this collaborative approach as we discuss other frequency bands and the potential for sharing in those bands. Moreover, we have to be open to trying a number of approaches based on the specific systems we're dealing with. If we try to come up with a single approach too soon, we risk discouraging the development of other approaches in technologies that could prove to be more superior, and as a result in designing our process in 1755 to 1850 with separate working groups focusing on separate systems we hopefully will encourage some experimentation with a number of different solutions.

Now, I don't want to minimize the challenges that are in front of us. In addition to the technical issues we will obviously need to address a number of practical questions, such as determining who has priority, what will the process be for coordination, what will the enforcement regime be. These issues are going to require as much attention as the purely technical ones. And I'm glad to see that this conference will begin to address some of these issues. But we cannot let the technical and practical complexity of this challenge to be used as a reason for not aggressively and wholeheartedly confronting and solving these issues as quickly as we can. We have to solve these sharing issues in order to meet the growing demand for spectrum that shows no signs of abating.

So I encourage all of you to roll up your sleeves the next two days and thereafter, and be creative in your efforts. Let's look for how we can increase the use of spectrum and not just get trapped by all the reasons and all the barriers that have limited us for the last 100 years. We are at a historical and critical junction in terms of spectrum management and spectrum allocation. And your contributions can be a key part of the effort to keep the mobile band revolution going, yet ensuring the continuing success of our mission critical federal users. So I look forward to healthy and lively discussion over the coming days and in the months to come, and a continuation of the collaboration between government industry and academia that's a hallmark of these ISART conferences. So I thank you all for attending, and I hope you have a productive conference. Thank you very much. (Applause.)

MR. STRICKLING: Now, I realize I'm the only thing standing between you and your first coffee break. I know usually that comes at the end of the day when you want to go home, but some of you guys look like you already need some coffee. But they did want me to take questions, which I'm happy to do. I'm going to also take on the executive privilege of deferring questions to Karl Nebbia, if he hasn't left the room, because he can probably answer some more specific technical questions if you have them, where you'll get out of my depth pretty quickly. So if you have questions come to the microphone and identify yourself and your organization, and let's get a discussion going. If you have a question for the White House we can have Tom Power answer those questions. I'll just play traffic cop up here. Questions? You guys really do want the coffee. Okay, thank you very much, and have a good conference. (Applause.)

## 1.3 Session I: The Federal Spectrum Ecosystem

MR. NELSON: As I mentioned in my introductory remarks, our first session to be moderated by Tom Kidd is the Federal Spectrum Ecosystem. The purpose of this session is to really get in and fully understand how the federal government shares spectrum right now. Tom will have some introductory remarks and will talk a little bit more about that. The session will have a moderated discussion by Tom. At the end of that there will be Q and A. Unfortunately we lost an opportunity this morning to ask Larry Strickling some questions. But let's not lose that opportunity with this panel. We're kind of anticipating the need and the desire to really have a lively, engaging discussion to really probe and understand how this process works. If you do have questions we do have three microphones set up. There's one in the back and then here too in the aisle. There's a power switch right here on the center of the mic. You just flip that toward you. And I've been told just wait a couple of seconds and the mic will engage if you do have questions. With that I'd like to—(Discussion off the record.)

MR. NELSON: Oh, yes. And also the stairway up to the platform here for the speakers is on that side. There's a tripping hazard here. With that I'd like to pass it on to Tom.

### 1.3.1 Tom Kidd: Introduction

MR. KIDD: Thanks, Eric. Thank you, Chriss, for setting all of this up. I really appreciate it. In the past this panel or some semblance of it has come later in the conference and we've sort of set them behind because this group often gets a myriad of questions after people have talked about technology solutions, capabilities, things that we want to roll out quickly. We sometimes, those of us that are involved in these practices are either seen as a hindrance to that innovation or we are, or our process is simply not well understood. As Mr. Strickling pointed out, the process that we're talking about here has evolved over the last 100 years, almost exactly 100 years, a few weeks short of that. And it's still evolving today. It's not a 100-year-old process by any means.

As the, as new technology and new innovation and new requirements that that equipment places on the spectrum come out, the processes evolve. And in fact the frequency assignment subcommittee on the federal side is the principal subcommittee that proposes changes to the NTIA manual, which is the manual that lays out much of this process. So what we're going to talk about is the current process of sharing; the way that we currently coordinate, discuss.

I think it's important to point out that there are various kinds of sharing; we heard that mentioned earlier. And they fall into different kinds of categories as well. If you and I decide to split a parking space, okay, and we work out who is going to be in that parking space which day, we're sharing the parking space. Everyone in this room is sharing this space. We're sharing this space roughly analogous to the way we share the spectrum, which is we've all come into this room, figured out roughly how much room we needed, and we kind of carved out our own little space, and that's where we are. And we try not to elbow our neighbors, etc. Unfortunately, whereas when we ran out of space in this room we brought in more chairs, we can't really do that in the spectrum. We can't just bring in more spectrum unless we go higher or lower.

So with that I want to pass over to our first speaker, who is Mr. Bruce Washington. And what he's going to talk about is that process, that frequency assignment process within the NTIA and how that works. And then we will go along. And please start thinking up questions now. We have a lot of time. And we've anticipated those questions. And I don't think there's any of us on this panel that are shy about answering questions. With that, Bruce, I'll let you take the first—let me see if I can figure out how to bring up your slides.

### 1.3.2 Bruce Washington: Current Federal Frequency Assignment Process

MR. WASHINGTON: While Tom is doing that, first let me say good morning.

THE FLOOR: Good morning.

MR. WASHINGTON: Okay. Let me give you a little interesting tidbit. One of the CSMAC members, the Commerce Spectrum Advisory Committee member, reminded me in your booklet apparently my bio is not there. So I said, Oh, wow, that was not deliberate. So I think before I begin let me tell you a little bit about myself. I'm sure you guys have been looking through that very quickly. I currently work with the Office of Spectrum Management in the NTIA. I am Chief of Staff. I work for Karl, those who know Karl, and Larry Strickling is the Secretary. Before that I served with the Department of Energy. I see two of my Energy representatives here today. And before that I worked for the Department of Army, the Army Reserves as a lieutenant colonel in the Signal Corps. Any Army folks out there? Marine Corps? Navy? Okay. This is a quiet crowd.

Let me just say that as a soldier, we tend to speak up and speak out, and we tend to be very enthusiastic on what we do at all times. So if this crowd is going to be a showstopper we're going to have to just break it up a little bit. This is an exciting time in the spectrum community. And you guys are part of that. If you have not recognized it, then you need to ask someone; that's what my daughter would say. So really be excited about what's going on here.

When I left Energy I, knew I was going to a place that had a lot of energy and was fast thinking and fast moving and the spectrum community wanted to do a lot of great things, and support the mission overall; more importantly, looking toward the NTIA to see what could we do to help, actually be part of that process, and understand that process a lot better. So I'm here as not just a representative from NTIA, but more importantly, the Office of Spectrum Management to give you a general overview of the Frequency Assignment Branch because, quite frankly, I'm sort of pinch hitting for the deputy of the Spectrum Planning Committee, Tom Woods, who would have been delighted to be here, but as you guys know there's a budget crunch. And Karl said, "Well, since we're all here and Bruce, you already did, as the designated federal official for the CSMAC, looks like you don't have much to do the next day so why don't you just sit in for Tom." I said, "Well, I definitely can't beat Tom so I'm going to be the best I can be in front of you guys," and we're going to lean forward and see what we can get you guys to start talking about sharing in a wholly different concept.

So I looked at the agenda. And I told Tom Kidd, "Look, we were told ten minutes." I said, "So, you know, we put down some slides for about a ten-minute presentation which, you know in the Army community that's two slides, you know." You're on, you're off, you lean forward and it's over. And I said, "But it's two hours on here." I said, "Two hours!" I looked at my guesstimate and said, "I hope you guys got a lot to say because I was told to follow orders, and that's normally what I do." No, we're going to see whether we can get you guys going here a little bit.

So I bring a lot in the way of being around a community in two respects. One from the federal side being in the Department of Energy managing spectrum over there, spectrum lead for the headquarters, and also coming over to NTIA during a great time as the chief, Chief of Staff for working for Karl, who is a great leader, a great vision, host of knowledge. Those who know him and know Eddie Davidson and recently we got Julie Zoller on that team as well, those who know Julie. There's a lot of energy we have there. There's a lot of energy we have in the room. We've got a couple of folks still here. I don't know if John Hunter is in the room. I know Peter, I think I saw Peter hereabouts. A lot of energy is going around.

We're also asking ourselves the question, How do we share? You know, we're getting inquiries from Congress, from the Hill, from you guys out in the community from the commercial side, the non-federal side—How did we do this? So it's causing us to rethink our processes in-house. One of the things that Karl had challenged the leaders, the directors in the Office of Spectrum Management to do was to reinvent the process, to streamline the process as much as possible. What can we do? What if we did this? What would it mean to the community, the customer, the American people, and you-all? And you ought to be able to look back and say, Wow, we're about to do something different. And you ought to be excited about that. We're about to do something different.

For years people have been in position and been sort of blocking procedures and processes, safeguarding their assignments and things of that nature, you know, and making sure the process went through the process whether it was long or short because that's the way we did things; that was the culture at the time. We're about to change that culture, so in changing that culture, we're going to need stewards like yourself to bring forth the questions, to ask the what if, the possibility to understand in-depth what it takes to do what we do at NTIA, to what is happening in the agencies, and what their processes are to make sure that we're doing things smartly.

Are we using technology? Are we advancing with technology? Are we still using old technology how we do things? Are we using the right algorithms? Where is all this coming from? What does it mean to us? What does it mean to you? Not to go on and on, but what I was asked to do today this morning was to basically first pitch the chart, the allocation chart. So if you hadn't seen it before this is actually a brand-new chart. If you notice, the date is—should be August 11. I hope I got the right slot up there. They've been working, we've been working on tweaking this chart for a very long time. I'm sure if you go around a lot of federal agencies you will see it hanging up on someone's wall, inside a book or inside a pamphlet. Folks have used it to their benefit to market, you know, spectrum, you know, to put a face to spectrum, what is it, what does it look like, what are the allocations associated with it. Folks are looking at it.

We decided it couldn't be a wall chart; it had to mean a little bit more to be up to date. So if you don't have one of these they're actually hot. I think they're registered now, that you can get them on line and order them through the Government Printing Office. So we took the next step in making sure you guys can get those. There's a few in circulation so have at it. And be excited about it.

Let's move on to the next slide. Are you driving or am I driving?

While he's surfing for that what I'd like to do is basically tell you guys a little bit about the process of frequency assignment. Just by a show of hands how many federal representatives are here from agencies? Okay, okay. So just wondered. And I assume everyone else is non-federal. Okay. Well, the process, you know, I was pretty happy to do this. I remember as a signal officer in the Army active duty serving overseas and domestically and also as a reservist with the signal command out of Hawaii—and no, that wasn't a vacation. We actually worked in a bunker isolated for days at a time—one of the things we had to do was deconflict and get assignments very quickly. In the federal government it works sort of like this. An individual out in the field needs an assignment, a new assignment. They may be working on a new endeavor, and they have to go through both their own agency and the headquarters and make their way over to NTIA, okay, because we're sort of the clearinghouse for the federal government, the clearinghouse for the commercial side, the non-federal side is the FCC.

So that being said, that process comes in through, you know, your agency, your representative out in the field whether you have a district or region or whatever, and that assignment comes up through your headquarters. Right now the process with using that is in some agencies is SPECTRUM XXI. Bottom line in the Redbook it tells you the process and procedures for submitting assignments forward.

Once an individual or individuals or organization or director decide they need an assignment, they submit that through, they submit it on to the frequency assignment subcommittee or the frequency assignment branch under the auspices of the Office of Spectrum Management, which is under NTIA, which is a whole bunch of guys in a classified room in the bottom of the Department of Commerce. If you've never been at the Department of Commerce in the basement, it's not the best place to work. But to let you know, there's folks down there doing good work. And it is submitted through them, those guys on average a day get 350 requests for assignments.

They put forth, as they get that assignment they put forth what they call an agenda. They look at the assignments against everyone else putting in assignment and all previous assignments and they deconflict and run analysis on the assignments, see if they're missing any data. SPECTRUM XXI is form-fed. They put in parameters. They run those to see whether or not we've got any quick wins or losses, if anything's missing as far the input to that, and they run that in the form of an agenda. That agenda is passed through the agencies to relook again to see whether any parameters were missing, in fact whether or not their request is a quick win or is it suffering any problems or losses as far as missing any data or conflicts, or is there any interference problems.

Normally when it comes, when it's out there on the agenda the agencies are looking back on it again. NTIA standard—and it's not just an OSM standard, it's not a frequency assignment standard—NTIA standard turns that agenda back to the agencies within nine days. We actually report that on our score card how well we do every year, actually every quarter and how we do every year. Since I've been there we've been doing very well. We've been meeting the threshold of nine days. I've only been at NTIA for two years so I don't have any past history of that. But I understand by being at Energy they turn around assignments pretty good, turn around assignments pretty good.

Once those assignments have sort of cleared the frequency assignment branch and the agencies have put in their two cents and acknowledged, you know, any concerns or problems with the assignment, whoever is asking for it, then it's kicked back out to the agencies with approval or denial or whatever information is needed, and then it's placed, it's placed in the Government Master File. And basically that's the process. But before then, the agencies have a lot of work to do as far as getting that assignment through their own agency and clearinghouse so to speak, their own process. That process can take anywhere from, you know, 30 to 60 to 75 days in house.

And if in fact that assignment that they're looking to use for whatever reason needs to be coordinated with the FAA or DOD, then it has to go into another sort of a subcommittee, to the frequency assignment subcommittee to be cleared off because there are certain assignments and bands and allocations that as soon as you ask for an assignment, if it's associated with the FAA or DOD, it has to be reviewed by those individual and then they'll kick it back out to the agency. So, you know, a lot of times folks don't know what's happening in the background. A lot of people are involved in the process, whether you have a project manager who is trying to get a platform off of a Navy vessel and needs an assignment, or someone's doing research and development, a lot of people are in the process. So that's very very important that we, the NTIA, can turn that around as quickly as possible. I know that's one of the outstanding questions, you know, Why does it take so long to get an assignment? What's all involved in that assignment? But I can assure you that at NTIA we're trying to fast-track that.

You'll hear a little more about our new platform we're kicking off, FSMS. Show of hands: Everybody knows what FSMS is? Okay. That's big hands, not little hands. Our project manager is in back. So Rob Hite, raise your hand. He's the sticky, okay? That gentleman right there we've got a lot of confidence in to make sure the Federal Spectrum Management System comes to fruition. I believe final rollout we're looking at 2014? '14, '15, correct? And every day I am on him every day, What's going on, Rob? And we want to know how the project is going.

We recently have been challenged by both OMB and in house, Department of Commerce, to take a quick look and dive in that process, and ensure that that investment—and it's truly an investment—is moving forward. Because quite frankly, you know, we can't do business the way we've been doing. We have got platforms that are significantly old. And, you know, it just reminds me, you know, back in the day when I did have hair—and yes, I had hair. I see I have a few club members out there as well. And, you know, you're not used to some things. And sometimes when you lose something people get a little bit antsy and say, Why are we doing this? Because we need to. So whether you're losing it, if it's hair that's half there, just shave it all off and start new. That's what we're going to do. We'll get rid of all our platforms and start new.

Not everybody is comfortable being bald. But I can tell you I am, because I realize that sometimes you just got to reinvent yourself. At NTIA we're trying to reinvent ourselves. That's a good thing. You got to go forward like that. What can we do? What is the what-if? What can we do to make the process better? Moving on to the next slide, what I'd like to do is we asked the question—do you want to get that? I'm sorry you got to jump up and down.

We've asked the question in preparation for this basically, NTIA, can you share with the audience that is enthusiastic and really wants to know what sharing's like in the federal government. They're so enthusiastic. What does that mean as far as allocations? What does allocations mean? What is, you know, what type of sharing really are we doing? What can we get credit for? We know we've got to find, together with the FCC, 500, make available 500 megahertz of spectrum. And I understand that people are asking for more. And there's not much out there. So where are we now? What can we say that, you know, what we're doing now and how we're doing that?

Of course many of you know, if not all of you know, that, you know, we're actually sharing spectrum now; we are sharing spectrum. And in the avenue of space and time we're sharing spectrum. When it comes down to allocations we're sharing the bands. Different operations are going on a different band. I'm going to try to keep this simple. There's no need to throw out, you know, which bands and which assignments and things of that nature. The bottom line is there are allocations out there on the federal side and non-federal side, state and local doing great things.

I can attest to that by being, you know, a former soldier that, you know, I was part of a lot of domestic situations and, you know, you get out there and it's a simple process, you know, You, this is me, over. I can't talk to you. Come over to my hootch. Let me give you this radio, give you this assignment, and you come up on my net. Well, I can't do that because I don't have equivalent equipment. No, we've got something for you and you can stay on here.

Is that sharing? If I give you my radio and you get on my net and you do your operations is that sharing? Are we trying to share the assignment? Are we trying to share or enable the user to be able to talk effectively? What are we really doing? In a case where, you know, I'm not in that area or we're not in that area we've got government agencies using that assignment on the East Coast and not using them on the West Coast. You may have an agency like Interior saying, Can I use that assignment? And give space and time, coordination is made and that assignment is shared. Is that sharing? Okay, I've got one head. Can I get two? I got two heads. Can I get three? Okay, I got three heads. Okay, that's good. It's important to note that that means a lot to us.

And if you look at the chart—and we don't want to go back to it because we don't want Tom to jump up again—but if you go back to the chart, it's color coded. At the bottom of the chart there's a color and it's black. And that black indicates that that band or that allocation is being shared. It's being shared, you know, with the federal agencies. In some cases in coordination with the FCC, when someone is doing testing, experimental testing near a testing missile range or one of the manufacturers want to do some testing, whomever it may be—I see a few, few manufacturers in the room—but if they want to do testing near a DOD base that has to be coordinated, okay? And those assignments, you know, it has to be coordinated with the local managers. And in fact there is some sharing going on, on a temporary basis for experimental reasons or for just testing reasons.

So there's a lot of sharing that's actually going on between federal and federal, and federal and non-federal. In the case where you've got, you have, may have fires out on the West Coast and you've got local responders, you know, local fire department responding to a fire and you're calling in reinforcements, in fact, you know, they need to be on the same bands; they need to be communicating for safety reasons and to protect life. And so those assignment are shared on a temporary basis. So sharing is going on. So you have to be excited about it. You might not jump up and down, but we at NTIA and OSM, we jump up and down because we consider it a win, and when federal agencies can share among themselves, when we can share an assignment with a non-federal agency, that's a good thing too.

So throughout the table allocations you will see that black indicator where sharing is going on. So I heard you guys, you know. To get one of the wall charts it has been updated. I can assure you hours upon hours have been dedicated to making sure that it's no longer just a poster sitting on somebody's wall perfectly framed, but in fact it can be absolutely useful. So we talk about, you know, allocations, and we talked about allotments. And typically area sharing is a pretty simple process which I described a little bit earlier, and that is, you know, you're not using the assignment in the same area. And someone needs to use it and it's worked out between the agencies for, you know, a given period of time and space, separation and usually there are rules in place on how that is done, and agreements that are put in place for that, and that's quite all right. In some cases if an agency has an allotment somewhere else on the East Coast and they're not using all of those, and then someone needs, the FBI maybe needs to use something on the West Coast, you know, permission is given through a formal process in which they can do that. That's another avenue of sharing.

One of the other things once again that I am sort of going to wrap up here and I just wanted to sort of reiterate, you know, our investment that we're putting a lot of money in and we're monitoring it on a daily basis is the FSMS process or the development of FSMS. You'll hear a lot more about that later. I think you guys will be really excited once we roll that out. It's going to allow us—and I won't steal any more of Rob's thunder, but it's basically going to allow the federal government, NTIA, the Office of Spectrum Management, to process assignments and really look very closely at where we can leverage opportunities where assignments are not being used and we can, you know, there's across the board hopefully the data that's supporting that is up to date, is up to date by the agencies and it's good data and it's real-time data, and hopefully FSMS will be able to produce the results that we're looking for to get us down from a coordination point of nine days much lower than that, and we certainly want to be able to do that.

Again, that's how we're getting excited, despite the fact that we're answering a tremendous amount of inquiries from the top down on a regular basis about, you know, what are we doing with sharing, and looking at internal processes or how we can do better as a federal agency to provide better spectrum management back out to the American people and back out to the federal agencies as well, and how we can support our mission. I'd just like to thank you guys. Rob, I don't know when your presentation is. I would say to you guys, stick your head—oh, I guess this is the only business isn't it, so I guess you have no choice but to hear from Rob. But I would encourage you guys to ask questions about, you know, what we're doing in NTIA and OSM, Office of Spectrum Management to be better spectrum managers. I saw Karl walk in. I'm sure he's taking any questions that relate to that. But we're excited about it. We want you guys to be excited about it. And so continue to ask questions. We've got a great group of panelists right here. We'll do our best to answer your questions. What we can't answer I see there are more capable folks out there in the audience that are associated with NTIA in some way or some form that will jump in and answer your questions. Should I turn it over to—

MR. KIDD: No. You-all thought we were a bunch of stuffed shirts, you know, bureaucrats. Who knew it was so exciting to work in spectrum? Those of us who work in it, we knew it was that exciting on a daily basis. I'm glad to hear that things are. So Bruce was talking from the perspective of the NTIA, the overall federal regulator. The rest us on the panel in one way or another are their customer in a sense, including myself. I represent the Department of the Navy at the IRAC. And up next is one of the major customers. They're all, you know, everybody who access, all the federal agencies who access spectrum, none are more important than others. But sometimes we look at various missions and things like that. Department of Justice has some very unique challenges when it comes to accessing the spectrum. Some of their coordination and sharing concerns might be slightly different than some of the other agencies. Up next is James Craig. I'm going to play with this computer to see if I can bring up his presentation.

### 1.3.3 James Craig: Department of Justice Perspective on Spectrum Sharing

MR. CRAIG: Thanks, Tom. While Tom's bringing that up I'm here to give you a federal perspective, federal law enforcement perspective on how we use spectrum, how we share spectrum. The reason I got, how I got here is I made the mistake of talking to an NTIA official one time, making the mistake of saying, We actually share spectrum. So I was asked to come up here and actually show how we actually share some spectrum. Being a customer of Bruce I can tell you he's very stingy when it comes to actually giving us assignments, so he actually does his job very well.

Talking about DOJ. The main components: ATF, DEA, FBI and Marshals. Those are the four law enforcement components that use the spectrum for law enforcement purpose. ATF came to the Department from Treasury after the 911 merger. We have numerous assignments between two megs and 22 gigahertz. Go to the next slide. All right.

How we use spectrum. Day to day mission critical assignment land mobile radio radio. The other is video surveillance, surveillance activities both video and audio surveillance. The big factor for us is: anywhere at any time. We have to be able to access our equipment and spectrum for surveillance purposes. One of the challenges we have going forward is the relocation of what we call agent safety critical applications. I especially like DEA and FBI where they have undercover agents involved. Those undercovers for safety purposes are wired, both audio and video, all covert, usually low power, 200 milliwatts, but again, it's anytime, anywhere. The challenge has been finding the technology, still analog technology, that can get us into a digital format, narrow band format, wide meg channels.

The other channels for us is robotics between ATF, FBI robotics. A good example is three days ago here in Aurora, three different robots were used. Those were all analog, all in the LMS band, all 17 and 22 meg channels. The challenge is—finding the technology, it's not so much the challenge is to the technology of where we go. Do we go down in the band? Do we go up in the band? Do we use public safety broadband network? Do we use 4.9? Do we use a combination thereof? Do we use commercial?

Two types of applications of surveillance, what we call fixed and transportable. Transportable is what I just talked about, the undercover operations, the surveillance. Fixed is more point to point. We have numerous point to point namely for backhaul of the surveillances across the country.

You know what? Go back one. I forgot to mention, there's been talk about U.S. and PS assignments. If you look, only eight percent of DOJ assignments are actually U.S. and P. There's a lot of folks out there in the private sector think we have quite a few U.S. and P assignments across the country, but in actuality it's only eight percent. We do share channels across the spectrum especially after the last AWS spectrum auction. We reorganized the assignment within the department amongst the law enforcement agencies.

Give you an example. Let's just take New York City. DEA will have X number of assignments. I want to say it's about four or five assignments in the New York City metropolitan area. FBI will have about the same. They've got about six. ATF has three, and the marshals have two. Then there's four to five DOJ shared assignments. So with DEA using those three or four assignments that they have and having the additional surveillance or additional need then they'll coordinate locally with the components in New York City for using those shared assignments. And we do that across the country. And again, after AWS 1, we actually went back, reorganized, and made more shared assignments. Again, deconfliction is done at the local level or the headquarters level. Within DOJ we have a spectrum management office that coordinates with all four components. All the components have their own spectrum management shop as well.

Next slide. The other thing is equipment purchases as moving forward again from AWS 1, we do buy our equipment in multiple band. When I say multi band, usually after AWS 1 we bought—equipment was up in the upper L band, and we bought equipment in the S band and the C band for surveillance purposes. The challenge for us moving forward is we're not whole yet. And where we have major events we do run into issues. We actually have to turn down surveillance and bring other things up to handle large events, i.e., Superbowls or any major event or disaster in a major city.

Moving forward, the use of video surveillance has I want to say in the last five years quadrupled for federal law enforcement, especially for DOJ. There is a trend for us moving forward looking at commercial—I want to say probably about 50 or 60 percent surveillance is right now on commercial networks. That is a challenge for us. Latency becomes a challenge. The networks get saturated, we lose surveillances. So typically any surveillance that's sensitive will be on a government spectrum. I hate to use the word routine. Nothing is ever routine in law enforcement. But a routine surveillance will actually use commercial applications.

The challenge for us forward is as we lose spectrum moving forward more and more commercial, the costs go up. And everybody knows about federal budgets right now. And the cost going up, the point is the budget's not going up and the costs for surveillances are going up and the need for surveillances are going up, so that's a challenge for us.

Next slide. We do, we do sharing with land mobile radio. We're doing quite a bit with DHS and the Department of Interior. Our strategy going forward is to consolidate all of the components from one land mobile radio network, that is the FBI network, the VHF network. Currently DEA is a UHF network. Each of them have standalone land mobile radio networks. For the past—everybody heard of I-1. And they actually tried to change the name. That didn't work. But it is not a failure; it is moving forward as we do get budget. And again, to consolidate them on to the FBI VHF network, most of it will be conventional networks, not trunk because we can't afford trunking.

For example, in the national capital region currently we have a new trunk system going in. We're actually sharing with Treasury, Interior, and DOJ components on a trunk system. Everybody brought spectrum to the table. So the plan going forward would take DEA off UHF, put them on VHF and give them increased interoperability. In addition, working with our state and local counterparts to promote interoperability and spectrum efficiency because we're buying them dual band radios, and we're actually putting them on state and local systems with dual band radios, consolidate them on the FBI networks so they have DOJ interoperability and interoperability with state and locals, and that's proven quite effective going forward. And of course the result of this would be AES and narrow band, one of the mandates which we still haven't met. Next slide, please.

The other land mobile area network we do with state and locals. We've done it. You can see the states up there, Montana and Wyoming are good examples. We've actually brought federal spectrum to the system. And we go through the IRAC process to make that happen. Again, very effective for us. We put our users on those systems, again giving them better coverage, better radios, better interoperability, and at the same time sharing spectrum.

Next slide. I hesitated to show this one. It's really in a draft format. We've been talking to DHS currently about a draft plan to share with NTIA moving forward where you take federal law enforcement, move them to a certain block of spectrum, and where we cross the entire federal law enforcement system, we actually share that spectrum in a dynamic way. I mean, we had meetings yesterday. We all talked about is it sensing? Is it databases? Is it a combination thereof? And most of the components I work with and the people on the street, they don't really care; all they care about is that when they get the equipment they turn it on, it works. How they get the spectrum they don't really care.

So moving forward I don't think you'll have any resistance from most federal law enforcement about what I call dynamic sharing. Give us a block of spectrum, put it out there. We've got to go get the equipment, purchase that equipment, but then use that equipment where we need it. We share all the time right now. We share with DHS enforcement operations. We might have an undercover agent over here working in the L band ten blocks from here, Homeland Security may have another operation two miles from here in actually the same band. They don't interfere with each other. Low power type operation. We can coexist. We do coexist today. So that's still a draft. It's still floating between DOJ and DHS. At some point we'll be sitting down with NTIA, Bruce and others, talking about this.

Next slide, please. Again, we already talked about the goal, sharing plan. Establish a maintenance and law enforcement, again, spectrum management shop, a joint shop. We're actually talking to DHS about collating, co-locating our spectrum shop and our wireless shop with their new joint program office over in Chantilly. We have an MOU now in place. Next slide, please. We already talked about this. As an example—I didn't want to put the agencies up there, but this is an example of the 2200 band where across the board five different federal agencies, you can see how we overlap. We do share in different parts of the country.

Like Bruce mentioned, I may be on the West Coast using 2.2, and over on the West Coast DHS is using 2.2 or again ten miles away using 2.2. So if you look at it we currently share. All those you see most of them are still wide band analog channels. We still have to narrow band a lot of our equipment. I want to throw this up there.

During AWS 1 I know CSMAC we got five different working groups working with the private sector. We actually tried this from a DOJ perspective, mainly DEA, but we brought ATF and FBI to the table. And we picked certain cities across the country with TMobile and went out actually in the field and said, Can we coexist? Can we do this? The answer is clear we couldn't; we tried. But with proper planning, prior planning—again, this was actually after the auction. But I think lessons learned here for us is to do a lot of this work up front and things will move faster. You can see it took us about 18 months, but again, that was a small chunk of the spectrum now, to move entirely out of the L bands would take more work. So from a federal law enforcement, federal agency perspective, having the funding and the ability up front and the R&D efforts up front and working together up front, things can go a lot quicker and a lot smoother, and that's proven with what we did with TMobile. And that concludes my presentation. (Applause.)

MR. KIDD: Thanks, James. It's a really good point that you make about where we have like missions, like requirements, federal agencies, we share together. And nowhere from my personal perspective of course is that more evident than with our next speaker because we share the maritime environment with the U.S. Navy and the U.S. Coast Guard. And so we work hand in glove. We work very closely all the way from the ITU level down to within the federal government we've got each other's backs in all sort of environments. With that I will tackle the technical challenges here. And we'll introduce Mr. Joe Hersey from the U.S. Coast Guard. Joe is going to do his own slides. Outstanding. I don't have to pay attention.

### 1.3.4 Joe Hersey: A Maritime and Coast Guard Perspective on Spectrum Sharing - Making it Work

MR. HERSEY: I'm going to mess it up, and Tom's going to have to help me straighten it out. Thank you for that. That is a packed audience. I didn't expect that. But I appreciate that. I'll learn more than probably you're going to learn from me, so bear with me. I have three case studies. I'm going to sneak in a fourth one if I do it quietly and not ask permission.

The three are a C band and S band, both of which have a lot of interest for broadband right now, and VHF, which doesn't. But unfortunately from the old allocation table, VHF is the Coast Guard's program; that's as broad as we get. The fourth item, it's going to be another case study involving medical devices, which is something the Coast Guard doesn't normally get involved in, but I'll explain that later.

Regarding C band, I think most of you know that the middle class tax cut bill that passed earlier this year mandated NTIA study opening up two sections of the band 5000 to 6000 megahertz. IEEE has channelized throughout the whole gigahertz for the purpose of eventual broadband use. Coast Guard is actually using the lower portion of the band. When those bands were opened up several years ago we were not involved; we had no systems in there. But because of the changing of our cutters and modernization we now do. So we are affected by this as is the Navy. We are working closely with the Navy to determine what the impact is. Our missions are a little bit different from the Navy. I've listed them up here. Our cutters do those following jobs. And if there's a problem with sharing, those missions are the ones that are affected. We have some concerns in looking at this.

Probably the biggest concern that we have is that interference might be out there, but the operator will be totally unaware that it's happening. If the constant false alarm rate certifying that the computer is working too well, it will see that interference and it'll recognize it as something that shouldn't be there, and it will take it all away and the screen will look perfectly clean. The problem is that the targets are taken away too because of the amount of interference, and the targets, the important targets, lifesaving targets may be lost as well.

The second one is Wi-Fi is pretty ubiquitous. If Wi-Fi can be found to be used as a low cost jammer for people who shouldn't be jamming and they don't want the Coast Guard to know where they are, that could be a neat little technique to use, and may be actually more effective than GPS jammers, which are technically illegal right now. Those are the two concerns we have.

I don't think that any of those concerns are showstoppers. We're going to make sure that we're going into this assuming that it's going to happen, and we're here to help make it work. We just want to make it work in a way that's not going to hurt us well. We plan to do some tests this summer to determine whether these problems are there and to the extent that it's there.

The radar that we have in our new cutter is also at a training center in Petaluma, California. And Navy and Coast Guard both use that particular radar for test purposes since the radar is relatively new and available for that. And the tests that we're planning to do are threefold. One is to test it against currently allowed Wi-Fi devices, the bands that are currently allowed to operate. The second test will be to include operations in the bands that are not currently allowed to operate in. The radar folks call that this the refugee band. That's the lower of the two bands that the middle class tax cut is asking to be open to broadband.

And the third one is probably the most serious one. That's if the radar is affected by this interference will the operator of that radar know that he's being interfered with, will he see it, and if so, will he have the ability to DF on the source of that interference? If the answer is yes to both questions, that will help us a lot in the sharing capability because it's inevitable that somebody's DFS somewhere won't work, and if that happens and we needed to know that it happened and take care of it. If there's a feedback mechanism, enforcement mechanism that will help the whole process work better. I think it can help all of us to do that.

Some of the remaining problems that we found with the radar that we're using is classified. That means that we're passing the classified statistics back to NTIA. In the past when we've done that, the statistics, the characteristics of the radar or characteristics of anything that is classified end there, and the people that need this information never see it and never know it exists simply because they don't possess the clearances. So they will review all the characteristics of the unclassified federal systems and they will work diligently to protect that. But the classified systems they won't see because they don't have the clearances. That surely doesn't do us much good and it's not a solution that's easily solved for us. But there is a simple solution for that, and that's the broadband DFS developer's clearances. It's not a significant clearance; I think we're talking about confidential or something. But they still need that clearance. If they get that, then we'll be happy to share the data with them. I think that will do us all good. Sharing of data is beneficial to both sides. We want that to happen. Without the clearances it won't happen. That includes the folks that are participating in the IEEE attempt to eliminate C standards as well. I think that the clearances, they'll get all the information they need to protect those systems.

The second problem is the radar manufacturers have not been engaged in this effort. That's not true universally. I think some of the federal systems such as NEXRAD and whatnot—NEXRAD and C band, they've certainly been engaged in these processes. For the C band, the radar manufacturer we deal with is a foreign manufacturer. We reached out to him to get him engaged. He is still studying the problem. We haven't heard back yet. I don't believe that they're engaged in CSMAC or any other issues. So it's left to the federal agencies to defend the operations or radar. And that middleman is not necessarily a good way of dealing with technical problems.

The second problem is what happens when the broadband population explodes. DFS may work for low/moderate populations; it may not work when the population grows like we think that it might. How do you locate it when we have malfunctioning DFS amongst large populations of unlicensed devices? Those are questions we don't know.

By the way, we worked with the DOD in doing simulations against the radar which will be included in the broadband report. Those simulations show that without DFS we can't operate; we have a serious problem. But with DFS most of those problems go away. Right now our cutter is based in Alameda, California, San Francisco Bay. That's where the simulations were done, in San Francisco Bay. That's what the results show, it won't work if these broadband devices don't have DFS. If the DFS is there and it works, most, not all, but most of the interference goes away; that's encouraging.

S band. Let me jump into the S band a little bit. Right now S band doesn't, isn't being studied so closely. The PPSQ report recommends that the upper end of that band be opened up for broadband with setback requirements to coastal areas. PCAST has picked up on that. They're noting the problems with that, and they're recommending a different approach to S band. S band is cool if you can open it up. There's almost a gigahertz—not quite. I think the upper limit is

1630—it is almost a gigahertz of spectrum that could possibly be opened up with broadband here. I think our assumption is this it is inevitable that this band will be opened up to broadband, and that is exactly what PCAST is recommending, that this band be targeted right up top for sharing. I think we're going to have to deal with that.

The U.S. Coast Guard doesn't have government radars operating on this band, at least not that I know of; however, the marine service does. The PCAST report noted that shared spectrum, in shared spectrum, federal agencies have predominant federal/non-federal. That finding surprised me. I noticed that they'd footnoted that finding. It was an statement that Mr. Nebbia had made. Mr. Nebbia nodded his head both directions so I'm not sure whether that's true. But that was surprising. I'm not going to say it's true or not true, I don't know. I had assumed that it wasn't but obviously I don't know things that I don't know. So it's certainly got my interest.

Nevertheless, the Marine band is actually used by commercial shipping primarily as well as small commercial units in the United States. X band is their preference normally because it's cheaper and higher resolution, but S band works in a rainstorm and more so in a snow squall where X band won't. So the IMO has required large ships to care both. And as a matter of fact a number of ships do carry both and certainly S band just so that they can work in foul weather. Ships need to navigate, their need for navigation, to navigate in foul weather is probably where it's mostly needed so there's good reason for S band there.

The problem is most of the manufacturers are off shore. Their standards are based upon international maritime organizations and their certification is based upon the International Electrotechnical Commission, IEC. IEC is an organization made up primarily of manufacturers themselves, and commercial entities; however, the Coast Guard is a believer of standards. We're a member of IEC, and we participate in that. We've actually invited ITS Boulder to participate in the standards here and there, too, working on this.

I'll talk about some of the results of those particular radars. Right now marine radars have experienced interference from broadband, from broadband systems operating at 2690 megahertz. For a system that operates primarily at 3100 megahertz that's sort of surprising and that's sort of disquieting, so that's the type of problem that we're trying to face. We have some ongoing work that we've asked ITS Boulder to do. This report on nonlinear interference effects in S band marine radar caused by broadband is in peer review right now. It should be published shortly. They've been working on this the past year.

They have a second report coming, which would include solid state radars where the marine radar is manufacturing towards away from magnetron radars. This is a type of work, conclusion that they're measuring right now, probability of protection; it's a measure of interference power. That result will be presented not only publicly here, made publicly available, but it will be presented to the ITU as well.

The problem with the work that ITS Boulder is doing is that it's difficult to know what to task them to do because things are moving so quickly. The current process allows broadband to operate in allocated spectrum right now below 2700. The UK is looking at allowing broadband systems to operate up to 2750 megahertz, which is a little close to the marine service but not so close as to give us a problem; that could give FAA far more serious problems than us. Some of the questions we're looking at is if DFS can protect several marine radars. That's difficult because some of the marine radars, some of them are ancient, not very well documented and also not federally owned, so it's difficult for us to get the characteristics. I think the answer is eventually yes, but certainly further study's needed.

This chart caught my attention. ITS Boulder in their work did an RF selectivity chart of typical S band radar. That doesn't include the IF selectivity which of course would be a whole lot better, but would show how a radar receiver could be overloaded from broadband. The dark line is the effective RF selectivity of an S band radar going from 2500 to something close to 3500 megahertz as you can see. The radar band is outlined in blue; the broadband band is outlined in yellow and shows, explains a little bit why we may be seeing some broadband interference in some locations down to 2690 megahertz, even though the dark blue is above 3000 megahertz. This is a bit of a problem; this is surprising to me. It sort of makes one think of the Light Squared experience with GPS.

The third case study is VHF. There's not a whole lot of broadband here. The maritime service, the Coast Guard is low, but the civil maritime service is probably the most important maritime spectrum resource there is and that's because of it's the one available outside of high frequency and medium frequency that provides for international operability: Their ships in our waters, our ships in their waters, et cetera. This VHF spectrum is used for a variety of purposes internationally and in the United States. Most of them are voice with the exception of distress and the exception of automatic identification systems, which is a broadcast type transponder type system which revolutionized the maritime industry, new technology.

This confusing little chart shows how public spectrum, how VHF spectrum is allocated in the United States. I think most of you are familiar with Part 90, which is yellow and public safety and industrial business. Part 22 is the pagers, which is sort of a dying industry, but they're allocated. Part 74 is broadcast; Part 74 D is remote broadcast pick up VHF spectrum, which we believe is also one of the issues that broadcasters and remote sites, something that when we get there we should have. The little crosshatch thing in the top is the internationally allocated VHF spectrum. If you notice it doesn't upgrade well with the U.S. The two little blocks on the upper side crosshatch are duplex channels, coast side transmit, shore side transmit, and the bottom side is either ship transmit or simplex, ship-shore transmit. There it aligns up a whole lot better. That Part 80 maritime a little bit in red is where the service is.

The little purple thing on the upper right-hand side called auction, that's both on the post station side, upper side and lower side. That was auctioned back in 1999 to a company that wanted to open up a commercial public telephone VHF public marine operator service, an automated one back in the dot com bubble that was occurring. Cellphone industry, like a lot of industries, wiped them out very quickly. He won the spectrum and ended up losing his whole business. He did not go bankrupt; he kept the spectrum. He actually sued the Coast Guard when he discovered that he was required to give it to us and decided he'd rather sell it to us instead. However that was resolved. However he's still in business as a spectrum speculator. There are a few spectrum speculators out there. He's also, for us, he's holding onto some very valuable spectrum because of this international interoperability bit. Other than going after the railroads, broadcasters in the brown and green, or going after public safety, something that's probably not a winner for us.

That's the type of situation we've been dealing with in trying to get new technology, particularly data capable technology into the maritime services internationally. The problem that we're having is that there are no data channels except for AIS and distress. There's no provision for growth. A lot of the spectrum was auctioned to a spectrum speculator. Some of the solutions we're looking for, we have a letter into NTIA asking for their assistance. They're holding onto it right now. We're told, we've been told by them that we are not allowed to go to a spectrum speculator and get spectrum from them. That's an obvious solution, but we can't do that.

However, the Coast Guard for years have had very close ties to the standards organizations. And Radio Technical Commission for Maritime Services is one of them. They developed the standard for VHF FM digital message services which is a way of sharing data over voice existing maritime channels. That has been completed. We're looking at doing some tests on that. RTCM has submitted that to the FCC asking for a rulemaking allowing those as provisions.

The reason I mention this is it brings us to PCAST. Certainly some of the solutions on here that we're looking at, PCAST made a number of recommendations that I think actually are appealing to us. There'll be a whole lot more discussed on this later. One of their findings, one of their conclusions was making sharing by federal users with commercial users the norm. When I read that I guess the first question I had is, Can this mean federal users can share non-federal spectrum in that same way? I was going through the PCAST Report. I don't see that they recommended that. But one of the PCAST—seems to me that that question was on their mind even though it's not recommended it's an obvious fallout that sharing is going to happen both ways. I think that's appealing to us as federal agencies and maritime services too as higher priority spectrum needs such as broadband basically take the spectrum, when we have new requirements, where do we go? What do we do? PCAST is possibly opening up some opportunities for that, so we're very much interested.

Finally is my fourth case, which is not up on the power point. Back earlier this year the FCC had done some pretty incredible things in opening up spectrum for medical devices. One of those medical devices was to a firm called Second Sight, which is a prosthetic for blind people to see images and outlines using I think an HF radio frequency. That particular FCC decision before it was announced was coordinated through the Department Radio Advisory Committee for agencies to review. We noticed right away that the frequency that Second Sight planned to operate on was a frequency licensed to the Coast Guard for use throughout the United States, certain locations throughout the United States up to one kilowatt; Coast Guard Auxiliary, actually. We noticed, and we found that Second Sight will not cause a problem to us. We have no problem with interference with them. We're committed to making this thing work. We don't want blind people to lose a prosthetic device. We want to make this thing work.

But what happens when a blind person gets too close to one of these Coast Guard transmitters? What happens? Is anything going to happen? Does he lose his sight? Is a blind person crossing a busy intersection who suddenly gets radiated from one of these things and suddenly finds himself sightless at a bad time? What's the impact on this? I think in discussing this with NTIA and FCC they basically said, That's not our problem. Our problem is interference with our systems. That's somebody else's problem there. These devices Second Sight has concluded was allocated on a not to interfere basis to federal systems. It's not an issue, it's not a concern. And it was not a concern to NTIA. And in discussing this with the FCC I think it was basically the applicant's problem; they weren't concerned.

I think our concern was similar to the garage door type of things that PCAST looked at. And was actually in the news here yesterday because of an incident down in the Navy submarine base in Groton, Connecticut. It's not just San Diego that has a problem; Connecticut has problems as well. And the technically the problem with garage doors not being opened isn't a problem with the Army or the Navy; it's a problem with the garage door openers and operators. That doesn't necessarily go over well with those folks. It may become our problem even if regulatorily it's not our problem. What happens if the same garage door type of problem happens to a person, a person carrying around a medical prosthesis of some sort? Is that something they need to be concerned about? It may very well be this is not a problem at all. It may very well be those devices are protected from radiation like this, but we just don't know. We have no way of knowing. I want to thank Tom Kidd and Mark Settle, who opened up a teleconference with the Federal Drug Administration so we could discuss with them and try to learn how they certify devices like this. It was a very good conversation; I learned a lot.

Unfortunately FDA and the parent department, Health and Human Services I believe it is, are not IRAC members. They used to be years ago, but they are no longer. Nor are there any plans for them to become one. They don't participate in this process. When we talked with them about this device in particular they were surprised to learn that the Coast Guard had devices that operated in the same way. They had no idea. And that sort of disquieted me a little bit; however, they've been working on NY problems for a long time.

FDA staffers are involved in two standards, one of which I'm a part of myself, IEC. The U.S. Coast Guard is a member of IEC and FDA as well. Even though they're different technical committees we're very familiar with both parts of the process. And then another one, which is a U.S. private one, which we're not, that writes certification standards for devices such as this. And FDA has looked at a new work program for something called a coexistence standard. Coexistence standard would be a standard for EMI operating on the channel for interference coming over the channel for which a device is intended to operate on. It's not RFI, out of band RFI. This is actually co-band, co-channel interference. If they're forced to share a band what would be the effect?

This new work plan has never been accepted by the standards organization because right now there's no support, there's no industry support for it. And unless the medical device industry is prepared to support it, there won't be a standard for this type of thing. But if there were a standard for this type of thing I think that would allay our concern if there were standards we could identify. That would help sharing.

I think the message in all this is that these standards organization such as IEC are probably a solution to making sharing work, because we can work with them. In general federal spectrum managers don't participate in this group. We do just because that's important to marine communications and safety and navigation. Even we're struggling to keep up with that. The medical industry I think has difficulties. Everybody has difficulties getting the resources and staffing and funding to continue participating in that. If we can do that, that could be a solution. If FDA finds a solution to the coexistent standards, I think the problem with sharing medical devices would largely go away, at least our concern would go away. That's it. I said a lot up here this morning; maybe too much. But thank you for listening. (Applause.)

MR. KIDD: Thanks, Joe. And the medical scenario is a great example of how federal spectrum users are still citizens. I mean, we're still people. We see these scenarios. We've had this concern that where the regulatory process may protect us and we don't have a legal, there's no real legal issues or anything, we still empathize with the folks who are going to be using these devices, and we see potential stumbling blocks and we're exploring all of these different avenues so that we still are sharing as good citizens of the spectrum not just from a regulatory side.

So far we've been hearing about the federal side of the spectrum processes. That's just one side of the coin. And it is a really nice, bright, shiny coin like an 1856 Morgan dollar or something. And the other side of that coin is the FCC. These are two sides. And of course for those of you who deal with the federal process often we know that if you go into the general public and you go to, you know, local civic organizations and you start talking about spectrum, there's only one organization that regulates the spectrum and that's the FCC. Then we always have to explain that there's this other process. So the rock star of the spectrum world is the FCC, so with that, give it up for Mark Settle. (Applause.)

### 1.3.5 Mark Settle: Coordination of Non-Federal Spectrum Use

MR. SETTLE: Just as I get started, I wanted to take a quick second to, you know, respond to the medical issue. I don't think it would be a fair assessment to say that NTIA or FCC either one are unconcerned about the interference with medical devices; I think it's fair to say we don't have medical staff or doctors on hand to make a determination as to what is safe for a patient or not safe for a patient. So what we do is make sure that the manufacturers and vendors are aware of their responsibility for the patient safety aspect of those devices. And we are very concerned about it. But we certainly do understand the issues that you brought up so thank you.

I think as has been mentioned, the authorities under the telecommunications act are divided up based on the user of the spectrum. In the case of the federal government users, NTIA is the authority. And in the case of non-federal users, FCC is the authority. We effect coordination between those two agencies. What we do at the current process is to use the interagency IRAC process that has been established since 1922; is that right, Karl? 1922, including all of the various subcommittees, planning subcommittee, and the frequency assignment subcommittee, which is the one dealing directly with the shared use of spectrum.

Within the FCC the way we license frequency, we have various bureaus and offices that each have different responsibilities based on different user groups that come before us in the FCC. We have five main bureaus and offices that do frequency licensing. The international bureau, these are the folks that deal with all the satellite international broadcasting licenses. They have an—and I'll get into this in a little bit—each of these bureaus and offices have their own databases and their own procedures and processes for processing license applications. Our media bureau deals with broadcasting, TV, radio. Public Safety and Homeland Security Bureau issues licenses for state and local law enforcement, utility services. And they, as well as the Wireless and Telecommunication Bureau, they both use universal licensing systems that do this licensing process. But Wireless and Telecommunication Bureau is responsible for licensing commercial services like the carriers as well as the maritime aviation folks. I know the folks that—and Danny will be speaking in a minute on behalf of AFTRCC, but those folks all come for licensing through the Wireless and Telecommunications Bureau as well as the maritime community is licensed through Wireless and Telecommunications Bureau as well. And then within the Office of Engineering and Technology, which is where I am, we have an experimental licensing branch that deals with licensing of frequencies not in an operational aspect, but for testing measurement purposes for various experimentation.

So kind of getting back to one of the things that Joe had just mentioned was that sharing of data is beneficial on both sides. I'm trying to, in this slide, outline a little bit of the way that the various systems send data back and forth between the licensing bureau offices, which I've called LBOs here, and in OEC we have a system called OETFACS, OEC Frequency Assignment Coordination System. This is basically a system that parses and collects data from the various formats of all of our licensing bureaus, licensing bureaus and offices, whether it be ULS from the wireless bureau, experimental licensing ELS from OEB, IBFS, International Bureau of Filing Systems. All those have different data formats and standards. OETFACS takes those, consolidates them into one standard that we've agreed between NTIA as to how we should process and report the technical data associated with the frequency assignment.

So once we've received—and before the licenses even get to the licensing, licensing bureaus, there's a coordination process that happens actually outside the FCC. We have multiple third party coordinators. AFTCC is one, AVCO is one. Mark Gibson here from ComSearch is one. There's a separate coordination process that doesn't even show on this chart that is happening before licenses get to the licensing bureau.

What you'll find is that that is very duplicative of some of the coordination processes that happen within NTIA. One of the reasons that we haven't been able to really collapse those into one process has to do with the availability of federal data. For various important reasons a lot of that data is restricted access. And while that's very important, there's also important reasons to share some data. Right now I think that one of the challenges in the future is going to be to try to really dig into where that line needs to be. Without being able to share that data it's going to be very challenging trying to make great progress in dynamic sharing or these other technologies that really at the core need data to be able to make these determinations. There certainly is a trade-off as to the importance of the data integrity requirements that the government has versus the need to have that information to effectively facilitate coordination.

So once an application comes to OET for coordination it's got several different routes it could take. I heard Tom earlier mentioning about—I'm sorry. Maybe it was Bruce—about the differences between the FAA and the DOD processes. Assignments and certain frequency bands go right to the what's called the Aeronautical Assignment Group, which is primarily the FAA, before they go to NTIA for coordination. There are also assignments in specific frequency bands that go directly to what we call military assignment groups. These are all groups established by NTIA. And the dotted line in this slide is the division between FCC to the left, NTIA to the right. So in those cases those applications actually go for a round of processing before they are sent to NTIA. Once they get to NTIA, the agenda process, then they go through the nine-day review cycle where each of the federal agencies that sit in the VFAF and participate in that process look at, review, evaluate, and comment on those applications that are under review. Once they've completed that cycle, if there are changes needed in order to effectively coordinate the records, we may have to go through a second nine-day review process. So our typical response, a question we're asked a lot is, How long is it going to take to get my license? And the typical response that we would give them is six weeks. That's a good average time that it takes for us to, from the time we get the application to go through the processing at the LBO as well as OET, and through the review process at NTIA, which I don't know that six weeks is—it's not considered a bad time today.

But I don't think that that's where we want to be. I think we're looking to try to improve that, vastly improve that from six weeks to, you know, a matter of days. In some cases we were talking the other night, you know, how can we do this in a matter of milliseconds even? I think again the issue that Tom hit on is that data is going to be key. Without that data it's really going to be tough for us to make those accomplishments.

Finally I wanted to point out the different databases and tools that we have available on line. All of the FCC licensing databases are available publicly on line. So again I won't read these to you. But the two things I would point out is, one is the general menu reports. This is a very good database search tool. It's not a database in and of itself, but it will actually go into each of these various databases that the commission keeps, and report results based on frequency location. You can set up the searches to basically search by radio service codes. The only drawback to general menu reports that I've found is that it's not very good at finding area-based licenses or market-based licenses. But something that is very good, that is the new spectrum dashboard that's been stood up in the past couple of years. Again, we do have the commission data available on line publicly. Certainly we understand the data requirements and integrity requirements that the DOD and other agencies have. I think that's one of our big challenges is to find ways to get at that data and make it available for future use. Thank you. (Applause.)

MR. KIDD: Thanks, Mark. Our final speaker is Mr. Dan Hankins from AFTRCC. As Mark mentioned, AFTRCC is one of the third party coordinators. There are several of them out there. They've been around I honestly don't know how long; many of them for decades. These were set up in essence to answer a question of sharing where specific attention needed to be brought to specific bands to ensure that multiple parties could use those bands more efficiently, more effectively, et cetera. So to talk a little bit more about that is Mr. Danny Hankins. While he is speaking definitely pay close attention to every single word he has to say, but also start thinking of those questions because I've got like four that I've thought of. So I'm going to rely on the audience, and hopefully you're still all energetic and jazzed up and drinking plenty of coffee, and we'll have a myriad of questions to ask these panels. Danny? When you're filling out your survey please don't put, Tom Kidd sucks at bringing up presentations.

### 1.3.6 Danny Hankins: AMT & MBAN - A Spectrum Sharing Solution

MR. HANKINS: Hello. I guess first of all let me tell you a little bit about our organization, AFTRCC. It's the Aerospace and Flight Test Radio Coordinating Council. It was established as a nonprofit organization back in the 1950s; it's older than I am. We have been coordinating shared spectrum on behalf of the non-federal side for aeronautical mobile telemetry since at least sometime during the 1960s. And currently in addition to being the chair I serve as the HF/VHF frequency coordinator, and also sometimes do the telemetry coordinations when there's a need.

We are nonprofit. We don't do it for money. We do it so that we can all share the spectrum. And our membership is made up of representatives from various companies in the aerospace industry. And we want to ensure that we have spectrum so that we can test our aircraft and develop them. We work with the DOD very closely on this. In fact, we usually refer to them as our DOD brethren.

So what I'm really here to talk about today is probably a lot of you have heard the hoopla about the MBANs, Medical Body Area Networks. We're still not quite sure how to define the acronym, although I think the FCC may have done it for us. When I was asked to come up here it was to give you an idea of what to expect in trying to reach a sharing accommodation. And so my presentation doesn't dwell on pictures; it's more of a narrative and a timeline. I want to give you an accurate idea of what's in store. I call this the cycle of contention. It sounds ominous. And that ran on for two years.

Essentially in November 2007 our AFTRCC attorney contacted our executive committee and said, I've been talking to one of my cohorts in DC, and they have a proposal for a low power medical system. And they think they can share the 2360 to 2390 band with us. Actually the original proposal was for less than that. It didn't take us very long. We thought, That's very noble, you know. A low powered system for monitoring patients in hospitals, save lives, you know. We all have relatives that are in hospitals. Untether them from the wires. We said, We'll take a look at it.

And we have a technical consultant, Dr. Dan Jablonski, who teaches at Johns Hopkins University applied physics laboratory. And he took a look at it and said, Well, you know, really we're going to need to get a bit of geographical separation distance in the case where there's a line of sight. The problem being the near-far problem. If you have a low power transmitter in close relatively speaking and your higher power transmitter is at a great distance then the low power transmitter in close can interfere with receiving those long distance communications. And in the case of aeronautical telemetry we often test out to 200 miles, sometimes much farther than that using a ten watt transmitter. So the one milliwatt signal from a single MBANs transmitter, if it's only a few miles away, can create a problem. We can actually see that with our big parabolic antennas that we use for autotrack, we can see that for 100 miles or more and actually transmit data. We did tests where we transmitted data using a one milliwatt transmitter over ten miles. Worked great.

Anyway, to get to the timeline, we went back to General Electric Healthcare who had made the proposal. And we said, Well, the separation distance is going to have to be much greater than what you're talking about here as far as—you know, at that time we were thinking simple exclusion zones. How much of a space do we need to clear around an AMP receive site and not have interference to our operation from the MBANs transmitters. We're all, we like to accommodate, but we have our business to do too. That set off a series—I'm not going to get into the bullets on that. But that set off a series of filing of comments at the FCC, which became increasingly contentious. And, you know, we felt that we were right. I'm sure that some people on the other side felt that their analysis was proper. We took this to the point of spending a lot of money out of our company's pockets to actually conduct tests. And the tests that we conducted quite frankly, it was worse than what I had feared, the ones that we ran. So for all intents and purposes we felt like we were stuck; that we were at an impasse. And of course, you know, the atmosphere became very clouded as a result. I'm going to go to the next slide here.

In October 2009, AFTRCC filed comments that said, Well, you know, one of our main concerns is that these MBANs would be used inside. But what's to prevent a patient who isn't tethered from walking outside, and then something that wasn't line of sight or being attenuated by buildings is now blaring away under one of our antennas. And that actually led to a response and comments by Philips Healthcare. And they said, We have a technological means to make the MBANs change to other spectrums when a patient walks outside of a building. And this created an opportunity. So we quietly went to the Philips Healthcare people and said, Let's have a telecon and discuss this.

At this point in time we had lost the ability to believe what the other side was saying because of the comments cycle and the nature of the comments. We didn't have trust. And you need a measure of trust. I'm not talking about blind trust, but you need a measure of trust to be able to hold these negotiations. Without trust you're just not going to get very far. And you have to be convinced that the other guy is hearing what you're saying, and this opened that trust up. It gave us an opportunity to explore. And so quietly we discussed this.

The Philips people convinced us that they had the technology; that the technology would work. We had a demonstration of the technology, and the demonstration was successful. And of course in all of this, you know, AFTRCC is a non-federal coordinator. But there's another player in this, and that's the Department of Defense who also uses this spectrum. So while AFTRCC can agree to something it's also necessary that the federal side is aware of what's going on and agrees to it as well. So we were working closely in that regard.

Once we had the successful demonstration of the technology we began to draft rules that we felt would watch out after our interests, protect AMT, and enable MBANs to work profitably in almost every location. We did trial coordinations. We spent several months coming up with the coordination and analysis regimen that we thought would yield results and enable them to make the most use of MBANs, but still give us the protection on the AMT side that we needed to be able to operate without worrying about losing our links to our aircraft. Then when it came to the certain point we went out and we brought in the rest of the medical community and shared with them and said, Here's where we are at. So give them a little time to ramp up and analyze it and buy in, and it worked. So they were on board.

The next step was to go to the FCC all hand in hand as one unified effort, and present to the FCC—Mark Settle over here played a very instrumental role in this—and tell them where we were at, what we wanted to do, show them the rules that we were proposing and so they could go back and discuss it among them. And all this played out over a period of several months.

Next slide here. And then we had the agreement. This slide may be a little bit out of synch here. But this is the general thing that we were, points that we were looking at that MBANs, you know, must be secondary because essentially our AMP operations are also safety of lives. You know, aircraft do crash during testing. And the purpose of this is not only to gather more data quicker, but also to enable real-time monitoring of aircraft that are being pushed beyond the limits of what, you know, you would expect them to be put through, especially in the case of general aviation. The FAA has very stringent guidelines. If you tell an aircraft operator or customer that this aircraft is going to go a certain speed, certain altitude, it's going to take certain G force, you got to be able to show that it does that plus a margin. So you're pushing it to the limit, and every once in a while, you know, there's an issue.

So we felt it was very essential to protect our primary status; even though this was going to be shared, that MBANs would have to accept whatever interference they get from us. And by the way during some of our testing we did verify that a low flying aircraft could disrupt, for a matter of a few seconds, MBANs communications, although the design work will allow them to hop to other frequencies where they're not being affected. A lot of this doesn't appear in the FCC rules, which I'll get to here a little bit later. But we wanted to make sure sharing the Coast Guard's concerns that we're not going to come back and get sued if a patient that's being monitored, you know, happens to die within that 20-second timeframe that an aircraft is going over the hospital or healthcare facility.

You know, there's still a lingering memory on our part of the digital high definition TV incident in which the stations in Dallas went on the air and caused interference to WMTS medical telemetry healthcare facilities near the transmitters. And it was the digital TV stations that were required to shut down, you know, even though they were operating in their spectrum. So that's, you know, that's something that we're very aware of. And I'm sure the Coast Guard is too. Anyway, we came up with this criteria here that we wanted to see. And essentially the rules accommodate pretty much—well, probably all of this. Except some of the real technical stuff got taken out, which in some ways is good. I'll get to it in the next slide.

Okay, the current status, May 24, 2012, I watched Mr. Settle on the web. And the commission voted to approve in MBAN's proposal. The FCC did modify the draft rules that were jointly proposed. But most changes were of little to no concern. And actually I think, you know, my own humble opinion is that they did a superb job. And, you know, the things that are left, arguably even from my point of view I believe may well work out better for us in the long run. But we do have some work ahead of us that I hadn't expected, and more work than I had expected. And part of that involves a gentleman sitting in the back here, Mark Gibson who works for ComSearch. We're going to be working on trying to negotiate an agreement to dot the Is and cross the Ts so that we can get this show on the road.

Speaking for myself, after having spent so much of my energy and time over the last few years on this effort, I kind of look at the MBANs as a stepchild or a surrogate child. And, you know, I really want to see them succeed. I'm going to wind this up by reinforcing what I said about trust. When you're convinced that the other side hears your concerns and is really truly looking for a way to address your concerns, and you do the same for them, you know, and be open minded about it, think outside of the box, you know, you can probably come up with something in a lot of cases. I'm not saying in every case. But we were convinced for a long time that we couldn't. And come to find out we can. So I'll end with that. (Applause.)

### 1.3.7 Session I Q&A

MR. KIDD: Hopefully you guys have been writing down some questions. I'm going to throw out the first one here. It's kind of always been a favorite question of mine whenever a conversation or a discussion touches a little bit on history, and then mostly we talk about the current state of things, which is what we've been talking about here pretty much, the current recent history of how things work. I like to ask folks, Where do they see the future? What do you think this ecosystem that we're talking about here is going to look like in the near to mid-term future? What do you think near to mid-term is? Some of us that deal with the ITU know that near to mid-term can mean something very different than if you are dealing with coordinating a piece of equipment you want to try and sell. So from your perspective I'll ask this just down the line, what do you think the future is going to look like or has to look like to accommodate? Basically what is going to be discussed in the balance of this symposium?

MR. WASHINGTON: Well, from NTIA's perspective obviously we've invested a lot of monies and resources in FSMS. Our near term goal or objective is to roll out FSMS in a manner which is productive for its users as customers' bottom line. And, you know, if the end justified the means, it's up to NTIA and the FCC to find the means to the end. The bottom line is we've got to get the service down to the customer, the person, the kid in the school, the farmer out in the field, the scientist in the laboratory, whatever is needed, we've got to assist the federal agencies in getting there. And so for near term for NTIA and for us is to roll out FSMS as the investment that is holistic across the board, that is fresh, that is new, that can bring in the data that is needed to make the proper analysis of how fast we can get assignments out there without interference, and folks working together.

MR. CRAIG: I think in the near term, I mean, there's obviously some options coming up. I see a portion of the L band, whether that's 1755, 1780. I see federal agencies relocating, some that cannot, will not be able to share. I see other federal agencies sharing more in the future. I see a change in the way federal agencies approach sharing. I think they'll be more open because I don't believe they have a choice. One of the places we really got to look at is in the S band—very valuable band—as we relocate federal agencies up in there. And then I see new technology going forward that will allow us to share.

MR. HERSEY: I think sharing is going to have to work a whole lot better than it's working now. I think cooperation between the federal agencies and the non-government has to be established in a way that's effective a whole lot better than it is now. I believe the role of the standards organizations on both the federal side and non-federal side are going to be instrumental and key into making this work. I applaud the PCAST Report. That 200 page report is worth reading. I particularly recommend that to the federal spectrum managers to read that in some detail. There's a lot of good stuff there. There's a lot of stuff that may be impossible to achieve that we'll have to work on. My question to you folks, and maybe Mr. Strickling and some others, is does the PCAST recommendation have political legs? Maybe it's just too soon to know that. Is this going to be the policy of the country? Or is that something that's not going to be? The problem of the PCAST Report is that it's recognizing that auctions of spectrum isn't going to solve the national deficit problem; it's not going to be as much money from that as people thought there would be. Looking at the mechanism, taking that into account, how do we essentially spur innovation while making spectrum more open? It's a different approach. It's actually, in my opinion, a valid approach. So we're, as a federal agency we're looking at is this the policy we're going to have to follow? Or is this going to be competing with something else? We're going to have to do something different on that? So that's the question. Regardless, sharing has got to work a whole lot better than it is now. Federal spectrum management and non-federal spectrum management as it exists now has to turn, will turn over on its head. It's going to be a whole lot different than it has been.

MR. SETTLE: I think that in order to increase sharing in the future the one biggest need we have is increased certainty for the incumbent users, as well as those who seek to share the spectrum, in that the incumbent users certainly want assurances that their systems are going to be protected from interference. The incoming users certainly want assurances there's going to be some spectrum availability for them. Again that takes sharing of data, and enforcement of the policies in terms of interference protection.

MR. HANKINS: I think the sharing is going to be quite challenging. I think it's very doable in a lot of scenarios but it's going to take a lot of hard work by a lot of people. I know it sound simplistic. But the opportunity is there. I would also say that the other side of the house, the broadband, which is what we're doing all this for as far as I can tell, needs to explore their options as well. I've been reading some—and I believe they are. I've read some really what I would call encouraging press reports on some of the things that we are working on. And I won't get into that here. But those things that they do on their side can make, there are things that they can do on their side that would make them better neighbors for us, you know, for sharing. We, of course, are doing what we can on our side.

MR. KIDD: To demonstrate my mental instability I'll answer my own question as well. I think that at its core the processes that we have in place right now for sharing work fairly well in the end; they just take too long. We need to figure out how to speed these processes up. When Bruce was talking about the review process and the agenda, many of the determinations that are being made on the agenda are being made by people. I think that for much of the technology that's being developed that will enable dramatic spectrum sharing, people are going to have to come out of the process. I don't know how we're going to do that, but I think it needs to be done. I think these processes need to be sped up. And the future is going to be, we're going to be looking at coordination processes that are faster in multiple orders of magnitude. Not just increasing them by 10 or 20 percent, but increasing them by factors of hundreds or thousands to speed this up. The technology will demand it. The technology is becoming our customer. Much of the evolution that we've seen up until this point over the last hundred years have been driven by our customer, the changes. So now our customer is demanding that we do this process much much faster. I don't have an answer how we do that. I just think that when we all get together in 10 to 15 years and look at our processes, much of what is being done by people today won't be being done by people then. With that, we'll open it up to the floor and hopefully you have hundreds of questions for us to answer.

MR. FRITZ: I didn't want you to wait too long for the first question.

MR. KIDD: Would you mind telling everybody who you are?

MR. FRITZ: Not a very sensitive microphone. So this is Dave Fritz. I work for the Mitre Corporation. So I just kind of wanted to weave together a couple of thoughts that I heard, you know, during the panel this morning and in other sessions partly yesterday. So the title of this panel is the federal ecosystem. And I'm wondering to what extent—and maybe this is partly brought out in some of the recommendations in the PCAST—maybe we need to be moving towards a national ecosystem. How do we get there? We've heard some discussions about, you know, the FSMS drive towards, you know, improving efficiency, getting things to run faster, getting things better for our customers, right? But then we heard the FCC talk about their business process. Sounds like there may not be too much commonality between the business processes on both sides although there are key points where they come together and data is exchanged. But it doesn't sound like we're anywhere near a national ecosystem that may be what we really need to get to the point where we can begin to do the kinds of things you're talking about, Tom, you know, resolving these things faster on a national level where they do involve this coordination between non-federal and federal. Just a thought; maybe generate some discussion in the panel.

MR. WASHINGTON: I think to answer your question, Dave, you heard from Mr. Strickling this morning. We need to go back there as a starting point. And that is, and I think maybe Joe had mentioned this, but we've got to change the culture of what we're doing. We've got to get commercial or non-federal to work with federal, and working groups we've got going on now under the auspices of CSMAC trying to find solutions on how we can address the issues that came out in our report is a start. Sometimes you got to look for the small signs that something is happening. I mean, it's not going to be a mountain just coming down which is going to break all barriers. But we got to look for, the first thing is cooperation.

I heard someone say we've got to trust each other. So if the data is good, the information is good, people are earnest about their attempts from both sides of the aisles, from the FCC side of the aisle, from the NTIA side of the aisle, from the commercial side of the aisle, from the federal side of the aisle, then we're there; we're hopeful; we have to be optimistic and be encouraged that there are signs. And this is part of it. This is one of the signs we're progressing forward. So with the working groups, you know, going on right now, we've commissioned them not too long ago. They're up and running. I participated in two of them just listening in, working group No. 5. There was eighty people came on the line. I mean, there was fear there was not enough lines for folks to participate just in a kickoff meeting. That is a tremendous amount of participation. When you've got five working groups with that type of sampling going on, something's afoot.

And we need to get excited. That's why I first started off and said, You guys got to be excited. If you're not excited, if you can't see the end before you get there, we'll never get there. So we got to believe we're going to get there. We really got to believe we're going to get there. And we've got a big purpose. I think holistically, nationally we just got to get everybody talking. This is part of the forum for doing that. The other part of the forum is happening right now as we speak. Working groups out there planning meetings, coming together with industry and the commercial entity and the federal government. I mean, it's happening. When you can get the big operators in the room talking and hopefully keep the lawyers out for a period of time, you know, we can get things done and then they can figure out how to regulate it, put the laws behind them. But I think the fact that NTIA and FCC are doing their part just saying, We got to talk, most things happen because you bring people in the room and you start talking and you start respecting one another, and you start looking at the differences and the problems and you start working them out one by one.

MR. HERSEY: Another aspect too on that and that's a need for transparency and data sharing regarding radio frequency assignments. On the federal side we're hindered not only by classification but more seriously for official use only privacy limitations. It's really keeping us from getting the data out. But the non-federal side has it as well. And they're reluctant to share their data for commercial reasons. We certainly learned that in the VHF radio, VHF railroad frequencies I mentioned earlier. The Association of American Railroads believe that. They're not alone in that. They don't share how they use their radio assignments either. So on both sides transparency and sharing data is necessary.

MR. SETTLE: Certainly greater transparency, greater sharing of data is necessary. I think that there's often a misperception that it, especially when it comes to working in the IRAC forum and other area where we deal with the NTIA and other agencies that the FCC only cares about the commercial and non-federal interest. I think that that couldn't be farther from the truth. We certainly do support and try to always provide for the federal mission where we can as we can. And I think there may be a perception on the other side that, you know, the agencies don't always see the commercial side. And I think again if we can get past some of those perceptions as to what people's motivations are that, you know, we're going to have to get through this before we can actually successfully improve our sharing arrangement.

MR. KIDD: Brooks?

BROOKS: So the question I have is mainly for Mr. Craig. And you had mentioned that you had been able to move some of your sort of more mundane video surveillance and narrow band voice ongoing to commercial networks. And the question I have is have you thought about how you're going to use FirstNet as that gets deployed? Will you, will that be able to, or will you be able to move more of your video surveillance and narrow band voice onto that? Or is that not really the intent? Just kind of curious how you intend to use FirstNet when it's deployed. Thanks.

MR. CRAIG: Sure. Pick on me, right? When FirstNet first came around and the public safety broadband network first came around the move is, you know, voice, mission critical voice. You don't need LAM over radio. You got public safety broadband and that's where you're going. Unfortunately that technology, off network, push to talk capability, mission critical voice, is not available yet. When it will be, who knows. As far as video, yes, we did look at it and we still are looking at it. We did a pilot with one of the law enforcement components, specifically DEA where we're putting up a couple of LTE nodes and running video.

We also did a pilot with some public safety officials in McCallen, Texas, on the border where we actually did a mock scenario with LTE where we used a seven to eight hundred meg trunk system for radio. We brought in dual band radios from a particular vendor, and we actually stood up video, public safety video and federal video on—at this particular case it was public safety trust 10 megs. At that time we didn't have, the legislation hadn't passed, so we were working on the PSST. Could we coexist in a situation?

Because when a situation like in this particular case it was a railcar, a passerby saw smoke coming out of the railcar, called 911, fire responds. The first vehicle on scene was not a, quote, fire truck but a fire vehicle. As soon as he keyed the mic on that seven, eight hundred meg radio it killed the video. And apparently it was an intermod issue on the LTE mode we found out later. Police arrived, same thing. Key portable—these are all portable radios, five watt radios, also killed the link as well. So at that point the engineer's running around saying, What's killing this link? Of course they go to the feds and say, Kill your video. We had two cameras up. We shut down our cameras because the situation we had a mock surveillance going by near this facility again using the public safety broadband network. Should an incident happen, public safety incident, feds are doing a surveillance in the area, can we coexist? The answer was no, we couldn't coexist at this particular time. Doesn't mean we quit and move on. It actually became an intermod issue with the radios, not the video. I hope I answered your question. So we are still looking can we do it. There's no one solution for us. So it's going to be a combination of public safety broadband, LTE, commercial, and government spectrum for us. That's where I see us going.

MR. KIDD: Kind of on that same note, let me make one comment which is in broader sense than what Brooks asked, which is the offloading of some of our operations to either commercial systems or other systems, even if they're other federal systems. And I'm going to respond basically from DOD's perspective and my experience over the years as an installation spectrum manager, organizational spectrum manager, et cetera. And it has to do with extraordinary levels of reliability that are often placed on us by the people who, the customer who uses these systems, levels of reliability that are far above what would be necessary for you or I to have for a commercial system. If I come up out of metro and I bring up Google maps and it takes 20 or 30 seconds because for whatever reason, my 3G's fighting with my 4G, whatever, I have to drop my phone into airplane mode and then bring it out of airplane mode and then it's got the network and I'm good to go and that takes me a minute, that's totally tolerable to me. I'm not complaining; I'm not trying to turn my phone in. If there's a handful of folks trying to take the hill and they go to bring up their map and it doesn't come up and they're sitting there under fire exposed and they're having to figure out whether they need to reboot their system, whether this is a reality or just a perception, this is one of the challenges that we're up against whenever we're asked this. And this isn't a new challenge; this goes back to trunked radio. This goes back farther and farther whenever there's new technology when there's reliability compared to, what is perceived as an operational military reliability where there's a perceived disconnect, this is where some of this resistance comes from to make these migrations. I wanted to bring that up because it's kind of the same.

MR. CHAPIN: Sure. John Chapin with DARPA, but I'm speaking for myself, not the organization. I hear the garage door problem come up multiple times and the MBAN problem with people losing their medical things. And I wanted to throw an idea out and ask you, those of you who have struggled with this problem, to see if this would've perhaps reduced the resistance to sharing that comes from that garage door and that technical problem. What if there were a certification requirement on a secondary access device or secondary network that wanted to get in, use that shared spectrum? The certification requirement is they have to demonstrate there's no significant user visible functionality change when the primary, the protected incumbent signal is present? To make that work you would need probably to take advantage of some of Pierre DeVries' work on specifying the expected spectral environment in advance. Would you say that

that would reduce the resistance to sharing if the devices had to show that there was no user visibility functionality change?

MR. HANKINS: In the case of the MBANs the FDA also plays a role in that. They're going to be certifying that the algorithms that the vendors come up with to meet the requirements, you know, that it will do the job and won't let them down. As far as some of the other, well, in fact that's one of the bullets on my slide was the certification requirement for the MBANs transmitters themselves. Now there is some discussion on that. I feel pretty confident that when it's all said and done the FDA is going to be very diligent in making sure that those things, that they have a viable option to keep working, and at least provide some kind of minimal monitoring capability. As far as other certifications, we have problems right now with equipment coming into the country that is not FCC certified. And it gets found out every once in a while. I know that's not related to the MBANs, but I'm sure if we look around we can do a little research you'll find out that there is a problem with that. Everything is being pirated nowadays, and radio transmitters are a lucrative market.

MR. HERSEY: My answer too, I think talking to the Part 15 manufacturers there is a problem with the Part 15 rules that I think it actually prevents them from solving the problem. Right now the limitations in Part 15 apparently would prevent them. Certification would work but only if physics would allow a means for it to work. For example, frequency diversity, the ability to transmit on two frequencies or at least two frequencies would work. But at least we were told by one manufacturer that the FCC rules precluded that as a solution.

MR. CHAPIN: If I could just jump in, the solution I had in mind would be devices that would operate in multiple bands. So if one band isn't they'd operate in another one in that location.

MR. HERSEY: If that would be allowed, that would be perfect.

MR. SETTLE: I think the idea of certifying that the device would operate in the presence of the interference, actually the primary user, it's kind of contrary to the unlicensed model in that the whole idea that has been used at the FCC is that, and is, you know, codified in Part 15.5 is that users cannot cause harmful interference and must accept interference even if it results in unacceptable performance of the device. So I think it kind of turns that model on its head. Is it a good idea? For some devices maybe. But I think that the cost point gets too high for others. I mean, is it so important that I have every single one of those Part 15 devices operating one hundred percent of the time? I mean, we make decisions day in, day out, like maybe I can't use my cordless phone while I use the microwave.

MR. HERSEY: Maybe it needs to be turned on its head.

MR. SETTLE: Maybe. But I think that by doing so you eliminate a lot of the lower cost point devices that would just be totally not available for the public anymore.

MR. CRAIG: From my perspective the answer is yes. We do that on our own. When we go to share right now, like I say, working with NOAA down in the 1400 band. Can we coexist? So there's some certification processes with our equipment that we'll go through. So in a way we kind of do it now, but for the private sector from a government perspective absolutely it would help. But again, cost issues is a matter that needs discussion. Anyone from OMB in here?

MR. LEBERN: I am David LeBern with Raytheon. I'm going to sit back down because my question's on my laptop. I am asking this question as an individual, not representing my company. Determining the impact of spectrum sharing requires solid engineering knowledge of the RF transmitters and receivers that are both MBAN and in adjacent bands. We've heard today about critical time sensitive federal communications needs to certify spectrum. Mr. Craig, while not picking on you, you addressed very, a time limit on robotic systems, which according to the media were required last Saturday in Aurora to defuse a complex and dangerous situation related to the theater shooting. Weather warning is another similar spectrum application. Time is often measured in minutes to get to safety or to evacuate. Sharing these cases must be well thought out; I think we probably all agree on that. And those incumbent systems that are in or adjacent to the spectrum where this is being shared, we must take time really to let the engineers understand how current and future incumbent systems will function in the presence of commercial broadband usage. In critical systems, situations, logic tells you cellular usage ramps up at the times when these critical events occur. It's key to develop any sharing usage to recognize the detailed equipment characteristics. I believe that information may go well beyond the information that's in a spectrum certification. Perhaps systems were purchased by a federal agency and placed into usage a number of years ago. The data may not be immediately available in the design primers of that system because the agency had it developed a number of years ago and released the developer contractors. Things change. My question is this. How do we best do the engineering data gathering and analysis under the current time constraints allocated by the process and in some cases dictated by milestones in legislation?

MR. CRAIG: If I had that answer I probably wouldn't be sitting here. I think history has taught us, and we've had this discussion many times, start now. Take the current system, start now, do R&D now before it happens, before you move on obviously. Robotics is a good one. Do we move down into the, you know, 1400 band? We're going to go where DOD goes, with that and UAVs more than likely. Is it LTE? Could I use four nine as a backhaul, public safety band? LTE might serve a purpose there. Again, what band, where I go—and I agree with you totally. We need to start now. We've had this conversation with NIST on some of the R&D. There's R&D dollars in that legislation, but there hasn't been a lot of discussion on how those R&D dollars will be spent and where. Again, you've got to get FirstNet up. FirstNet's got to get its priorities together. Are they going to have a technical advisory board? Probably. Are they going to have a different R&D board? Who knows? Time will tell. I hope I answered your question, but it was kind of a tough question. My opinion, start now.

MR. KIDD: Notwithstanding the previous mentioning of transparency of data and those types of things, being able to share data, to do what you're talking about doing is in a sense modeling the EME, being able to determine what the electromagnetic environment is going to be in any given scenario. It requires a massive amount of data points. So the question has to be asked, Can we acquire accurately those data points? If the answer is yes, then I agree we need to start now. Now, how we do that, that's going to be tough. I don't have the money to put every single device that's going out to the Department of the Navy to some sort of a test unit that is going to pull millions of data points; not just hundreds like we gather today, but necessarily to accurately model the EME, millions of data points. We're talking about modeling the weather. I mean, we are. The electromagnetic environment is as complicated as the atmospheric environment. The other side of that though is if we make the assumption that no, we can't know enough about what's going on. If that's the case then we need to be encouraging more research into the fuzzy logic side of this, the assumption that can be made from the various scenarios so that decisions can be made that are good enough in a given situation that will enable the right equipment to be used at the right time with low probabilities of interference. It's not my area. I don't know whether—I mean, I know how much data we could probably provide. And at least given our current capabilities of gathering data, it's probably not enough. I don't know if we can get there or not. But if you didn't know—sort of like the idea of programming a car to drove from point A to point B. Theoretically you could program it to it do totally autonomously without any sensors. It would require an enormous amount of data. In so many of these conversations with spectrum that is an area, there's only a couple of buckets that the ball lands in and one of those buckets is data. We just, we don't have enough data often to do what we want to do or what we think we ought to be able to do.

MR. CRAIG: Priorities.

MR. KIDD: Yes. Who's next?

MR. BERGER: Steve Berger again. I want to pick up on Joe's comments at the end on the need for coexistent evaluation of medical devices. And about a year and a half ago FDA staff asked FCC 63 if they would consider starting a standard on that project. This study project they decided it was a good project. And that effort is ongoing as C6327. And that's a shameless invitation for anyone in this room who wants to be involved. My question is—and I've seen this in this effort and several others—when the opportunity arises very often there's a natural audience, in this case those who normally are involved in that body. And what happens is a failure to get critical mass of the kind of expertise that we have here, and so you get the wrong answer; you get substandard output, which obviously is going to really hurt the effort. My question is, How do we get better at that?

MR. HERSEY: I'm going to follow up with a recommendation I made earlier, and that is the federal agencies get involved themselves in the NTIA staff, into the standards process. We're not—I think Mark made a very good comment. We don't have doctors on staff to know. But we certainly understand radio spectrum management interference quite clearly. Maybe that's something that some of the agencies can help on. Then again, we need to gore some "oxen." I think if you gore the right "oxen" then the right people come out and participate. And maybe this is how we bring the industry out. Maybe if they saw the feds moving in on their standards it would scare the heck out of them and bring them in.

ANAN: I'm Anan from UC Berkeley. I have one comment and one question. The comment is a follow-on to John's excellent remark in the discussion that happened there. That is the idea of having devices not suffer when a primary user comes back I think is an interesting one. I think the point of having low cost devices also is interesting. But then there is a solution. It may be a degenerate one, which is to have devices flake out on purpose. You know, if they're going to be a flaky devices when the primary shows up they should just flake out randomly so that users expect that, right? And so intentionally. And then your users say, Okay, the garage door opener opens randomly anyway once every few days, you know, once a month, you know, just randomly. It is not out of the realm of possibility. Just wanted to put that out there. You can answer that if you want. But the more serious question I had was for all of you. When questions that arise that strike you as being, This is a research type question. This is not an, I don't know how to do this type of question, who do you call? Where do you go within the federal government or outside to get answers to questions like this? I can see from the academic point of view, the perception we get sometimes that there must be some organization in the government that does this stuff. And every particular one I've ever asked said, No, it's not us. Maybe it's them. So since you're all here maybe you would know the answer.

MR. WASHINGTON: I think it's only appropriate that I sort of start off as the designated federal official for the CSMAC, that's where we go. We go to the advisory committee to advise us on things that, questions that you're posing. Let me just say this for a federal person, for a civil servant understanding the government a little bit. And that is, you know, it's sometimes difficult, especially in our particular organizations, to get and maintain the level of expertise we need on both sides of the house regularly. And often not—just recently we recruited people in from the commercial side of the house so we have to have a constant mix of perception and experience coming in to the federal government and being sustained in the federal government so we can understand what the campus looks like across the board. And not only that, we have to do succession training and planning for, you know, strategic planning on going forward. I mean, we've got a lot of young people coming out of college. You say "spectrum," they don't care, you know. They know what broadband is, but they don't understand what spectrum is. So how do we train those people to come up through the organizations? Where do we go get them? What campuses are providing disciplines to make sure they're available in the future? The people in the spectrum community, as far as we're concerned, are coming out of DOD and other like organizations in which there is part of the community, part of the fabric of what they do to communicate, you know, shoot, move, and communicate. I mean, that's part of it; it's in there. So, you know, when we're looking for that think tank that you're asking for, first we got to look inside ourselves to see what level of expertise we have and then quite frankly industry. Industry sometimes has to just step up. I know that we get visitors often, you know, either soliciting for something or support. But sometimes we would love to go to some of the meetings and symposia but we have constraints and restrictions on travel and budget and things of that nature. It's a constant fight on the federal side to maintain our level of expertise in the industry across the board. It just is. The monies are just not there to continue to go to the symposia, to go to the universities and be a part of the research and development end of it. I mean, we've got things coming over the fence that are tossed over the fence all day long that we have to respond to so there's not much time left over to do the R&D, which we're not in the business of doing from our perspective.

MR. SETTLE: On the part of the FCC we do have a what's called a technical advisory committee—I'm sorry, technological advisory committee that's run where we do have, it's where we receive participation from industry and academia, issues like you're describing as well. All of the procedures and rule changes that the FCC does is done in a forum that you're certainly invited to throw out new and novel ideas such as the random failure of the device on purpose. I don't know that we'll take that up but you're certainly able to make that in any of the proceedings that the FCC takes on.

MR. KIDD: Within the Department of the Navy we have the Office of Naval Research and we can punt questions in their directions, and we do often. There are other forums where if it's a genuine question, I mean, they can be publicly asked, and academia and other, you know, will answer. We participate in those forums as well. Onto your first comment. I don't remember the company so I don't feel at all guilty in saying it was some unnamed company. Back in my very very younger days decades ago a manufacturer did what you were talking about doing. Basically they were putting circuits on boards. When that circuit would fail it would, it would fire off a test or a code or a light causing the owner—these were mostly industrial systems—to have to call the manufacturer and say, I got a 471 error. And then they would say, Oh, okay. Punch in blah blah blah and it will clear the error. What it was discovered is that what they were doing is using their customer base to test real world scenarios of failure. Oh my God was it—that was considered unethical on so many levels it was unbelievable. I have no idea who the company was. But I would bet if you go back and start Googling or searching the net for business cases and stuff of that scenario I just described you may not find the company but you'll find the era when that was being done and all of the fallout that came from it. Using your customer base as a Guinea pig is not always—you weren't proposing that; I understand. But that was the ramifications. And logically if we think it through the last thing we want is for this technology to be in the hands of some critical user, and then it randomly flakes out just because that's part of some social engineering that we're doing to try to train our customers that unreliable technology is really unreliable.

MR. CRAIG: So DOJ does not have a research department like the Department of the Navy so really the agencies do it themselves. That not a very good answer. They rely on relationships. For example, DEA does a lot of work with DOD. There's a thing called counter narcotics program office, technical office within DOD. A lot of times they'll take some situations to them. The bureau might turn to the intel community for some R&D. It's not a big budget item within the department. Then they have technical working groups among the components themselves too within the federal law enforcement system and the state and local system. They have twice a year meetings across the country. They come together. They know each other. They pick up the phone and say, Have you come across this problem? What do you think? It's really bouncing off each other and kind of unfortunately doing it on their own.

MR. KIDD: I'll rely on Eric to pull the plug on us on our time. We were worried about filling the time. This is awesome.

MR. DEATON: Hi. My name is Juan Deaton from Idaho National Lab. I first just want to thank all the speakers and panelists for being up there and being on the firing line so to speak. My question has to do with spectrum sharing. And more specifically how do you make a decision on whether or not two users are interfering with one another? And specifically my question is more or less to things looking like can you comment on things like propagation models, verification of those models, and maybe any modeling tools you may or may not use to perform that type of analysis? And then the second part of that question is that is there a possibility, when doing frequency assignments, that you may be doing non-optimal assignments? What I mean by that is in the cellular industry optimal frequency assignment is something that's really well-known and basically you want to get the biggest bang for your buck, and making sure, you know, you're reusing the frequency appropriately. I just want to know if there's any issues like that at least on the federal side, federal assignments of frequencies, and how you coordinate that or avoid that.

MR. SETTLE: Quick clarification on your first question. Are you talking about when they are interfering or when they are predicted to interfere with the coordination process?

MR. DEETER: It would be nice if you could address both specifically like how good are we at doing that.

MR. SETTLE: From the perspective when they are interfering that's not hard at all. We have various field offices throughout on interference calls and it's usually pretty easy to determine where that's coming from. They have direction finding equipment. And so there it's not a case is the model right or wrong; it doesn't matter. The interference is happening and it's easy to see it. As far as prediction and the way we use those models in the frequency assignment process, I would tell you that in every case we're probably not the most efficient that we can be. At times it's because of the type of service that you're trying to take care of. For example, for an aeronautical service where we've got safety of lives concerned we're probably going to use a much more conservative model because we certainly don't want to build something that would give us answers that would allow us the most optimum reuse with let's say a one percent chance we cross that line. That's not acceptable from a safety of life; we're looking for more certainty that the assignments are not going to cause interference with each other. So there is some margin that we look for for those safety critical type assignments.

MR. KIDD: Our automation tools are being continually refined. Probably one of the best examples is recently SPECTRUM XXI was reengineered, redesigned so that many of its tools—that's the software tool that we use for nominating frequencies along with coordinating, et cetera. And it was designed so that it's no longer taking quite as much of a worst case scenario look at things. Early on in the days of spectrum management when there was plenty of spectrum to go around, when there was a hole and you needed to put a new frequency you dropped it in the middle of the hole. About the timeframe in the '80s when I got into spectrum that whole mentality was changing so the processes were changing. So it would get—you wouldn't drop it in the middle of the hole, you would slide to the right or the left, up or down the spectrum as far as you could. Now that the automation tools are getting better and better they're doing more of that for us. So it's a scarce resource for everybody, including us. So we're continually refining our tools. Optimal frequency or best frequency of course is in the eye of the beholder. As Mark said, we sometimes have other criteria that means we may have to sub-optimize in one area because we have to consider a parameter that may not be, you know, totally used in other scenarios. But yes, our tools are in continual—I mean, we have folks that are continually looking at the tools, the technology, the techniques, the regulations, et cetera, to continually try to do it the best way we possibly can.

MR. SETTLE: There are also the more we work together the better we get at our use of parameters. One example that I can think of is where I call up my counterpart at the FBI and I explain to him, you know, You're using these frequencies at, you know, 50 kilometers. What if we use the same ones every 20? And he looks at it and says, You're right. We can make better use of it, and so we agree that, you know, if 20 is the right number we're going forward with it. We certainly optimize those all the time.

MR. KIDD: Lunch is ready apparently. Although it's been a fantastic and engaging conversation it's also been like three hours since many of us have had a chance for a bite. I would ask the final two folks if you want to talk off line or if it's something you really want to address right now we'll cross our legs and stay here a little bit longer. With that, we would like to thank everybody.

### 1.4 Session II: Current Initiatives to Facilitate Federal Spectrum Sharing

MR. NELSON: All right. If we could have everyone find a seat. Let's get started here with the next session. Session II, Current Initiatives to Facilitate Federal Spectrum Sharing. And a number of the folks here are people that Mike Cotton and I went on our fact-finding trip I mentioned in October of last year. I really owe them a debt of gratitude for the input we received from them on the specific initiatives that are going on in the federal government. Our logic was all the types of issues and technical struggles that federal agencies have to work through to develop sharing schemes themselves are perhaps even a simpler problem than opening that up to commercial services. So I think it would be very valuable to have the input from these agencies, and to be able to detail what they've had to work with without any restriction to data because they've all got access to the government master file. With that I'd like to introduce John Hunter from the Office of Spectrum Management in Washington who will be moderating this panel.

#### 1.4.1 John Hunter: Introduction

MR. HUNTER: Thank you, Eric. Welcome everyone to Session 2. My name, as Eric said, my name is John Hunter with NTIA's Office of Spectrum Management. While I am relatively new to NTIA—I've been with the agency coming up on a year—I'm certainly not new to the spectrum challenges that have plagued industry and government alike for the last several years. Prior to joining NTIA I spent the vast amount of my career in commercial wireless. I was director of network at AT&T Mobility Singular where we deployed the first 3G network in 2005–2006. Following my time there I went over to TMobile where I helped spearhead the AWS 1 clearing effort with thirteen federal agencies. I bring that up particularly when we contrast what was talked about during the keynote with Larry on having transparency and cooperation with the agencies and industry and also what Panel I talked about. That seems to be the resounding theme.

I just want to note that while AWS 1 was a relocation effort, there was in fact transitional sharing that ensued. And there was a lot of lessons learned from that. Thirteen federal agencies were involved in that effort. I think for that to be as successful as it was it definitely required that cooperation. I can tell you when we started off on that effort it wasn't an easy endeavor. It entailed a lot of getting in front of the right folks, and in many cases we didn't know which folks to get in front of. So I think we can leverage those lessons. And I'm reminded of the working groups that are going on, have a similar focus there; you got varying systems. And each one of those working groups will come up with some sort of sharing construct that are specific to those requisite systems that are going to be under study.

In a complementary effort, albeit separate, TMobile on behalf of industry filed an STA with the commission to begin the process of testing LTE service features of the band, particularly the 1755 to 1780 portion. That effort will first off be touched on with a monitoring phase where they will characterize the RF environment. Then we will get more detailed information from there to look at the service features and the components that will make that successful. So as we go into this next panel we'll examine a diverse set of projects throughout the government. And as we do I'd like everyone to think about what actions need to occur in order to bring these inactives from project to reality. So without further ado, Howard?

### 1.4.2 Howard McDonald: DSA Roadmap

MR. MC DONALD: Thanks, John. Good afternoon everyone. I'd like to thank Eric for inviting me to speak about what initiatives that are ongoing within the Defense Spectrum Organization. When DSO sends people out to speak people joke that we're going to lie to you. But I'm going to not say that. But what I will say is just so everyone is aware that DSO doesn't build radios; we don't build the capabilities that the soldier carries with him into battle. We build the echo system to help the soldier use those systems better. I think Jeff and John will talk about some of those enabling technologies the soldiers are going to use. And the reason I bring that up is I have some timelines in here that some of the activities that need to occur to meet those timelines aren't under my control. With that I'm going to kind of lead you with a garden hose real quick here.

We have a number of initiatives ongoing. I'm going to touch a little bit on the standard spectrum resource format from the perspective of this is a change in the way that we are doing data exchange for spectrum management. Our current spectrum management data exchange standard, standard frequency action format, is roughly a dozen pages and a couple hundred data elements. SRF is a couple of hundred pages with perhaps a couple thousand data elements that allow us to more accurately, more precisely characterize the characteristics and how users use the spectrum.

SPECTRUM XXI Online was referenced a little bit this morning. SPECTRUM XXI Online is replacing the current SPECTRUM XXI system. SPECTRUM XXI Online algorithms are being engineered to take advantage of the increased data that is going to be available through SFR. We are also, DOD also has a formal business process that's been automated called Joint Spectrum Interference Resolution On Line. This is a way for when war fighters experience interference they can get on a line and characterize what that interference is. And it sets off a series of activities that are elevated in term of importance depending on what function is being performed and is being interfered with, up to and including national assets that may be employed there. We are also working on something called the strategic spectrum common operating picture to help visualize spectrum data to help our senior decision-makers make decisions and engage better in some of the policy decisions that are going to occur here in the very near future. We also have an emerging spectrum technology program that looks at technologies that may either impose a benefit or threat to DOD access looking at the implications of emerging technology on business process and associated automation tools within the business processes.

One of the major spinoffs from that EST program is our activities regarding dynamic spectrum access and policy-based spectrum access. I'm going to spend most of my remainder of time talking about those activities here. We're looking at an earlier co-existence framework. Last year we focused mostly on the listen before talk 1900.5 based implementations of DSA. This year we're expanding that to include other ways to share spectrum database techniques as well.

We're also looking at building architectures, and architectures with respect to how are digital spectrum policies generated, distributed, loaded, and ultimately consumed by those end spectrum dependent devices. We're working closely with CERDEC on those types of things. We're also looking at—and my last slide if I have time to get to it—is looking at how we can bring policy-based spectrum management into spectrum operations. I'll defer that to my last slide.

We’re also participating in standard bodies. I won’t talk much about what we’re doing with 1900 other than we are engaged with, with that activity. And an important element of that is coming up with a standard lexicon for how we describe spectrum access in a sharing paradigm; that’s a key element I think going forward.

We’re also involved with an organization called TeleManagement Forum. I’m curious. Who knows the TM Forum? Okay, a few of you. That’s an industry group that gets together to develop standard data models and business models on how operators do network operation. Within DOD there is an increasing convergence of network management and spectrum management. We established an industry interest group in TeleManagement Forum who are looking at that convergence of network management and spectrum management. We’re also looking at that as a way to engage the commercial world with respect to what business processes we need to standardize to enable sharing. For example, if there is interference that occurs, you know, either way, with commercial interfering with federal, federal interfering with commercial, we need to have standard ways to do interference resolution similar to what DOD is doing with the JSRO activity.

Security implications of DSA. This is more than just the denial of service, jamming the sensing function of a sensing based DSA radio. This also includes protecting that generation distribution consumption of the digital spectrum policies, making sure that those policies aren’t modified either through accident or malicious activities as those policies are key to controlling behavior of these new breed of radios. Finally we’re also—it’s about a year old. My next slide is going to provide a graphic from that roadmap. DSO is engaging in all of the activities that are ongoing within the federal government with respect to DSA. We built a roadmap to help synchronize and align all those activities and help us to understand what we need to do with it, at the enterprise level if you will, to support these new breed of radios when they’re fielded.

Finally, the global electromagnetic spectrum information system, GESIS, is a DOD disbursed program of record for spectrum management. You know, believe it or not, we’ve been, DOD has been doing spectrum management forever, and this will be our first program of record dedicated exclusively to spectrum management. A lot of the activities above that last bullet will ultimately find its way within the GESIS program of record. So this is a slide out of the DSA roadmap. And see here this blue arrow comes right out of the DOD defense spectrum management architecture. It has various time epics. And what these attributes below here show are the SPECTRUM XXI Online, the SFR data exchange standard. Those activities are insufficient to support the deployment of listen before talk implementations of DSA.

So what we’ve done is take a projection of how those capabilities would be demonstrated and fielded over time with the first implementation of DSA being based on geospatial policies, not needing the function of sensing to do DSA as we work on the security implications of the sensing function of DSA. I believe, Jeff, you’re going to talk about PAACS, which talks about the creation of digital spectrum policy that supports that as well. I don’t describe that in much detail. I’ll defer to Jeff on that. As we begin to get increased confidence that these radios can be controlled and the end users, programs of record, regulators start getting comfortable that cognitive technologies are indeed something that they can rely on, we’ll slowly increase the capabilities and functionalities of those DSA radios going forward.

Then lastly this slide is somewhat visionary. If you can imagine when a joint task force is stood up, and DOD, you know, is deployed somewhere to conduct some mission, it's a very complex undertaking with many stakeholders both inside DOD and external to DOD, manpower intensive, and what we feel policy-based spectrum management may bring to the table to help solve this, this complex problem, is the creation of visual spectrum policy that's loaded into those end devices that reflect a commander's intent, what the commander wants to do to achieve that mission. If all those end devices can be under the control of this digital spectrum policy there may be a way to optimize the use of the spectrum to meet, you know, the commander's intent and ensure mission success. I won't get too much into detail as to the complications and the challenges associated with today's technology other than I think policy-based spectrum management provides an opportunity in the distant future to do spectrum management better within a deployment. With that—

MR. HUNTER: Actually, I had a question, Howard. As we listened to the presentation, one of the things I know that comes up quite often, particularly at NTIA we get asked this a lot from the industry folks, just curious. What acquisition process is being implemented in terms of supporting DSA type systems on future platforms? How are you determining through the acquisition process how that would come about?

MR. MC DONALD: So I think your question goes to the concept that we call the surveillance of death, right? We've got all these great technologies that CERDEC and DARPA are developing. And those technologies need to transition to programs of record. The program of record managers are risk averse. They're trying to balance time schedules. And employing an emerging technology like DSA is somewhat a risky venture to ask of program managers. I think we need to focus on, you know, reducing friction, the surveillance of death to—and I don't have the answer to that. It may be a combination of testing and demonstrating that these technologies work; it may be, there may be an element of policy where programs of record are incentivized, if you will, to look at some of the great technologies that the labs are working on to help them do their job better.

MR. HUNTER: Okay, thank you. Next up from U.S. Army we have Dr. Jeff Boksiner to outline some spectrum sharing R&D initiatives at U.S. Army CERDEC.

### 1.4.3 Jeff Boksiner: DSA Policy Generator

DR. BOKSINER: Good afternoon, everyone. It's a pleasure to be here. I'd like to thank John and Eric for inviting us and organizing this session. Just as a quick word for those of you who don't know CERDEC, CERDEC is a Communication Electronics Research, Development, And Engineering Center. We do applied research and developmental engineering for the Army. We work on slightly more mature technologies than, say, DARPA does. We are a nonacqusition organization so we don't acquire weapon systems, but we do mainly research and engineering.

And here I'm going to talk about some of the activities that we have in relation to spectrum sharing. And I won't really have time to cover all of them, but I'll try to hit on a couple of major ones. Just as a motivation why we're doing research on spectrum sharing, I think we all know, most of us don't need motivation.

But the important point I want to convey in the slide is there are two main drivers that are driving us to greater spectrum efficiency. One is a regulatory environment that exists for sharing with commercial entities. But equally important is there's an operational driver. We have more and more need to send more data and there are more and more spectrum dependent systems. And spectrum is needed, access to spectrum is needed for operational reasons.

So most of the technology I'll be describing was actually developed looking at these operational considerations. But they will probably also apply to the regulatory type considerations. And so one of the things I also wanted to mention is when we're looking at spectrum technologies in the context of a military network it's important that there's a difference between spectrum consideration for military and commercial technologies. I listed some of them here. One of them is that we, the military spectrum is very heterogeneous. We have a large number of different types of systems that are operating. It's not just three or five or maybe two systems. There's many many different systems. And if you are going to build an effective spectrum technology you have to take that heterogeneity into account. This is a key parameter.

Another parameter is that everything, most Army networks are to be mobile, expeditionary. We need this to work not just in the United States but in various countries. And of course as has been discussed before, there's all kinds of security considerations related both to underlying data as well as the operation of the network itself. So these are key considerations for developing network technology. And what I will do now is looking at various ways of sharing spectrum what we tried to do is break these different technologies into kind of a flowchart. And actually we do, we've been doing research in many of these areas. And these sort of are divided into areas of different technology types.

One way of doing spectrum sharing is you can do it by location or time. You can do frequency distance separations and you can do pre-planned frequency assignments. That's really how we operate today. That's the current paradigm. It could be made better if you have better data, if you have better planning tools. I'll discuss this. But that's the current paradigm.

If we move to the emerging technologies then we can look at other ways of sharing spectrum. And one way is to do policy-based spectrum sharing Howard was describing. And we can do that by pre-planned policy, but again usually it's location and time based, something we've been working on. We've really been leveraging the technology that was originally developed by DARPA. They laid the foundation for this work.

You can go a step further. You can do real-time awareness. If you have the capability to do that you can do spectrum sharing using real-time data. Once you leave that you can go to a sensing based approach. And from our point of view, because we're looking at a heterogeneous system, a heterogeneous, the sensing based approach must be policy governed. We done a fair amount of analysis of DSA systems and DSA system sensing based systems will not be effective without prior information to govern the system behavior and interpret the sensing that is done by the system. In a homogeneous environment you could probably get away with sensing. But by itself in a heterogeneous environment you need sensing and policy.

And the other thing is sensing based systems in fact could operate as a secondary system. So they could basically operate on a sometimes we'll do a harm principle but we can also operate on a priority access of the spectrum. And there's different ways to configure these sensing systems.

And finally another approach is through some sort of system negotiation through a broker or database or directly systems can negotiate with themselves, system to system negotiations. It may be some way off, but certainly approaches looking at the spectrum brokering databases are more developed.

What I'll do now is cover some of the research activities we have. So one of our main activities, and this falls into this category of pre-planned frequency assignments, which is something which we call electromagnetic battle manager. And this is actually an iteration of a system we had developed, developed in the past which used to be called collision joint spectrum management, a tool some of you know about. What electromagnetic battle manager does is it simulates an electromagnetic environment and the different systems in the environment and then, you know, advises the spectrum more on a frequency assignment plan.

So as in pretty much any spectrum planning system there are really three components. There's a data component, there's a simulation component and, you know, there's a visualization and administration component. The data component is really very crucial here because I think, as the previous panel described, you need good data in order to be able to plan a spectrum well. So a significant effort in this project was actually constructing the database which was called the spectrum knowledge repository, and taking the different data sources that DOD has and aggregating them together and creating a relational—a relational database. So data is key. Data drives spectrum planning. So this is a, you know, a fairly mature product. We've been working on this for a while. This really supports the spectrum management process as it exists today and as it will evolve in the near future.

Now, as Howard was mentioning, if we go beyond just the frequency planning and get into the policy-based approach, we've been working on developing an automated dynamic spectrum policy generation system, which is called PAACS, or policy altering automation and creation system. And what PAACS does, PAACS was originally designed to work with an XG based radios to automatically develop policy. If you look at, you know, if you look at a policy-based radio you have a policy creation tool and a policy management tool, but somebody has to develop the policy. And the policy, developing a policy is not just a sort of computer science exercise, an exercise of taking one type of policy rule and creating another policy rule. Developing a spectrum policy that will govern how the radio operates in a noninterfering manner requires spectrum modeling in order to determine what the policy is.

So we use, we use conventional spectrum modeling tools, obligation models, frequency dependence action, all of the things that we know work in the traditional spectrum management approach. And we use those tools and the data. So here we're using the SKR database I was describing earlier. We don't have to use that particular database; we can use any other database that provides data in the proper format, but using the data where we were able to perform analysis and generate a policy that is customized for that environment and that mission. And then we will work with the shared spectrum company to create a policy visualizer and simulator, which is the picture you see in the lower right-hand corner where you can visualize the policy and run a simulation as in this particular case. There's some lines in there showing movement of some vehicles. So you can run a simulation. And as it goes into different areas it shows you how much spectrum is available and whether your policy works in a satisfactory manner.

The key point is that generating the policy requires data on where the systems, common systems are, and then assess to drive the policy. You cannot drive the policy without spectrum data, spectrum analysis. It is a very important point in a heterogeneous environment. I should say the tools exists and it's demonstrated in a number of places, it's shown that we can create policy and create a radio that works. This has been shown. What I'll do now is I'll touch on some other projects that we have which are kind of newer and ongoing.

What we're now looking at is the issue, you know, with the tool that does policy generation is in order to utilize policy you need a policy enabled radio. And it will take time for policy enabled radios to become field available. There's a reason why we started with the policy direction system a couple of years ago is because we kind of looked and said, Look, we know that policy generation, policy-based radios will be fielded. And we want to make sure that when they're fielded there are tools available to the soldier to support and operate those systems, right? Because if we just field the policy-based radio, the radio will be there, but there will be no way of managing policy, creating policy. That's why we started with the PAACS project.

We also looked and said, All right, we have now a means of creating this policy. Can we do something for systems that are not policy managed? And now we're looking at various things such as doing real-time sharing amongst military networks, so, you know, getting real-time position data and modeling the data in real-time and creating real-time policy and trying to create it. And so these are all kind of ongoing projects so they're not finished.

We are looking at spectrum sharing not just between communication systems but between different systems, again real-time spectrum sharing. And we've done a little bit of work sort of to look at models that, where the spectrum coexistence between military networks and things like commercial wireless systems, base station subscriber type networks, that's really what is really mature at this point. So this sort of completes this. We have a number of other projects we're looking at. We're looking at enhancing propagation model and defense models, testing of DSA systems and so on that really support some of this. But, you know, our key goal is to really support greater spectrum efficiency, spectrum management, you know, in the U.S. Army systems. Thank you.

MR. HUNTER: Thank you, Jeff. One question particularly surrounding the policy generator. And understanding that this involves primarily federal systems, military systems. I'm just curious. Can any of this be leveraged to account for non-federal systems? And particularly, how would you implement a policy generator to support evolution of new heterogeneous systems?

MR. BOKSINER: So, so the policy, the policy generation system can actually work almost out of the box with non-DOD systems if we have the data on the non-DOD system because the policy-based system is completely driven by having data. And actually the policy-based systems can do two kinds of policies. It can do location specific policies. It can also do sensing policies and look at what sort of sensing works in the environments. But if we just focus for example on a spatial policy, which is what we've been focusing on, if we have the data on where the systems are and, you know, they can configure, we can run the policy generation system and it will produce policies that are specific to that one. Essentially the policy direction system does a direction environmental analysis. Spectrum modeling directs the policy.

MR. HUNTER: Thank you. Okay. Up next we have Joe Heaps from the National Institute of Justice.

### 1.4.4 Joe Heaps: Department of Justice Research on Spectrum Sharing

MR. HEAPS: Thank you, John. Good afternoon. It's a pleasure for me to be here at ISART. It's a pleasure for me to co-present with Jeff and John, with Rob and with Howard. The work that we do leans very heavily on dollars spent other places in the federal enterprise. And I look to the four people on the stage for guidance. It's a great group. I want to thank Byron and Eric for the initial invitation to participate. I want to point out Jim Craig in the back of the room strategically next to the microphone.

The work that I'm going to talk about today that is done at NIJ is specifically targeted towards state and local criminal justice, state and local public safety. So there's very important, very challenging federal use questions I'm going to refer to Mr. Craig in the back. And Jim, thanks for sitting next to the microphone. I also want to recognize the great work that's going on here in Boulder within Commerce. Jeff Bratcher, Derek Orr, their team and Andy Beeson in working through the issues of the 700 LTE with regard to the national public safety broadband network.

As John said, my name is Joe Heaps. I'm a policy advisor on communications and radio frequency at the National Institute of Justice. If we can go to the next slide, please. Oh, that's me. Sure, Heaps. My disclaimer is a little shorter than Howard's is. But these are my words, not for quote or attribution, and not necessarily the words of the Department of Justice. The commission of the Institute formed by the 1968 Crime Act, 2002 Homeland Security Act further laid out the roles of the Institute to provide objective and independent knowledge for criminal justice law enforcement, and as I said before, focusing on the state and local responders.

As I said, the '68 Crime Act and the 2002 Homeland Security Act. This is where the Institute sits within the Department of Justice. We are a part of the Department of Justice programs. How many people in the room, prior to getting the agenda or hearing me talk, had heard about NIJ, know what NIJ is, know what NIJ does? That's great. Organizationally we have a Senate approved director, two deputy directors. And my work is done in the Office of Science and Technology. We've got a great working relationship with the folks at Forensic Science and in Research and Evaluation. And I'll talk about some of our collaboration with the Office of Research and Evaluation as we go forward.

My customer base. NNA tells us that during my eight to ten minute talk there will be 4,500 911 calls per division in this country, fire, law enforcement, EMS. So all the work that we're doing is specifically targeted towards responding to the very challenging, very daily real-time questions that my customers have.

NIJ role within the Homeland Security space. Work very closely with the Department of Defense, with the Department of Homeland Security, and specifically targeting the criminal justice things and coming together at what we deem critical incidents.

A representative list of some of the technology investments from NIJ. The gloves. It's interesting. I was not aware of it. But the requirement for a law enforcement glove that may have to defend against the attack of a hypodermic needle may be very different from the requirements. So again, like the other work that goes on at the Institute, very closely aligned with the work at Defense but there are some things that the criminal justice, the public safety community needs that are a little different. So we work very closely with those groups, but in places where there are separate law enforcement, criminal justice, public safety requirements that we look at for those.

A couple of basic publications that we have. One is on standards and testing. We're involved in the body armor standard domestically. We work again very closely with the Defense Department and with DHS. And finally things to policy and practice. Sort of a one-stop shop for state and local criminal justice, state and local law enforcement to respond to research and technology questions. So strategically this is what our goal is at NIJ. First we want to work very closely with our customers to prioritize research requirements, award competitively independent projects to address those prioritized research requirements, accept proof of concepts of these research projects, and then work towards porting them toward a single common reference architecture. As Howard said, he's not building radios. I'm not building radios either. But my goal is to get functionalities around spectrum sharing, functionalities around dynamic spectrum access into trusted customers' hands to get operational feedback on what the operational so-whats of these functionalities will be in the criminal justice law enforcement community.

A subset of the RF issues and opportunities that my customers face. Many of the things that are being discussed in the room are of great interest to our customers. Our customers may or may not have the means to bring them to bear. And we do what we can to make that happen. As I mentioned, I have a technology working group made up of 12 to 20 sworn and former sworn law enforcement officials who advise me on their technology reports. The institute has another 18 multiple working groups in the forensic sciences and information sharing and officer safety. Very, very customer safety, customer friendly organization.

So, what have we done in this space? We have competitively funded what I will call proof of concepts in cognitive radio, in cognitive control of reconfigurable antennas and channel bonding across heterogeneous, heterogeneous networks. What I'm now doing is I'm bringing those together in a single reference architecture so we can take the independent research activities. We put together a facility for integration in bringing these together and working very closely with our customers to make sure that they are meeting their needs. We've established an area for the integration. We've delivered competitively awarded prototype functionalities for integration. We've adopted a standard based, open door near term architecture design and software integration has been done. We've done, we've done three demonstrations of the independent functionalities. We have done them at the FCC twice. Our facility is very close to the Commission. It's at 80 M Street Southwest down by Nationals Park. We're, we're clean on FJs and experimentals. And we invite anyone in the room that's interested in the process to come see the work that we've done and that we're doing.

The next part I want to talk about is sort of that operational so-what piece. So much of the work that we do is driven by—all of the work that we do is driven by our customers' operational requirements. So being able to measure, being able to look at operations before and after one of these technologies, one of these functionalities is brought to bear is of great interest to us. So I will talk very briefly about three operational evaluations that we've begun. I'll ask the group a question. We're very interested in others and how they're looking at operational impact of technology, questions that they're asking, metrics that they're using. We're hoping to evolve this program to be more robust.

So again, operational impact, new technology is critical to us. You know, comparing pre- and post-deployment metrics, deployed response time, being able to put a data network in law enforcement's hands so that it's easier to send reports to court, reports to records, reports back to the command so that my customers can spend more on target time, more time in the field and less driving back and forth to deliver paper documents. As I said, I'm just going to, I'm going to talk through three of them we've got currently going on.

You're all very familiar with the important work done by Mr. Strickling and Ms. Gomez and that great team at Commerce on the 700 broadband network. One of the things we've done, there's an existing 4.9 gigahertz public safety broadband network in Brookline, Massachusetts. And we've got an incredibly forward-leaning customer there and a lieutenant named Scott Wilder and we've got great command support there. So one of the things we're looking at is we're looking through records at Brookline to determine how the Brookline Police Department operated prior to deployment of the 4.9 gigahertz network, and then looking at how the department operates with the 4.9 gigahertz network. We're optimistic that the things that we learned from the measured, repeatable operational evaluation are going to deliver good information for the FirstNet board and for others as we look to push forward the very important 700 megahertz broadband network.

In a similar vein, huge problem with cellphones in the institutional corrections environment. The Mississippi Department of Corrections, the Director of Corrections there, Chris Epps, is again another person who, like Scott Wilder in Brookline and Alan Sadowski in the South Carolina Highway Patrol, forward-leaning technologies. They want to look at ways that next technologies can help them answer operational questions today. So the Department of Corrections in Mississippi purchased a managed access system. And we are down there measuring how they operated, how they pursued contraband cellphones prior to the deployment of the technology, and we're looking at how that, how that's done, how that's done after.

And the last I'll talk about is the North Carolina State Highway Patrol. North Carolina state has a, has a land mobile radio system that currently has 65,000 users, and that's growing to 72,000 over the next six to twelve months. And there's a huge operational impact of having to touch every device through over the air rekeying and over the air programming. So we're working with the North Carolina Highway Patrol to measure the operational impact of being able to do those things over the air initially in Wi-Fi, but then potentially in other spectrum in other parts of the RF.

This is my contact information. The other name up there is Dr. Nancy Merritt. She works in our Office of Research and Evaluation in instrumental—there's been great acceptance in our customer business for more measured operational evaluation. As we're all aware, there's a great opportunity for handing out iPhones and asking how it went, and everybody fills out the little worksheet that says, you know, It has a cool beat. I can dance to it. I give it an 8. But being able to measure operational impact of different technologies is really empowering our customers to ask different questions of vendors, and to think through operationally how we all know that when we get a new technology there are things that occur through operations that we may not have thought about before. So having those conversations up front it's been very rewarding. I look forward to coming back and telling you how these are going. But I'm very appreciative of your time and I appreciate the opportunity, John. (Applause.)

MR. HUNTER: Just looking across the audience I see some heavy heads. I know just after lunch—

MR. HEAPS: After my talk?

MR. HUNTER: We're going to move right through this and then we'll get to questions. Next up we're delighted to have Dr. John Chapin from DARPA. We'll go over the RadioMap Research Project.

### 1.4.5 John Chapin: DARPA RadioMap Research Project

DR. CHAPIN: Thanks, John. Thanks to those who organized this work, and to Chriss for keeping us going today. Okay. So I'm going to tell you about program that we are just launching at DARPA. The full name is the advanced radio frequency mapping program. The short name is RadioMap. In case there's anyone in the room that doesn't know, DARPA is the advanced research arm of the DOD and has had a lot of contribution to the kind of things we're talking about today through the work of two former program managers who are in the room today and a couple of others who aren't here, but we're well represented I think.

So RadioMap is driven by the convergence between a set of needs and a set of technology trends. Although the RadioMap program is focused on military needs, those needs and technology trends are shared strongly with civil issues. And I think there's going to be a pretty strong opportunity for technology transfer here once we've developed it in the RadioMap program. So the initial driving need, obviously the increasing complexity and density of the usage of the RF spectrum, that creates very significant challenges among them for spectrum management and for ever increasing efficiency with which we use the spectrum.

Real-time awareness of how the RF spectrum is being used would be a significant contribution to advanced techniques for solving those problems. But the obvious way of gaining that information, which is to put out a dedicated sensor network of spectrum sensors, that's pretty expensive. And that high cost is hard to justify in most of the operational situations where you'd like to have the information. So the driving need here is can we figure out a way to reduce the cost of gaining that information in order to do a better job of addressing all of the problems that are created by the density and complexity of spectrum usage.

The technology trends that enable us to go after that need are listed here. We have an increasing deployment of software defined radio technology. That means devices out there for one purpose can have software loaded on them to perform additional functions. We have increasing tuning range of deployed radios. On the military side the next generation of tactical radio devices have significantly wider tuning range than the previous generation, gigahertz up to multiple gigahertz. If we look at the civil side the trend is a little slower, but it's happening, right? The increasing diversity of bands allocated worldwide for global wireless communications is driving manufacturers to build ever more widely tunable devices. Finally, obviously, the effect of Moore's law and everybody's favorite *i* device we have the increasing computational storage capacity of all our global devices. They can do a lot more for us than they used to do.

So we put those trends together with that lead and we come up with what we're doing in this program. I'm going to give you the very generic statement of the mission of this program. We are going to use RF devices to perform additional tasks without harm to their primary function. Let me break that down. Use RF devices. I didn't say radios. And the reason is because we're interested in a technology that can exploit any RF device that may be made available to it. For example, yesterday I was talking to a representative who was at the WSRD meeting from Raytheon from the radar division. He said, Yeah, our next generation of radars, it's a bunch of transmit-receive modules with a computer behind it. So a radar could easily participate in gathering this data and providing additional functionality if the people who make it and the people who operate it choose to have it do that.

So we're going to use our RF devices to perform additional tasks. Our pathfinder task, the one where we're putting most of our investment, is RF situational awareness. You'll hear me call that radio mapping. But we are structuring the technology and the program to also support a mapping of other additional tasks that may offer value to the users. So in the military context, those are things like electronic warfare, intelligence surveillance and reconnaissance, navigation functions. For a civil application of the technology there are compelling lists of other applications that you would identify. And you could consider something intermediate between commercial and military, which is public safety where we should see some very strong things we might like to do with those devices in addition to their primary communication functions.

Finally, in terms of our mission statement we're using RF devices to perform these additional tasks without harm to their primary function. Notice I didn't say without impact on their primary function. It is the person who controls that device who determines what level of impact on its primary function is acceptable given the relative priority of what they're doing for their primary mission and the secondary tasks that they presumably also want the results of. So the job of the technology is to make is easy for the person who controls that device to specify what relative priority or what level of resources they want to be dedicated to the secondary tasks, and then the technology must assure that those secondary tasks are carried out entirely within the specified resources limits.

Once we've developed that basic core technology we're going to then do the work on user interface and IO functions and everything else that's needed to deliver that radio mapping capability to three user communities. These communities are very different, so this is three independent tasks. The first customer, our primary customer are spectrum managers and dynamic spectrum access systems—DSA systems being communication systems that autonomously make spectrum management decisions. So for these users we are going to provide real-time maps on how the spectrum is being used, enable them to do their job better of achieving higher spectral efficiency. I should say that Howard McDonald is a big supporter of this program and has given us a lot of advice and input since we started working from his perspective over at DISA.

Our second customer community are leaders of small tactical units. We're going to give these people situation awareness, what's going on in the RF spectrum around them using devices they already have. That might be something that's potentially of interest in public safety in support of their mission as more and more information is available in the usage of the RF spectrum around you.

Finally, electronic warfare officers. These are the people at DOD who have the job to monitor what's going on in the spectrum and take control of it if necessary. We'll use this technology to provide them mapping and queueing in support of their mission. That's the RadioMap program in a nutshell.

Now let's talk about what we mean by radio mapping a little bit more precisely. So in this program a RadioMap is a map of the signals that a receiver would hear based on where it is in the area of interest. More precisely, a map of signal type of power level that you would hear versus location, time, and frequency. I want to emphasize this is the signal that you would hear, not necessarily the location of the transmitter. That actually might be more useful for the spectrum management and DISA job because if you know what you can hear at a given location you know what you can't hear, and that tells you what channels and what places you could generate some additional energy without causing interference.

So let's look at this. Start with the map on the right side. That's a map of an area of interest. You divide it up into some resolution cells. For the purposes of experimentation we specified that those resolution cells are 200 meters by 200 meters in size. For each resolution cell we're going to give you a series, a time series of information. For the purposes of experimentation our time series granularity is ten seconds.

I'll take a slight divergence from my prepared remarks to point out that when I came out with the number ten seconds I had some people come into my office and say, That's way too fast. That's going to cost too much. Nobody needs that. I had other people come into my office and say, That's way too slow. We're not going to be able to get our jobs done. So I think I got it about right.

In any case, so for each of those ten-second time windows we give you this map that says what signals are out there, a cross frequency, what power levels are there, and to the extent we can determine, what is the signal type. So again to say what the system is not about doing. This technology is not about geolocating emitters and it's not about intercepting the content. It's about observing the externals, what you can hear at different locations. We'll leave the demodulation, decoding, and if necessary, decryption tasks to others.

So let's talk about the experiments down at the lower left-hand corner. The first phase experiment, which will be 12 months of the program just about, that is using 25 sensors across four square miles of dense urban area. And when we look ahead to phase 2, which is two years into the program, that's 75 sensors over nine square miles of dense urban area. If you look at, if you think ahead to where this technology might apply in the future, numbers like 25 and 75 seem pretty small. We would be talking in a military deployment about thousands of devices being carried by a large scale unit. But you have to start somewhere. And these numbers are certainly higher than any previous experimental work that I'm aware of where people were looking to gang together a sensor network and get a coherent view of a spectrum in a moderate scale area like this.

For the experiments we also chose to work between 470 and 928 megahertz. Obviously an operational system eventually would have to be far broader in its coverage. This band was selected both because it's relatively low in frequency, which means it's easy to receive in with existing off-the-shelf equipment that everybody can get their hands on. You have relatively good propagation, which means you can get a better map with fewer sensors. But there's a great diversity of stuff going on in Ancona City in that 500 megahertz of spectrum ranging from unlicensed operation at the top end of it. You've got television stations. You've got wireless rights. You've got current cellphones. Depending on how long it takes to get the experiments done we may have LTE operating in those areas. So there's a great range of things of interest, and it provides a nice test case, far more diverse than what you would see in any laboratory experiment.

This is a very hard challenge. We like to say the word "DARPA hard" at DARPA. We like to take on things that people don't believe you can do. The job of DARPA is to take them from disbelief to doubt we like to say, and in the end, Yes, it's possible, but now I'm not sure it's really what I want. That's the job of other people to make it operational. So what's really hard about this—we've got people in the room that have done years of spectrum mapping experiments, and they'll tell you that we're taking on a very very hard problem here.

First of all, we've deliberately gone after the hardest spectral environment. It's an urban area; that's where we're directing our performers to study. That means high multipath, high fading, high shadowing. We still want a nice, continuous map. Secondly, these urban areas, very dense signal environments. If you look at what's going on between 470 and 928 no question you have thousands of emitters per square kilometer to deal with. This is a confusing, high noise floor, highly dense environment. Third, you got limited receiver resources. You just can't afford to observe all locations and frequencies all the time. Even if you had a sensor on every building that sensor would have limited channel capacity, and it could only look at some of the channels.

So this is a sampling job. The job is to sample in space and time and be able to interpolate and extrapolate. One of the key scientific challenges that we're facing is how to do that interpolation and extrapolation job in a well-rounded way so that we can produce an output map which has accurately estimated error bars on the numbers that it produces. That's really necessary for people to make decisions on the basis of the data in the map. As far as I know, those kind of functions have not been carefully studied in the past, at least in these urban areas. We are looking to exploit not just the data that we measure from the sensors, but all available prior information.

So examples of this include models of the behavior of emitters and networks. If you know something about the pairing of spectrum in a cellular system, take advantage of it when you're building your map. If you know something about what happens at 2.4 gigahertz, the statistics of usage in that bar in that band, then by all means use that when you're extrapolating from the point that you were able to sample. Secondly, using maps, ideally accurate maps of the urban environment and terrain, put those together with propagation models—although we're certainly interested in propagation models that can be run in near real-time without requiring large scale supercomputers. And then finally spectrum license databases. I shouldn't need to say to anyone in this room that those databases often have errors in the data so they are at best a hint at what might be going on in the area of interest.

The final thing that makes this challenge hard is in a sense self-inflicted because we are not willing to put up the money to put out a dedicated sensor network covering the entire Earth for knowing what's going on in the spectrum. And because we're trying to take advantage of devices that are already out there for other purposes, that means that these sensors are not controlled by the RF mapping algorithm. So the sensors may be mobile, but the mobility is not directed by the algorithm that wants to figure out some information over there. It can't tell a sensor to go over there. So in the case of a tactical radio, that radio goes where the soldier wants to go for his or her mission, and we're just taking advantage of whatever happens to be in a given area at a given time.

Secondly, the sensors may be intermittent. So if you think about a device that has one channel in it, like a standard tactical radio, you may send it a collection task, and it's happily doing the collection task when the soldier keys it to life to make a transmission. You can bet that device is going to drop the collection task and go on to do its primary mission. So access to the sensors is intermittent; they come and they go. And we can't control when we have access to them.

Despite the limited receiver resources, despite lack of control over mobility, despite lack of control over availability and some other constraints such as network bandwidth, our challenge to the performers on this program is to develop a nice continuous map with well-grounded error bars that supply decision quality data. So I guess my challenge to you here in the audience is to say given the problems that you-all are facing, you know, how much better could you be at solving those problems? What techniques would you use if you had accurate information about how spectrum was being used right now?

Thinking about some of the data sharing transparency that we heard about earlier today where people may not be willing to share from the outside how the system is being used. But if you have a sensor network out there and things are properly controlled to protect privacy and national security then that may be high utility. Give you another example. I spoke to the FCC at one point, What could this program do for you in the near term? The answer was, Find cellphone jammers. If these people start having lots of jammers out there, these are easy to buy, cheap devices. Can sensing by all the devices that are out there already help find those problems quickly?

So in fact our phase 2 of our program two years from now, one of the tests that we're asking the performers to do is to quickly find an anomalous transmitter when it turns on anywhere in the nine square area, nine square miles of this test. And we think by developing those technologies we'll be developing things that are of high utility in other domains.

Go on to the implementation strategy. Like I said, we're interested not just in radio mapping; we're also interested in supporting a range of other functions. When you look at the problem of building one of these applications that takes advantage of devices of opportunity to sense or transmit in the spectrum, what you recognize is there are a set of common problems that have to do with using those devices, taking the secondary access of these devices. And those problems are the same whether you're doing radio mapping or EW or ISR or navigation or anything else.

So as our implementation strategy we are taking, we're building a system, an underlying system which we're calling WALDO, Wireless and Large Scale Distributive Operations, although it originally came from solving the Where's Waldo problem. And we're building the solutions to those common problems into that underlying operating system. So for example, allocations of tasks devices if there are any of the devices in the area of interest. No human being is going to look at a screen and click on the three of them that you want to use to satisfy a given collection task. That has to be an automated allocation process that takes into account the locations of the devices, their current resource status, what difference of them have different hardware capabilities that may be more or less suited to satisfy that task, and a bunch of other considerations, put them all together to figure out which one is the right one, or which group are the right group to send a given task to.

Similarly, if you have multiple applications running at the same time you may need to deflect those tasks. And you have this problem of a great diversity of applications and a great diversity of devices. You'd like to enable any application to use any device without having to specialize each of them to the other. Because if you do you're really running into a terrible software development and validation problem.

Finally, WALDO serves that function of ensuring no harm to the primary functions of the devices. So no matter what those applications on top try to do, WALDO ensures that you don't exceed the specified resource limits just like an operating system does on your PC. I'll say a few more words about WALDO. What does it actually look like? Because that was pretty abstract. Well, first thing to say is this picture here is notional. It's actually, we're entering into a one-year architecture development phase and it may end up looking something quite different than this. But this will help you understand the underlying intent. Part one shown there on the screen is a software component. That's something that would get ported onto the actual end user device, and perform the reception, transmissions, and processing tasks on behalf of various applications like radio mapping. One of the goals of our program is that by the time we get to the end we have produced a reference implementation that any vendor could easily grab onto and quickly port onto their device making it compliant with the WALDO system.

Part 2, up at the top there, there's a distributed software system that performs the command and control functions. In the military environment it would run across a range of servers, some of which are at a base somewhere, some of which might be in an airborne vehicle or in a local Jeep or Humvee near the point where things are operating. But it's the one that actually sends the tasks to the RF devices, collects the results, manages things on behalf of applications.

Finally part 3 there, an over the air protocol. A key thing to say about that is something that would run over existing communications networks. We're not talking about building a new communication network; this is all about exploiting resources that already exist. We've been in discussion with a number of military organizations about existing protocols that might be a good basis or a good interoperability target for the WALDO protocol. That's how it would work.

Here's my slide on what makes WALDO hard. I had a slide earlier on what made radio mapping hard. There's a number of systems issues here. I don't know how many of you have worked on sort of narrow waist systems before. But making it so that any application can use any device is hard in and of itself. It's critical that the system be robust. It has to be secure. We're opening a new port on the backside of the devices so we can't create a vector for adversaries to look into the device. It has to be efficient. It has to support multiple simultaneous applications, highly scalable. And to do all of this under very challenging operating conditions such as low network quality of service, and uncertain information. So the way we structured the program, we actually have one major research task on the radio mapping algorithms and we have a separate major research task on underlying WALDO later that will support radio mapping and other functions.

So status. The VA came out this winter and said awards are expected this summer. Actually the selection letters just went out yesterday so now we're entering military procurement contract language. You probably have experience with it. It's challenging to make it move quickly. We have the 12 month phase 1 that will implement an initial radio mapping prototype and get us to a field trial next summer. That's the one I was telling you about, four square miles, 25 devices. We're also designing the WALDO system. We're doing some lab studies as part of that. And we're doing analysis of other applications that might exploit the system.

We go on to phase 2, the subsequent 12 months. There we improve the prototype. We start going to heterogeneity in terms of the sensors. We add mobility. We add intermittent access to the networks making things more operationally realistic. We get to field trial in summer of 2014. Also at the same time we'll be trying to, we'll be putting out all of the solicitations for the whoever is going to lead the design and development of the operational system. When we say "operational," in DARPA context that just means something that's capable of showing to the military that what we're doing is possible in an operational context. Then it has to get picked up after that by a program of record to actually be turned into something that the military would use.

Then we have a two year phase, what we call phase 3. That's developing that transitional capability actually implementing the WALDO system. And we're looking to demonstrate two additional applications in addition to radio mapping showing the range of things that this capability would be able to offer the end user porting it to fielded radios. That's the end of my presentation. I guess we'll take questions now and later.

MR. HUNTER: Thank you, John. Yes, we'll take questions later. I appreciate it. We're going to turn it over to Rob Hite. (Applause.)

MR. HUNTER: He will be going over the federal spectrum management system.

### 1.4.6 Rob Hite: NTIA Federal Spectrum Management System

MR. HITE: Good afternoon, all. My name is Rob Hite. I work with NTIA. I am the investment manager for OSM's federal spectrum management system. Actually the very first release of the Federal Spectrum Management System went on line just the end of June this year. We're very happy about that. The first thing you notice is I have no disclaimer other than the fact that I'm an IT guy so when it comes to the questions keep that in mind. This has been really interesting today for me. Some of this stuff is new to me; some of it I've heard many times. I'm not sure if this is like a minefield I've stepped into, or if it's like a field of dreams, I'm not sure which it is. It's a little bit of both. But it's been very interesting.

MR. HUNTER: We like to think of it as a field of dreams.

MR. HITE: I think we all know what the problem is. The problem is there's just not enough identifiable spectrum out there for use. So the idea behind the FSMS is to take our systems for what was at one point just basically an administrative system that tracked this organization was using this frequency over here for this purpose, and turning it into something that we could use for analysis, turning it more into an analysis system in addition to the record keeping that it currently does.

Now, I may answer some of the questions that were asked earlier this morning as I go through this. We have three basic business processes over in the Office of Spectrum Management. One of them is the frequency assignment process, which is handling the assignments in the federal space, and coordinating the commercial space with the FCC. We also have a spectrum certification business process where we can do a risk analysis of systems that the government is looking to build and determine whether or not we can actually, if they did build it, would we be able to provide an assignment for that particular system. And the third business process that we have is spectrum analysis. That's probably the long pole in the tent, the spectrum analysis pole.

If you look on the slide here where I talk about equipment characteristics repository, that really is what is going to enable the more enhanced analysis than the FSMS system does as compared to the old legacy systems. The legacy systems are very stovepiped, they're very separated. If you use one system you're going to get a different answer than if you use another system. So the idea behind the FSMS is to pull all the things together, put them into a service architecture so that the processes can be reused, and to beef up that data model so we have a lot more equipment than we have today. With the equipment characteristics repository really what we are looking to do is build a dataset of the equipment, what the potential for the equipment is, and then what the actual intended use for the equipment would be. That is what enables our more advanced algorithms.

So the way that we operate within the program, we work very closely with the Office of Spectrum Management, we work very closely with the IRAC and its subcommittees, and we work closely with the DOD since they're actually our development partner for a large chunk of this system. Howard had mentioned SPECTRUM XXI Online process. SPECTRUM XXI Online is used actually for the preparing of met use cases for the FSMS in order, in order for them to, our users to create the proposals, submit them over to NTIA, and then NTIA can process that information in its back office.

So we work very closely with the IRAC. We work very closely with our engineering groups. There's a technical subcommittee within the IRAC. We work very closely with those folks in order to make sure that the engineering does what is necessary for the systems in the future. We have completely changed what the system architecture looks like within the FSMS. Instead of the disconnected stovepipes and a lot of the batch processing we do today we've gone to a multiple tier architecture where we have our datasets on the back end, we have an elevator, we have a hierarchal data, we've got expel data, we have recording engines on the back end. We have a business logic tier that is truly service oriented. We have a lot of web services that run on our back end. They're connected to an enterprise services bus.

This gives us a lot of flexibility not only in building the system today but enhancing the system for tomorrow. Our user interface is all web based. These systems are all online systems. They have a very rich user interface. The SPECTRUM XXI Online interface looks very much like, if you're familiar with Microsoft Outlook it looks very similar to that. So the learning curve on using our interfaces is very low.

Now, my job with the FSMS isn't so much to make spectrum sharing happen. My job is to make sure that I don't interfere with spectrum sharing. My job is to make sure that as you folks are coming up with more advanced radios that I can handle them in my system; that I can define them within the system; that I can identify what the operation capabilities and parameters are, and I can process those in a timely manner. And timely is important. We were talking this morning about assignments taking nine days, and nine days was a good thing. We're talking about reducing that to a matter of just a few days. Or in some cases we're talking about the potential to put something through the system in real-time.

And that's really key to how we build these systems with the service oriented architecture with the idea of a lot of queueing of information, with the concept that everything that we're dealing with is a transaction, with the ability to have systems interfacing directly with our system. We provide the capability to do things in real-time whereas today there is just no, there is just no shot; the systems cannot do it.

Like I mentioned, we have, have improved the engineering algorithms. We had very simplistic views on how we would handle our data and how we would look at a signal that was transmitted across either irregular terrain or smooth earth. What we do now, though, is we have more advanced algorithms that can actually do a statistical modeling around a given area where we can move the transmitters and receivers anywhere within that space and identify exactly what the interactions are going to be. We can determine whether or not there's going to be interference or whether we will interfere with anybody else.

Now, these can be really intensive processes. Some of the processings can actually execute within seconds or minutes. But some of them can be very intense and can actually take hours to execute. And I think that's the long pole in the tent when it comes to the, when it come to the spectrum sharing is the EME environment is very complex and it's all about the data. And it can be very complex and processor intense to process that amount of information quickly.

We have mapping systems in the new system. And we have various charts in the new system. These enable us to better visualize what an assignment might do to a particular area, how it might interact. So all these things come together with the FSMS. Like I said, the idea isn't so much to make sharing happen within the FSMS. The idea of the FSMS is to make sure that we can allow for spectrum sharing. The roadmap for the FSMS, like I said, the very first release went into production just last month. We have an unclassified version of the system in production. It is equivalent to the SPECTRUM XXI Online capabilities, plus it has some additional features that are, that are civilian agency specific.

The second release includes a classified environment as well as the unclassified environment. And in the second release we have the back end process built as well as the front end process for our assignment processing. And that allows us to actually run these systems in parallel. But after we run, after we run a transaction through the new system we actually take it and run it through the old system as well and that allows us to do a comparison between what we actually got from the two systems and see if the system is working the way we believe the system should be working. So that parallel process will run for a period of at least a year. At the end of that parallel process we could actually retire some of these legacy systems, specifically our FMRS process.

And that's going to have a big impact with anybody who is using our data today. Today our data is formatted in what we call a GMF format, a Government Master File format. And in the future we have an XML format for the new systems. XML format we actually have published. We worked with DOD on that standard. We worked with NATO on that standard. We came up with a very strong XML standard that can be used to share information. It has, it has, as Howard mentioned, there's about 200 data elements in today's systems. And we've gone up to about 2,000 data elements. There's a lot of them that are still administrative. But there's at least a thousand data elements in the new data format that actually are very useful as far as analysis is concerned.

In release 3 we start looking at reporting statistical analysis capabilities. We look at our certification process and start pulling in the back end of our certification process. When we get to that point in release 3 also we will have already built a database of equipment records within the NTIA. And in release 3 we'll be building a capability to allow industry to come in and provide us with their equipment specifications, and identify whether or not their equipment actually meets the NTIA compliance standard for what that equipment is supposed to do. And if so, then we can use that information within our systems, and that lessens the data entry burden for our user base in entering these new frequency assignment requests in the future.

In release 4 we have the front end process of the certification process that takes over what we currently have, our ELCD program. We'll be replacing that with the EL-CID on line type program, which has very similar functionality but is served on line. And also uses the same processes that we built in release 1, 2, and 3. So with each one of these releases they each build upon each other. So that's it for the FSMS. There's probably a lot of questions that you have in regard to it. But I tried to keep it within ten minutes.

MR. HUNTER: You did very well. Thank you so much, Rob. Appreciate it. (Applause.)

MR. HUNTER: I'd also like to thank all of our panelists for sharing their projects with us today. We will go ahead and open it up for questions.

### 1.4.7 Session II Q&A

THE FLOOR: Thank you very much. That was very informative. I have a specific question, maybe two questions for John Chapin. That was an interesting presentation. I have a question for the sensor devices. Is it the intention that those devices will be separately produced and designed? Or would those be devices that are already part of the ecosystem like LTE devices, cellphones, Wi-Fi devices, et cetera? And the second question is regarding the phase one trial that you have a four miles, four square miles area, 25 devices, would those again those 25 devices be specially designed, and what is your predictions or expectation of the pixels of information that would be provided for the spectrum, what information? Would it be—it probably wouldn't be 200 meters; it would probably be much larger than that. And is a lot of extrapolation expected using propagation model and such?

MR. CHAPIN: Okay. Thanks for the question. I think I'm going to take some of the details of what you asked me off line. I'd be glad to talk to you and others afterwards. In the general sense, the first question you asked about was whether the sensors would be specially designed. As I said, our primary mission is to take advantage of existing devices and use them for performing additional tasks. That doesn't rule out combining the information you get from that with special purpose built devices that are deployed for that. But we assume that the bulk of the sensors that are in the field would be things that are already fielded for other purposes. Then you asked about the phase 1 trials. Just to make things easy, we said to the performers that they could use whatever devices they were comfortable with. And as far as I know, nobody proposed actually using a tactical radio as the phase 1 device because there's a whole lot of software specialty stuff, things you have to do to get things working in that environment. So it's really just people using, you know, usurps or things that they have from their company, whatever is available in their company for these experiments.

MR. HUNTER: I just wanted to add to that I enjoyed the presentation as well. You know, I was excited about it thinking, you know, this is something we can put to use immediately. I think as I said in my opening remarks we have an STA under way which the first phase of that process is monitoring the RF environment to better characterize the coexistence of the incumbent and new entrant system. So looking at that program you have there, John, I think would be very useful in mapping out the potential sharing environment in the future.

MR. CHAPIN: That's great. We can talk.

MR. HUNTER: Any more questions? You got it there? Jim Craig shut them all off. Thank you.

MR. MODY: Thank you for the panel. It was a great panel. My name is Apurva Mody. The RadioMap program, it does offer a lot of things. Especially one of the things I'm interested in that when people reserve spectrum are they actually using it. And there has to be eyes on the ground to corroborate whether people are doing what they actually say that they're doing in the database server. I think one of the things that you could use is also for that application. The other thing is the last panel I didn't get a chance to make a point. But one of the things that Mr. Hersey said was that just as commercial users are trying to use the spectrum for federal I think the same goes for them as well because when the spectrum gets available maybe federal users can come in and use the commercial spectrum back. And one of the easiest examples could be white spaces. Coast Guard is already using VHF USF. Maybe they could involve the use of the white spaces. Obviously I don't expect that there would be any transmitters in the middle of the ocean but, you know, that could certainly be a possibility.

MR. HUNTER: Got one right behind you first.

MR. REASER: This is sort of putting this in context of the panel this morning. Rick Reaser from Raytheon. Has there been any thought of trying to look at whether FSMS some of these programs can be made common with like those on FCC? FCC has some of the same processes. Has there been any kind of interchange about how those kinds of things might work to have a more common process? As you share and share more, it would seem to me that your databases and the way you manage spectrum and we allocate things and keep track of stuff ought to be a lot more in lockstep in the future as you get into all this heavy sharing. Is there any dialogue? I'm not sure what role the FCC played when you applied for a FCC license on line and something happens, you know. So I'm not sure what goes on. Could be a bunch of hamsters in cages, I don't know. But I guess the point is, it seems to me if you share more you'd want to maybe have a more common set of processes and data system and databases and stuff like that. Have you thought about that?

MR. HUNTER: I'll take that. Actually, we have had conversations with the FCC. We work very closely with the FCC. If you saw Mark Settle's presentation earlier, one of the systems is the OFAC system. And it does interface with systems currently today. And it will continue to interface with our system in the future. So the FCC data that's available we have full access to that. So when we do our analysis and in the future when our customers are working with the FSMS and they're entering their proposal information into our system they can see what's in the spectral environment, including what's in the commercial environment, and can see if they're going to interfere with any of the commercial space or commercial space is going to interfere with what they're doing. And also when we look at that spectral environment including the FCC data, and when we provide a nomination, when someone asks for us to nominate a frequency for them to use, basically coming to us saying, I have this purpose. Give me a frequency that will work in the area without interfering, what we do is we look in the area included in the FCC data, and the new system will actually, if we have a swath of bandwidth that's about this big where we can fit somebody, instead of getting them right in the middle like we do today, we're going to fit them right over here. We're going to jam them right up against there as long as we know that there's not going to be any interference. So we use it a lot more wisely. But we do interact with the FCC today, and we'll continue to interact with them in the future. So they're actually a partner with us. We've had many conversations with Mark.

MR. HUNTER: I just wanted to add to that. As the new guy at NTIA, having spent the vast majority of my career in the private sector, and filed a lot of licenses with the commission, definitely you can see that there's a need for a lot of streamlining of the processes. Rick, that's primarily I believe the context of your comment and question was more around process oriented. So I appreciate that question. I think it's certainly not lost on us that there definitely needs to be more collaboration and streaming as it relates to that effort.

MR. MC DONALD: Alternating some of those processes in terms of making sharing more dynamic and closer to real-time, we're not in a position right now with lack of requirement how we're going to implement sharing methodologies yet. So when the engineers start talking between NTIA, FCC, and federal agencies we'll be talking over actionable requirements that can be, systems can be built to support sharing.

MR. HUNTER: Next, please.

MR. CROWLEY: Hi. My name is Alex Crowley, Department of Homeland Security. Jeff, I had a question for you. On the last slide you talked about wireless application. I wonder whether or not that's currently being tested or going through R&D at the future process. Regardless what that answer is, I'm wondering if this is a standards based solution and what band you might be playing in if you have any operational feedback.

MR. BOKSINER: So the last slide was talking about basically the network to network sharing. So as far as the actual, we're not, we're not building a new radio system. What we're doing is building a system that can reconfigure whatever military radios. What it does is it's collecting, it's collecting real-time information like where the radios are, it's putting it in a spectrum analysis process. This network is there assessing interference and, you know, developing a new frequency plan if necessary, and then controlling the radios. That is an ongoing project we started in '12. So we're going to go through a series of intermediate tests. I don't expect it to conclude probably for another year or so. But really the purpose is to look at the type of radios that currently are in the process of being fielded and trying to bring DSA to those radios, not waiting for policy-based radios. I can talk to you off line.

MR. CHAPIN: If I can answer that as well, DARPA has been pushing on those wireless networks for a long time. I don't know if Preston's in the room, but his baby, his program, wireless network after next, is getting to much larger scales than have previously been in field trials. I don't know if the number's public so I won't say it right now, but there's a field trial happening in the spring that's substantially larger than anyone's done before. And it combines it with dynamic spectrum analysis. So I would track the public releases about that program if you're interested in learning more about the leading edge in deployment.

MR. BOKSINER: The other thing I was mentioning policy-based generation system actually does support also because that is also a policy-based radio.

MR HUNTER: Thank you.

MR DEVRIES: Hi. Pierre DeVries, Silicon Flatirons. In this panel and the previous panel we heard a lot about the big data problem, so collecting huge amounts of data that have to be flowed through a process that leads to assignments. I'm quite interested in hearing from you about closing the loop; in other words, validating that these cycles actually worked, and the assumptions that went from data to assignments were the right ones.

MR. MC DONALD: I'll take a shot. One of the reasons why DSO is so interested in Dr. Chapin's RadioMap program is from a tactical perspective forces are moving so quickly that we refer to that as up tempo. The up tempo is much accelerated today as in previous efforts or activities that, you know, the assumptions that went into identifying the frequency assignment and determining the frequency assignment for radios, you know, are no longer valid, you know, seconds and minutes after those assignment are made. So if DOD can have the ability to update in real-time databases to enable the generational policy for policy-based radios or the generation of spectrum access rule sets or frequency assignments, if we can update that background environmental database in real-time through capabilities like a RadioMap, that would help us reduce the amount of interference that, you know, is many times self-inflicted because we don't know where our systems are because of that accelerating up tempo.

MR. BOKSINER: If I may add one thing, when we talk about large amounts of data, the data actually is of two types. There’s the data that is equipment data and it requires the characteristics of equipment, antennas. And that data is fairly static within the system. So a lot of cases the collection of equipment data that has been, that needs to be enhanced, its transmitter, receiver and antennas and so on in order to make good modeling decisions with computer interference. That’s one set of data. And the second set of data is the instantaneous data of the position of the system and radio, state of the radio. For that data we do need, we would really like to have real-time situational awareness because that would make our process more accurate. That’s besides the fact that when people a lot of times are talking about having many many more fields during this process they’re not necessarily talking about the instantaneous data but the data that requires the equipment parameters which, you know, for all systems may need.

MR. CHAPIN: If I could speak to that as well, I think, Pierre, there’s a key undefined term in your question which was the right assignment. In the end I would submit the right assignment is determined if everybody was trying to use their wireless devices to get an acceptable level of service for whatever they’re expecting or whatever they need. So it’s as much an application level question as it is a question about whether there was a certain level of interference or not. So I think the answer to that question is, one would take feedback, real-time feedback about how all the systems are performing. And then you’ll want to determine for the ones underperforming is it actually caused by radio frequency interference, which is virtually radio mapping or other terms. I’m not going to put a plug out there for a commercial company. But there are several commercial companies that are doing basically drive testing for commercial cellular, drive testing which measures how much data rate do you get at the locations, is the system tuned well. They do all that with an app that you run on your iPhone or Android that feedback to the database. It’s a much cheaper way of gathering that information and it can be done by third parties as well. I’ll be glad to talk to you afterward if you want to see what’s going on in the commercial world right now.

MR. HUNTER: I think a big part of it as well is data integrity, data assurance with respect to sharing. I think that is absolutely going to complicate matters moving forward. We’ve got to get that right. I was encouraged by Jeff’s, you know, DSA policy generator. And how do you implement something of that nature moving forward knowing full well that systems will evolve over time. So it’s imperative that we have a policy in place that ensures that we don’t have inconsistencies in data moving forward. Any more questions?

MR. ROBERSON: As with many of the questions my question is a comment as much as a question. This discussion about the large amount of data that’s needed to be able to deal with the problems at hand is a curious descriptor, especially for an old guy like me. I remember when 640 kilobits was a tremendous amount of data. It isn’t viewed that way anymore. And in fact I now sit on the board of a company where in the meetings, our discussion is in terms of petabytes, which is the largest data system in the world. So they only sell in terms of multiples of petabytes. So we really need to be thinking when we talk about these imprecise terms like “large data” because what was large yesterday isn’t large today; it’s tiny. A single drive now has four terabytes of information on it. And our ability to handle it has also grown tremendously. So I guess with the upfront diatribe here, the question really is, how large is large? How much data do we really need for some of these systems to be able to have effectively all the information we’d ever want, especially in the context that you’ve just described where so much of the data is actually static? How much data totally do we need? How much dynamic data do we need to be able to ultimately drive the kinds of systems that we want with the down to the millisecond sorts of levels? I know that is a difficult question to answer off the top, but maybe I'll throw up a tough one to let you run with it. This is Dennis Roberson from the Illinois Institute of Technology.

MR. MC DONALD: You know, Dennis, I don't know if that's answerable, quite frankly. And that bogie I suspect will continue to increase over time as our systems become more cognitive. Our systems are really systems of system. So I guess the caution that I would throw out the term questioned during WSRD was, John, you characterized it really well, Don't let perfection stop the achievable. So, you know, will lack of data, lack of all the data elements that are in XML exchange data standard, that shouldn't stop us from moving the ball forward on a lot of these activities.

MR. BOKSINER: If I can take a crack at this, the issue I think isn't so much the volume of data, talking petabyte, terabyte, whatever. The issue is if the volume of data, it's the qualitative nature of data that's being requested. And the reason why there is an increase in the number of data fields being requested is increasing is because it allows you to do better modeling of interference and spectrum use. So if you have less data you can still do all those models; it's just that your answer will be more conservative than if you have more data. So not having data doesn't stop you from doing an analysis. There are various things within analysis, driving data defaults, making assumptions. So you can go through a hierarchy of how can you do the analysis with a little data. But the more data you have, the better the analysis will be. I'll give you a technical example like an antenna. You can have one field characterizing an antenna, antenna gain, or you can have an antenna pattern that tells you direction or you can very sophisticated modeling of antenna. So the more data you have the more accurate analysis you can do. That data may be hard to get in certain systems. It's not the quantity of it necessarily; it's the type.

MR. HUNTER: I don't want to oversimplify your question. I would say you need as much data to be successful as what you're doing. And I really think it's as simple as that. If you're going to share, there are different types of sharing mechanisms that are going to happen. So you're going to need whatever data is available to ensure that you've got, you can do an appropriate EMC analysis to make that come forward. You know, it's a complicated issue. I don't know that there's one right answer to it. But I think as you evolve through the process I think to determine what that level of data is required.

MR. CHAPIN: I just did a rough order of magnitude calculation with pen and paper. So if we want to know everything that's happening in a 10 kilohertz granularly across six meters of spectrum where there's 100 meter, square meter resolution cell and it takes ten bytes per entry to do it, that's 36 megabytes a second per square kilometer, which sounds like a big number, but doesn't add up very fast when you're talking about a petabyte of data. That's, you know, that's everything you might want to know for what that's worth.

MR. HUNTER: Any more questions out there? Again I'd like to thank our panelists. Thank you so much for being here. Thank you. (Applause.)

### 1.4.8 Institute for Telecommunication Sciences Spectrum Survey Activities

#### *1.4.8.1 Chriss Hammerschmidt: Initial Results from Three Spectrum Survey Campaigns*

MS. HAMMERSCHMIDT: Okay, all right. I'll start. So first I wanted to introduce myself because I know that I'm probably the newest member to this community. It seems like a lot of you know each other very well. I started at ITS two and a half years ago. My background is not spectrum at all. I'm a measurements person. My specialty was network analysis. And so I came over here pretty cold to the whole thing. But I was hired to replace Randy Hoffman, if you guys know who that is. Over the year and a half he force-fed us everything he knew about spectrum measurements and how to data process and all that kind of stuff. And so Heather and I, who are now working together, Heather Ottke, we are just coming up to speed. You know, we're starting to ask questions about, Is this the correct way to measure this? What can we do to make these measurements better?

So I'm going to give you the current state of what we've done. I'm going to show you results, just a few brief results from three spectrum surveys in this report. First of all I'd like to thank Eric Nelson, who was very supportive through, through all these measurements. He's our Division Chief at ITS. Let's see. So here are pictures of the three measurement locations. The first one is Table Mountain, which is located just north of the Boulder area. We do a lot of research there. It's a quiet zone in terms of radio emissions. The first one we did was in the Denver metro area, which is the center slide. And that was our first campaign into spectrum surveys actually testing our new system and collecting data and processing. So we spent four weeks. We spent four weeks. We took four weeks' worth of data there. At Table Mountain and San Diego we only took two weeks' worth of data. And I can explain why if you have a question about that. And then the last picture shows us at San Diego. In the background you'll see San Diego Harbor, and off to your left would be North Island.

So first I want to talk a little bit about the motivation for these measurements. Then I'll talk about the equipment. I'll talk about the four different algorithms we used. I'll show you some results. I want to give you some preliminary understanding of our results, and then I'll talk about a current application that we use these measurements for, and then I'll just make some general conclusions. So our first motivation was the presidential memorandum to find 500 megahertz of spectrum for wireless broadband. We thought this would be great way for us to help the community. We noted the FCC databases show assignments, but they don't really show spectrum activity. So we thought we would take our truck out and we would do some spectrum surveys so the community has kind of an idea of what's happening out there. I know this has been a hot topic for the last couple of years as I attended ISART. People want spectrum surveys.

So I'll kind of show you what we've done, and maybe we can collaborate to make these measurements a little better. So first of all we run two systems simultaneously. The first system we measure LMR frequencies. We use an antenna at the output. It's a discone antenna. We see that through the first preselector. That preselector's only purpose is to make noise calibration measurements to calibrate our system gain and our system noise figure. The other preselector is the LMR preselector that was specially designed to measure only LMR frequencies. The second system which is between a discone antenna and either an Omni antenna or a dish antenna and a noise diode. The Omni antenna, or the discone antenna measures frequencies below a gigahertz. The Omni antenna measures frequencies above a gigahertz. The dish antenna we use to measure point to point emissions.

The preselectors are set up pretty much the same. The first preselector is mounted on the antenna mast, as I will show you here. So on the left is a picture of the truck at the Denver location. The antennas are up there and the preselectors are below them. Then we feed cables into the truck, and the rest of our equipment is inside the truck, which you see in the picture on the right. The LMR system sits in the right rack. And what we call our high frequency system sits in the next two racks. Or depending on the configuration we can change it around.

We used four different measurement algorithms. Spectrum surveys are very complex measurements to make, especially when you're measuring from 108 megahertz to 10 gigahertz or 10 and a half gigahertz like what we're doing. You want to make sure that you're using appropriate algorithms so that you get valid data. So our first algorithm is our swept spectrum algorithm. It's used for most of the measured bands. And as I go through the bands I'll try to remember to tell you which algorithm we're using.

The second algorithm is a step spectrum algorithm. We usually use that for radar bands where we have to change the sensitivity of the system so that we don't overload the spectrum analyzer. So we set the sweep time to the rotation or sweep rate of the radar, and then we step from frequency to frequency.

The third algorithm is kind of a new algorithm we're experimenting with a little bit. And we use this mostly in our LMR bands below 500 megahertz where we want to minimize the impulsive noise that we see. So we use the time domain mode of our spectrum analyzer. Our capture time is approximately 200 milliseconds per sweep. And we take a median of five traces to try and minimize that impulsive noise. So if there's impulsive noise in the measurement, the median of five will throw out some of that impulsive noise as it takes the data.

And then the last algorithm is our azimuthal scanning algorithm. We use a high gain antenna. And we scan in the azimuthal direction or angle. Data is captured only in point to point microwave bands.

So I just included this. This was from our Denver spectrum survey. And I just wanted to make sure that we measured at all times around the clock. This kind of just tells you what times the measurements were taken. And I thought that was kind of important so that we don't bias our data, or minimize the biasing of our data. We've also done some calibration statistics on our data so we know the average gain and the standard deviation and the average noise figure and the standard deviation for that average noise figure. This is just one of those bands.

Okay, so the plots that you will be seeing are very complex. They are not traditional plots, so I want to go through each of them and explain them to you a little bit. Then we'll put them all together as we show you the results. So the first you'll be seeing is the standard peak mean, median, min, and max system noise plots. Mean system noise is shown by the magenta line on here. At the top of the plot we'll show the allocations for the bands. Then you'll also notice the numbers at the top of the graph. Those are the band edges for each of these allocations.

The second plot is your traditional time versus frequency plot spectrogram, waterfall, however you want to refer to it. Since we collected so much data, four weeks' worth of data, it's a lot of data to display at once. It takes a long time to process this data. So we took the maximum trace from each event and we plotted that maximum trace, and therefore what we come out with is just a median time. This is not a running, or this is not all of the data that we took. Eventually what I'd like to do is if I could develop a kind of player piano kind of thing where you could scroll through each of the traces, just load a certain amount of data at a time, and that way you could see the actual data.

And the final plot is going to need some explanation. I'm going to take the next few slides to kind of tell you what we're doing here. These are a percent probability plots. And it gives you the percent of time or the probability that the signal exceeded the field strength level on the left-hand side of the graph. And the reason we use field strength is because we want to know what the field level was at the input to the antenna. We think that systems are going to be different. And if we can make it all the same reference point we think that would be more valuable to the community.

Let me talk about these percent probability plots a little bit. These are power versus frequency histograms. And what we do is we determine the minimum value for all the datasets for power. We determine the maximum value for all datasets for power. And then we use these bins. And we just say, Okay, this, during this, or this power interval we saw this ten times; we saw this power level ten times. And we do that for each frequency in our event table. This is a plot of real data. So this is a PDF. And it's the number of power hits per the total hits, so it gives you the probability that that signal occurred at that power level, or that bin of power level, I should say. Then we calculate the CDF. And this tells us the power that we pick is less than the power on the X axis, so what probability that power level will occur. Then we do a CCDF, which tells us the power level, the probability of the power level we choose, how often it exceeds that power level.

And so what I've done here is I've picked out seven data points, which is what we use in those power probability distributions. And what we do—this is a plot of those. And then we do that at each frequency so each of those lines that you see are a different probability, so that gives you some idea how often that signal occurred. Okay. We can also use these for signal classifications.

This is a plot showing a CW signal, which is the green signal. If you pick those percent probabilities, you'll see that there is no difference in those levels. So in a plot of percent power probability, you would see all those lines converge at the top of the distribution. The system noise is shown by the blue curve. And you see that you get a certain spread in your data as you pick those probability levels, so it gives us some idea of what the signal is when we look at that power probability distribution.

The other thing we look at or the other thing we've looked at is intermittent CW, how would that look. We see that the lines, the high probability values are pretty much evenly spaced. But as we get to the lower probability values, you get a wider spacing in your data that tells you that you've either got impulsive noise or your signal was intermittent.

So as we go through these results I put this on an automatic timer so we're going to go through this pretty rapidly. I'm going to show you the Denver metro area results first. Then I'm going to show you the Table Mountain results. Then I'm going to show you the San Diego results.

This particular band was measured using our FFT algorithm. And I guess just save your questions for the end if you have any. This is a TV band. Since we're talking about TV white spaces next I thought I'd let you see the difference in TV white space. We also had some results that we didn't quite understand. Instead of you posing a question of me, I'm going to ask one of you, and I'm going to ask you to answer it for me. So you see between 584 and 590 megahertz we have what looks like an NTS signal and we also have an ATF signal, or ATFC signal, I'm sorry. So my question to you is, since we were sitting in San Diego, are we looking at a high definition TV signal in San Diego and an analog signal in Mexico? So hopefully somebody can answer that for me. Okay.

The next band is our ISM band. We know there's a lot of activity in this band. I'll show you what our measurements look like. I find San Diego a very interesting place to measure. Okay. So these results I've chosen this band, and then I followed it up with a band adjacent to it so that you can kind of see how it transitions, how all of these things transition in the spectrum. And the next band. Now, you guys have a lot more experience with spectrum than I do. I'm not familiar with these signals. If you could provide me input and, you know, just help me learn, I would really appreciate it. Okay.

This is a band just before a radar band. And when we get to the radar band those plots are a little bit different. I'll explain those when we get to them. I picked these bands because they have some interesting characteristics. Okay, so again the San Diego measurements were taken over a two-week period. So you see this signal between 2625 and say 2685 that appears only for a short amount of time while we were measuring. Again, I'll say a caveat, we used a scheduler to schedule these measurements. So we may be missing some data while we're measuring other bands. I want you to be fully aware of that. And that's where Michael filled in all the gaps with his radar band measurements. He did a continuous measurement during these bands. We do try and measure the more dynamic bands more often. So some of the radar bands here in Colorado—we didn't measure the maritime radar bands very often because we didn't expect to see them very much here. But in San Diego we measured them more often. And we can provide access to that scheduler, you know, the event tables, all that information if you would like that information.

Okay, so the next one is a radar band. And the way we plot our radar bands, because we don't measure them very often, is we plot the standard—max, mean, min, and peak system noise since we measure with a peak detector. And the bottom graph is just a composite of all the measurements that we take or that we've taken. San Diego is very active as you'll see in some of the other radar bands that we measured. So this was a swept measurement that we did. I'm trying to compare swept measurements across a radar band with radar measurements in a radar band. So the frequencies don't line up exactly. But this data will be available after the conference so if you want to take a closer look, you can. These are swept measurements across part of a radar band. Okay, here's the radar measurements across 5250 to 5925. Again, San Diego, there's a lot of activity there. Okay. This is also a radar measurement across these radar bands. Okay.

And the last band I want to show you is with our azimuthal scanning machine. These results proved very interesting to me so I thought I would share them with you. On the left-hand side you'll see azimuthal scanning measurements from 4000 to 5000 megahertz. You'll notice between 4200 and 4400, which is a radar altimeter band, that we have all these little points. And we thought, Hmm, are those really radar altimeters? Can we really pick those our using an azimuthal scanning routine? And so what we did—oops. I need to go back—is we took a Google Earth and we plotted where out data measurement site was, and we plotted the surrounding airports. And you'll see that Rocky Mountain Metropolitan Airport is about 9 degrees counterclockwise from zero, which is about what we're seeing in our plot here. And then DIA is between—I don't know, you know, how close they come to the ground, but between 70 and 110 is kind of where DIA where planes start coming in. And you can see that is kind of spelled out in the, if you look at the azimuthal angle. So we think that these are actual radar altimeter signals, signatures that we picked up with our azimuthal scanning routine purely by accident. And then on the left hand you'll see some points which are probably real point to point microwave links that we're seeing.

Okay. So an application that we've developed is we can take our measured data, which is shown here for an aeronautical mobile band, and I can put our received latitude and longitude on this plot. I can determine a search radius, I can search the FCC and GMF databases, and I can come out with assigned frequencies. This was for possible transmitters in the immediate vicinity. What we're interested in is the high power emitters; how close are they to our location, and can we possibly use that data to look at some propagation models. That's one application.

So I picked out the entity. I picked out an assigned frequency. I like to plot the power if it's available. I determine a state if we're in Colorado or California. We can look at the transmission type. We can look at the license data. I don't know if that's, I don't know if it's valuable or not. Then I can plot which database table it came from. Now, I developed this all on my own. And I really didn't know what I was doing so this can further be refined. But there is a possibility of using our measurements to maybe cross-correlate with some of the data in the databases.

So our algorithms and system are still being tested and refined. We kind of vetted it out in the community. You guys are the first to see this kind of data with our new system so congratulations. We have a technique report that is in review right now which describes all of the above techniques and how all of these methods were kind of developed, the history behind it.

And then our report for the Denver metro service or survey. It's awaiting review, but I might make some modifications to it. In that report there was also, we also did some drive tests around Arvada and then around the entire city of the Denver metro area in the 406 to 420 band. Those results are also included in there. It's been so long since I've written that I don't remember exactly what my point was. I mean, we wanted to compare, but I don't exactly remember what I said so you'll have to wait till that comes out. The Table Mountain report has been started. The data has been processed. But I want to go through some of the bands in a little more detail. I spent the last two weeks just hitting this data really hard and I just haven't had time to digest it to make sure I don't have inconsistency. And we are planning a possible survey in the Chicago area with IIT with Ken Zunig up there. And that might happen in September 2012. So with that I guess I will turn this over to Mike. (Applause.)

#### *1.4.8.2 Mike Cotton: Spectrum Occupancy Measurements of the 3500-3650 MHz Maritime Radar Band Near San Diego, CA*

MR. COTTON: Thanks, Chriss. Hi everybody. Good to see all your familiar faces again. Like Eric said, you know, we took a lot of last year's ISART where we took a look at radar spectrum management and usage. And there were two panels in particular that drew me towards this work here. One was the broadband business panel. They talked about how attractive this band is because there's an adjacent band at 3650 to 3700 that is already available on a soft license regime for usage and so this 100 megahertz is an attractive extension to that band, especially since manufacturers are developing equipment and things like that. We also had a radar spectrum management panel, and they went over kind of the difficulties that there are in sharing radar bands so there was a good debate there in last year's conference, and we felt like this was a good place to direct some of our measurement efforts.

So the outline of this paper, I'm going to go over the S band maritime radar band to provide a little context information. I'll go over measurement strategy, give kind of a qualitative view of the observed signals and patterns, and then be a little bit more quantitative of those results, be more mathematical about it and give some statistics. Before I go on further I also want to acknowledge some of my colleagues. Geoff Sanders is a colleague of ours. He has provided a lot of coding that I leaned on a lot to develop this system. Frank Sanders, I'm sure all you guys know Frank is the radar expert at our institute so I got a lot of information out of him. And I also leaned on Roger Dalke helped me a lot with the math.

So in the S band radar, as Joe Hersey was talking about, it goes from 2700 to 3650. The lower S band is from 2700 to 2900. NEXRAD is in there. There's a number of airport surveillance radars in there. In the upper S band, it's 2900 to 3650. And we are focusing on the higher end of that, in which SPN-43 radars operate. Now, the SPN-43 radars are a critical part of the U.S. Navy carrier air traffic control systems. They marshal inbound aircraft before negotiating their final landing. It's an unclassified system in the GMF.

These are some of the specifications on that radar that I pulled out of the military standardization handbook. Its operational frequencies are from 3500 to 3650. Pulse width is on the order of a microsecond. Port pulse interval is about a millisecond, and there's antenna rotation rate. The way it appeared is about 40 seconds. So I think John gave a presentation last year where he was kind of trying to fit in some broadband bits in between a rotating radar. And none of that, I don't take into account any of that type of fine detail in the white space, here, we're going to, so any of the occupancy statistics that I give later, if we wanted to apply those types of white space we'd have to multiply it by that duty cycle. We'll talk about that later.

At a high level of measurement our approach was to measure a high usage maritime radar environment. So I piggy- backed Chriss' and Heather's effort and went out to San Diego where there's the San Diego Naval Base. We also, there was another advantage to that site, is we had measured that from, spectrum surveys from that site from like 20 years ago so there were a lot of logistics worked out, though Geoff Sanders would probably say he had to just rework them all again. We were there for about three weeks, maybe even four. I was there for two weeks. And I basically wanted two weeks in order to capture, you know, what we would expect as a weekly cycle of naval exercises.

So in terms of channelization of the 150 megahertz that we measured, we decided just to divide it up in to 150 one-megahertz channels. That's one over the pulse width of the radar. I think it's a logical increment, although broadband systems are usually more bandwidth than that. You know, if you think about maybe a quality of service regime or these sort of broadband systems where you kind of pay for bandwidth, maybe one megahertz is a reasonable increment. And it also gives us good resolution in our statistical evaluation.

The next slide will go into system design and measurement procedure. This is basically a stripped-down version of what Chriss presented. So going from left to right we use an omnidirectional antenna with about a 65 degree beam width and about a two dBi nominal gain at the horizon. And that antenna is connected to the front end into an RF switch that switches between the antenna and the noise diode. The noise diode had a 13.7 dB excess noise ratio, and that's used for calibration purposes. The switch goes into a band-pass filter that protects from out-of-band emissions and then we go into an LNA and then finally into a spectrum analyzer. The spectrum analyzer gives us, you know, peak detection functionality and sample detection functionality, frequency sweeps, and time domain measurements. The LNA parameters was a 33 dB gain, which overdrove the relatively high noise figure that's this spectrum analyzer. And there's also a maximum output power of 30 dBm, which is high enough to ensure that the spectrum analyzer was the thing that was overdriven if a strong signal came in here. And because the computer controls both the spectrum analyzer and the front end, you can kind of monitor the overdrive of that system by monitoring the spectrum analyzer.

I'll take you through the measurement procedure real quick. The top plot, in the top plot will be, we performed that Y-factor, that well established Y-factor calculation to complete the noise figure and gain. That's advantageous to do. I did it on an hourly basis to just make sure the system integrity was good, and also to calculate the system, the mean system noise as KTB times the noise figure times the gain. And I spent a lot of time kind of nailing down these peak statistics of the system noise because I wanted to pay close attention to the threshold for occupancy.

So on the bottom plot this is a frequency, this is a frequency plot. And there's this gray band, horizontal band across there. That gray band is bounded on the bottom by the mean system noise, and on the top by the peak of that system noise. You know, the peak is tricky because it depends, the peak is dependent on the number of uncorrelated samples that go into this peak detector. And the number of uncorrelated samples is proportional to the bandwidth that you're using and also the dwell time. So the longer you dwell, the more uncorrelated samples there are, the more the peak goes high. So in this particular measurement, this frequency domain measurement, we're dwelling in each channel for six seconds because we want to capture the rotating radar that comes around every four seconds. So in a six second dwell time with a one megahertz bandwidth, the peak to average of that system noise is about 12 dB.

You'll see a little bit later we're going to go into some time domain measurement and time domain measurements have dwell times on the order of milliseconds and even microseconds And the peak to average for those dwell times are down to about five dBs, so that horizontal band there is going to shrink. You just have to pay attention when you're, when you're really taking a look at these measurements as to what is it, where is the threshold for these occupancies.

Okay. So there's 150 channels, 100 megahertz channels, and we measure for six seconds for each channel. So every time we frequency sweep it takes like 15 minutes. So every 15 minutes we get a frequency sweep, and then at the top we plot those versus elapsed, elapsed time a lot like Chriss showed. So this kind of reflects those signals there in blue. Then we determined the frequencies. Those, both of those signals that were measured right there, you know, take up a number of different channels. We find the channel where the maximum power is, and then we move towards time domain measurements.

In these time domain measurements we measure in, for about 25 seconds to capture the beam scan and then for 10 milliseconds to capture pulse interval, and then we sample detect down at the microsecond level to capture the pulse widths. We have, you know, a lot of signal characterization data here if we need it.

So moving forward for the rest of the presentation we're not going to talk about time domain measurements anymore because really the spectrum occupancy parameters are really based on the frequency sweep data. We do have that if we need it. And then also all of those measurements, this is the measurement GUI. All the measurements are combined into this measurement GUI. You know, it's all automated; it runs 24 hours. We come back after some time and we can monitor all the signals being measured with time.

So now I'm going to move into some of the observations that we made. There were four primary observations of signals and patterns that I want to demonstrate. This is the qualitative part of the presentation. I'll just go into it slide by slide. So the top plot, I want to familiarize you with that real quick. The font's really small; I apologize for that. This is that contour plot. The frequencies are on the Y axes that go from three five to three six five. This is the full two weeks of measurements that we took. So in the bottom plot the first observation that we made was there were these two signals operating at 3530 and 3542. They were on the whole time. In the contour plot you can see them going across horizontally the whole way. We came back and looked into the GMF and we found out that there's a corporation called SelectTech I think that has a license to operate WiMAX to test for export markets. And so obviously they were testing a lot during these two weeks, and those were on for the entire time.

We measured some SPN 43s at 3520 and 3530. Those things were WiMAX signals, so I'm curious if there wasn't some interference going on there, if people are aware of what was going on on both sides. So also in the middle of the two-week time span we measured some high power signals. Last year we talked a lot about how radars operate in a nonlinear regime a lot of times which causes spectral spreading; very common. The regime works closely with Charles Bayless who is trying to work these problems out, these amplifier problems out with radar.

But I think this is a good example of that spectral spreading that happens. You can see in the contour plot that, really, when the spectral spreading occurred it filled in the whole 150 megahertz; it raised that noise floor for the whole 150 megahertz. It also overdrove the spectrum analyzer. You can see that red line. And the final observation is later on we saw multiple SPN 43s as shown in the lower left hand frequency plot.

And what happened just a little bit after that is we also noticed some adjacent bands of power coming out into this band. And the adjacent band power really is another thing that caused emissions to cover this full 150 megahertz. It didn't, this one right here in particular, that kind of hotspot on the low end of the frequency of the band, but there are examples kind of in here and throughout where the full band was filled in and there was never any hotspot. And this was due to adjacent band emissions. That was a real … like, for me, I actually lost a lot of sleep out in the field due to that because this system was developed here in Boulder measuring a very static radar environment. We measured the 27 to 2900 megahertz radar band here. We went out to the field. Chriss was there. She'd been all set up. I turned the thing on. And you saw how closely that had my system noise characterized. I turned the thing on and it's 15 dB in before my noise figures, so my threshold is just exceeded from the, from the very get-go. And so I'm going, What the heck is going on here? Do I have amplifier compression or what is going on? So a lot of the, on the left-hand side of the contour plot you can see vertical gray lines. Those are measurement downtimes because I was working on characterizing all the comments and basically redoing my system. So we finally got to the end. We confirmed for ourselves that everything is linear and ready to go. So that's the excuse for all the downtime. Okay.

So now I want to talk a little bit on a more quantitative level. I want to talk first about channel occupancy to quantity—this is where—I changed these slides late last night and got the wrong slide in here. So my fumble fingers. I apologize. Channel occupancy is the fraction of time that a channel is occupied. So in this horizontal—oops. There we go. If you think about one frequency, one channel, it's the fraction of time a channel sits on over the—versus time. There's also band occupancy. If you think about it in this plot, band occupancy is at a single time across the whole band. It's the fraction of channels that are occupied divided by the number of channels in the band.

Okay. So let's set up this problem. We'll talk about channel occupancy first. I'm taking a lot of the nomenclature and the basic setup for this from a 1977 paper by Spaulding and Hagen that Chriss exposed me to prior to the meeting. So channel occupancy is a two-state random process that's dependent on levels. The state is occupied if the signal strength is above the level, and the state is unoccupied if the state is below the level. Now, the state is a random process so it's unpredictable at any time *t*.

Okay, so but that doesn't mean that you can't explain things with probability here. That's what was set up here. We set up this random process *X(t)*, which is a state process. And we also defined these random variables *U* and *V* where *U* is the length of time a signal continuously exceeds the threshold, and *V* is the length of time between transmissions. So you can kind of see *U* and *V* down there in the doing. These random variables can be approximated with observations of the channel. So we observe the channel, and we can give distributions of *U* and V, and we can give expected values of *U* and *V* based on those, based on those observations. And from those expected values we can compute mean occupancy data, which is the expected value of *U* over the expected value of—*U* over the expected value of *V*.

Let me just kind of get into some of the distributions here real quick. These are complementary cumulative distribution functions for *U* on the left and *V* on the right. So the X axes is the abscissa in hours, and the Y axis is the probability that the variable *U* and *V* maybe inside the abscissa. So if you look at maybe one—the units of the abscissa are in hours. So if you look at one hour here—oh, and by the way, the different curves on here are the different thresholds. So the lowest threshold is basically the threshold of the measurement system, and that's in black.

And so the highest—and then I increment the threshold by three dB as we go up. Left hand font for the one hour abscissa, the probability that *U* exceeds one hour is 40 percent. And the probability that *U*, which is the time that the channel is continuously occupied, exceeds one hour at the higher threshold is 10 percent. It's kind of really convoluted. But basically what that's saying is: at lower thresholds, there's longer times that the channel is occupied—which is expected. Also in *V*, for *V*, which is the time between these transmissions, it's the opposite. So for the lower thresholds, the time between these transmissions is shorter.

Okay, so in this table on the right we have—okay, this is where I changed. It's not in the table anymore; it's now in these legends that nobody can read. So the expected values of the *U* in this left hand font up here, which I'll read for you, the expected values of the *U* vary from half an hour to an hour and a half. So, and that depends on threshold. So when the channel is occupied it's occupied for anywhere from a half hour to an hour and a half in a mean sense. The *V*, the expected values of *V* for the different thresholds are anywhere from two and a half hours to seven and a half hours. So when a channel is vacant in a mean sense it's vacant for anywhere from two and a half hours to seven and a half hours, depending on what the threshold is. These thresholds are important because they're basically talking about noise figures of your receivers that you're talking about sharing, right? So it's basically what, it's what these receivers see. So it's an important parameter about how you're coupling all this together. Your noise figure, your receiver sees different things depending on its noise figure.

Okay, so then I want to talk about band occupancy. Band occupancy is looking at it the other way. At time *t* we measure all the channels, and we compute the band occupancy. It's set up in a very similar way except for in the frequency domain, it's in the time domain. We have a state variable *Y*. Our random variable here is *N*, which is the number of channels occupied. We estimate our distribution and our expected values for random variable and with observations of the channel, and then we give a mean band occupancy statistic, which is the expected value of *N* over N.

So this is kind of an illustration of what we're talking about here. You know, we're basically setting up a Bernoulli trial where we set up a threshold. And if it's above the threshold it's one and if it's below the threshold it's zero. So on the bottom, what was once a color map of blues and reds and yellows talking about signal strength is now a one or zero. So this is the lowest threshold. And up top in the top plot I'm basically summing up at each measurement the band occupancy, and those are the blue data points. So if it's full it's one, if it's empty it's zero. And then the red curve is an hourly mean of those.

So I'm going to take you through five different plots of the five different thresholds that I talked about. This is the lowest threshold. As the threshold goes up you would expect occupancy to go down. As you go up the threshold, a lower number of the signals cross that threshold. So that's kind of the effect that we're looking at. We'll go back down and up.

Okay. Now we go to, basically this is the CCDF of all the blue data points. There's important information here. There's some very interesting information here actually. If you look on the left hand side of the graph here that's the zero abscissa. The abscissa here is band occupancy now. So on the black curve it intersects the left vertical axis at about .55. What that says is the probability that the band occupancy exceeds zero is 55 percent. Well, if it exceeds, if it exceeds the zero 55 percent of the time then it's zero 45 percent of the time. Basically what that tells us is the probability that the band is empty is 45 percent, or in this column right here in this table it's anywhere between 45 percent and 66 percent. So the band is empty 45 to 66 percent of the time.

On the right side—I know I'm throwing a lot at you guys. On the right side we get the same kind of number, but on this side we can pull out the probability that the band is fully occupied, it's full. So the band is full, depending on threshold, anywhere from 1 to 13 percent of the time. So these are kind of some useful statistics that we can kind of bring to the discussion. When you take the mean of all those band occupancy measurements you get this mean band occupancy number. These numbers vary from 6 to 30 percent. And as you might expect, this converges with the data because we're basically integrating this way or that way from the dataset, so there's good agreement there.

Okay, so in summary there is, you know, white space available in these measurements. The mean band occupancy is 6 to 30 percent. The probability that the band was empty was 45 to 66 percent. The probability that the band was full is from 1 to 13. The mean time channel, the mean time that the channel was continuously occupied varies from a half hour to an hour and a half. And the mean time that the channel was continuously vacant was somewhere between two and a half to seven and a half hours. And that's all dependent on threshold.

So suggestions for future work, I'd say what makes sense is to measure at some other sites, possibly some sites with lower usage, you know. The fast track report put some exclusions on along the coast, and basically the whole state of Florida was excluded. So it would be interesting to go down there and measure the occupancy down in Miami, things like that. In a technical sense, I should have integrated the amplifier into the antenna, brought it up closer. My noise floor wasn't as good, so that could be improved. And, you know, moving forward we've heard a lot about monitoring, spectrum monitoring, things like that. We can think about integrating the whole system as a single remote unit, and deploying monitoring units and accumulating things in dashboards and things, whatever. I'm not here to make those decisions, but this is just some ideas. That's it. So if anybody has any questions. (Applause.)

#### *1.4.8.3 Spectrum Survey Q&A*

MR. JOHNK: I guess I'll direct this both to Mike and Chriss and let you respond accordingly. By the way, I'm Bob Johnk from ITS in Boulder. Very interesting talk, both of you. It's a really fascinating subject. My question to you folks is basically are you pursuing a particular signal type when you do these studies? I mean, I can visualize certain signal profiles that might influence your channel occupancy results, and also I think—how dependent are these measurements on your instrument settings? Sort of my general question.

MR. COTTON: My measurement system was geared totally toward SPN-43. In fact, I think I could generalize it to radars in general because I basically I set my dwell times and my basic peak measurements, they're based on the parameters, the operational parameters of the SPN-43. So mine is very specific. I think Chriss obviously does the signal that is out there.

MS. HAMMERSCHMIDT: Yes. I think we've optimized our system to the point where now Heather and I can start looking at it further. And it is very dependent on the signal that we're measuring. We learned a lot about our detector type, all the statistics that go into those. So we need to look very carefully at each signal type and measure it accurately,

MR. JOHNK: What would make a very interesting problem too is the issue of intentional versus non-intentional radiation, how that might influence your statistics. It sounds like a very rich field of study. Thank you.

MS. HAMMERSCHMIDT: That's kind of why we pull up the GMF and FCC database because we do want to try to avoid measuring the unintentional radiators, although that could provide some information as well. And I would just say that you can take any part of our system and you can customize it just as Mike did. So as we look at these band by band occupancies I think we can take components of our system and make a single system to go and measure that specific band, you know, if you're looking for something to monitor.

MR. BUDDHIKOT: Miliand Buddhikot. I have a couple of clarification question. When you were doing the multiple band measurements did you know the polarization of the signals that you were looking at in the different bands? Because I noticed that using are of a certain polarization as in filter. If you look at the TV bands in the U.S., I think most of the DVD channels tend to be horizontal filters. I think there's a discrepancy in terms of how you're measuring. I just wanted to get a clarification, should you be using different polarization simultaneously with collecting data? Or am I getting something wrong here?

MS. HAMMERSCHMIDT: No, absolutely. But Heather and I, we came into a weird situation. Randy was leaving; we were trying to learn the system. And now we can go back and we can now start looking at different polarizations. We took vertical polarization as just a first step toward our understanding of what's in these bands and that type of thing. But, absolutely, you know that some of these signals either depolarize in the environment or they're very directional, like one polarization, a circular polarization. Those are things that we do need to pursue further. Another thing we don't do right now is measure satellite emissions, which would be an interesting topic. So there were things that we don't do that we want to do and we just, you know, we've only had a year to kind of explore them for ourselves.

MR. BUDDHIKOT: Now that you have the setup is it just a question of getting the right polarization simultaneously collecting? Or is there anything more that you would have to do to get more detail? I think, first of all let me thank you for a brilliant piece of work and sharing the results.

MS. HAMMERSCHMIDT: Sure, yes. You know, I do think we have to look further into each of these bands going back to Bob Johnk's questions. Knowing what type of signal and trying to measure it is very important. And in the report that's coming out we talk about electrospace and how these systems are impacted by the electrospace that they travel through. So yes, we will be thinking about it in future studies.

MR. DEETON: I just wanted to thank you for your results and everything. That's really really awesome what you did there. I'm Juan Deeton from Iowa National Lab. What I was wondering is, you have all this great data—and I don't know if you're familiar with the work from Wellons and the Mahon, but they did a while back they did 200 kilohertz measurements in a bunch of different bands and they were actually able to, fed a distribution to those models called the modified beta distribution. I wanted to know if you guys were planning on doing anything like that for this work. I think in terms of an academic research perspective and developing further maybe some analytic, close form analytical solutions for some of these problems. I don't know if you guys were planning on doing any of that type of work.

MR. COTTON: I am familiar with that work. I really have no plans. Actually I would like to talk to you a little bit later maybe about the model that you're talking about, that you're referring to.

MR. MODY: Apurva Mody, BAE Systems and White Space Alliance. So I'm actually surprised because your spectral occupancy is so much more than PRI of the radar. I'm just wondering because if I just look at the PRI information and the frequency and the fact that it is rotating and say, for example, you were on shore, you shouldn't be seeing so much spectral occupancy. So I'm really surprised that you're getting that.

MR. COTTON: So those, those numbers aren't in these numbers. So basically the duty cycle that's associated with the beam scanning and the duty cycle that's associated with the pulse intervals, those are—if I detect it by waiting on it once, it's all inside that number, right? So if the duty cycle of the beam scan is 50 percent and the pulse interval is even 90 percent, then these numbers would go down significantly.

MR. BOKSINER: Jeff Boksiner from CERDEC. This is great work. So I have a question. Have you had a chance to look at those threshold volumes, and correlate them to what might be required to prevent or to minimize interference to potential systems that could be deployed in the band?

MR. COTTON: No. But I wanted to lay this out so—that's exactly where we want to go, right? I mean, we want to basically have this tool where we have these thresholds that we can say, This person can operate here. But no, we have not gone down that path to do those evaluations. We just took these measurements in June. And this is what I've got. But I do want to go down and, you know, I work, I first worked in Eric's group, which is the measurements group. I'm in the theory group. We do want to, we do spend a lot of time in the theory group working on interference issues. And, you know, my colleague, Bob Achatz, is sponsored by Joe Hersey to work a number of the radar interference issues. You know, I haven't gotten a chance to collaborate with Bob. He's my project leader. We haven't got—we do want to plan and push these models forward towards analysis.

THE FLOOR: I am Brandt from Idaho National Lab. Mike and Chriss, great work on this. I'm sure that this is a kind of a precursor to what needs to be done in the 1780 megahertz in terms of emissions across. Two questions. One is, I thought you said and the picture shows, the graph shows that at some point of the time the whole band is occupied. I thought you mentioned it was because of a distant channel transmission. How far was the distant channel? I don't know if we'd seen that, there was an index that gives some information with that. The second is the results of WiMAX transmissions, which is already going on. So when the channel is fully occupied by the emission do you know what happened to the WiMAX? Is it still there or is it going on and off?

MR. COTTON: Repeat that last part again. What happens to the WiMAX when what?

THE FLOOR: The WiMAX network is also operating, right? So when have different channels in terms of coming in was the WiMAX method going up and down? Is it going down on a daily or weekly basis? Do you know any information?

MR. COTTON: I don't have any information. From the plots the WiMAX signal was just on all the time. I mean, it was swapped every once in a while. It's hard to say if it turned on and off, I guess. But when the thing's turned off it was immediately back on. So I guess I can't say for sure, but I think that they're on all the time. And the other question was regarding adjacent band signals. I don't really have any information about those systems at all.

MR. NELSON: Just one more question.

MR. WEISER: My name is Chriss Weiser with TMobile. Just kind of curious. I really appreciate your presentation. I was curious if you were going to make it available on line and if you were going to make I guess the underlying data available in addition to the PowerPoint. I know there are a lot of folks, those locations, and would love to have it to probably see the actual data points in the formats you presented it in.

MS. HAMMERSCHMIDT: The reports will be available on line at the ITS website. We don't say anything about the raw data yet because there's a lot that goes into processing the data. For instance, in some of the FFT bands we do try to take out a little bit more impulsive noise, although the data with impulsive noise would probably be valuable to you guys. We're kind of debating that in-house. And there's pros and cons to letting people have the raw data. As soon as the processed data is available in reports that will be on line. I really want to get it out to the community as soon as possible. But the review process, as you know, it's a government process. So we'll see how it goes.

MR. NELSON: Chriss, Mike, thanks very much. (Applause.)

MR. NELSON: As I mentioned in my opening remarks, we'll certainly be hearing more about the PCAST report tomorrow. Knowing that the report was going to be coming out about the time of this conference, in knowing that there was an emphasis on using some of the lessons learned of TV white space as, you know, kind of a common point of reference to explore spectrum sharing approaches, we thought it would be useful to have a number of people come and give us a background on TV white space and, you know, where it's coming from and where it stands now. We're all in the morning tomorrow aware of that context. With that I'd like to introduce Michael Calabrese, New America Foundation. And joining him will also be William Webb from Neul and Peter Stanforth from Spectrum Group.

### 1.4.9 TV White Space Tutorial

#### *1.4.9.1Michael Calabrese: Overview of TV White Space Rules*

MR. CALABRESE: Good afternoon. I think I'll just jump right into it since we're a few minutes behind. I'm Michael Calabrese with the New America Foundation, a policy institute in DC. I've been very involved in the TV white space issue from the beginning. So what I'll do is take, try to do, kind of a general overview and then turn it over to Peter and William for their perspectives.

So I don't think too many people need to know this basic a level, but essentially these are, the so-called TV white spaces are the unassigned TV channels that are unoccupied in a given area. So it varies, the channels vary widely by market, right across the 210 TV markets. There's few as we will see, a bit more, there's few in the largest metros and many more in rural areas. And the access that was open was for both fixed wireless and personal portable devices.

Also an important thing is that the signals cover far larger areas because of the propagation below 700 megahertz, and that's particularly important for rural broadband so you have WISPs, for example clamoring for white space access and right now the first in line to buy the base stations and CEPs that are coming to market by the end of this year because there's a big difference in CAP EX. Lower CAP EX, better coverage, a three to four, at least a three to four times difference when you're operating say at 700 megahertz, well, in the 600 megahertz band compared to 2.4, 2.5. The TV white space availability, as I said, it really varies. So it's great, you know.

The very first certified white space deployment, in other words, one that wasn't on an experimental license exactly was in January in Wilmington, North Carolina. They have 25 total white space channels, 150 megahertz to work with. In Lexington, Kentucky, at the University of Kentucky, there are 28 non-adjacent channels and some as 15 contiguous, so that's 90, you know, consecutive megahertz available at the higher part 15 power that can be used. On the other hand, you see New York, Washington. Yellow is the adjacent channels that can only be used at lower power. These, you know, only two in DC, three in New York, and one, only one of the higher power channels happens to be in New York because you need three of those in a row in order to use the middle one at the higher power. This may not be completely up to date because this was based on some of the pre-certification databases.

So now in terms of those two types of devices that can operate, they're subject to very different rules. So portable devices can operate only on TV channels 21 to 51, except 37 of course, which is radio astronomy. And the power limit is 100 milliwatts on—be nice if it was megawatts—100 milliwatt on the second, on a non-adjacent channel, but only 40 milliwatts on channels adjacent to TV, which is primarily what you have in the largest cities. The devices that have GPS and can access the database for, the TV database for the list of available channels can, can operate on an untethered basis. But the so-called mode 1 devices, you know, obtain channels from, they have to tether to a base station or other device that has Internet access, and they have to communicate more frequently. The fixed wireless device can use a wider range of channels from channel 5 to 51 at a maximum of 4 watts of EIP; however, they must avoid first adjacent channels.

So, in other words, you really need three unoccupied channels in a row in order to take advantage of that higher power, which would be very useful again, you know, as we said, for fixed wireless and technically rural. They must access the database at least once a day to verify channel availability, and can be up, and can be as high as 250 meters above average terrain. So what we envision is, you know, immediate uses for less amount of broadband for WISPs, for example, for wireless backhaul, and also for machine to machine uses such as remote video monitoring, sensoring, and so on.

So this is just a bit of a thumbnail history, a cautionary tale of how it can take a decade. And it literally is the tenth anniversary since this idea came up in the, during the spectrum policy task force process. Chairman Powell at that time moved quickly on it in terms of a notice of inquiry, which came out in December 2002. Then there was a notice of proposed rulemaking in 2004. We got a new FCC Chairman. It went dormant for quite a while. Then there was bipartisan legislation. My personal hero, Ted Stevens, despite, you know, tubes and other funny statements, noticed that he wasn't going to get wireline broadband to his villages in Alaska. We showed him how the regional telco up there, GCI, was using Wi-Fi to bring connectivity to remote Alaskan villages that had never had telephone service, and now they have broadband. He said, I want more of that. So legislation, bipartisan legislation—that was back in the days of some bipartisanship—kind of gave the FCC a bit of a kick in the behind, so a testing timeline was set to resolve the interference issues. And an order was adopted on election day in 2008 by a 5-0 vote. And that was going on four years ago. And we're just getting to implementation because of course we had to go through recons.

September 2010, a very important outcome there was to clarify that the devices could rely exclusively on the database if they had, again if they could determine their location, check the databases at least once a day, no need for sensing, but sensing alone would be possible through a special certification which is kind of down the road still. 2011, the first white space database and deployment were authorized beginning in Wilmington, North Carolina, a smart city deployment. And 2012 the middle class tax relief had the incentive auction provisions which implicate white space. And I'll mention a little bit more about that in a minute. And final recons, recons on the recons were resolved. And that led to things like, for example, OET raised the height above average terrain for use of the fixed wireless up to 250 meters, and a few other issues concerning the maps and so on.

And now two databases have been provisionally certified in some devices not yet for nationwide use because they're still finalizing the reservation system for wireless microphones. Wireless mics, in addition to having two reserve channels can go into the database and, you know, when they have a short, you know, maybe major event and they need, you know, 20 microphones can go in and make a reservation at a particular location with a one come protection radars so the database manages that level of protection.

This is Cliff notes on the recent middle class—it was adopted in February—middle class tax bill had spectrum provisions. Of course with all the headlines on incentive auctions, which will have an unknown impact on the continuing availability of TV white space—broadcasters, it's completely voluntary. They can decide to get paid to get a portion of the auction revenue for giving up 6 megahertz, which is their entire channel, for giving up 3 megahertz or not to give up any megahertz but to move from UHF to VHF, because most broadcasters have actually moved out of VHF for DTV because it's actually better for them in UHF. The broadcasters that do not participate still are subject to forced relocation when the commission repacks the band. But they will be compensated for their cost. I believe the auction revenue set aside for that is up to 1.75 billion, believe it or not.

There's a lot of issues about repacking that will implicate TV white space. The channels that remain vacant will be unlicensed, but a huge question mark looms around particularly the take-up rate among broadcasters because, you know, what they'll do is they'll pack from, they'll repack from the top down, in other words from channels, from channel 51 down toward 37. And there's disproportionately more white space up in the higher channels because there's very few TV channels, TV stations that are operating up in, say, channels 49, 50, 51 so you actually lose more white space. And that also makes the relocation less disruptive and cheaper if they start from up there and work their way down, which is one reason they're doing that. It's adjacent to channels 52 to 69, many of which were auctioned previously.

The other issue is what to do with the secondary licensees in a band, low power TV, boosters, translators. Will they just fill in the white space after the repack? Or will they be, not be reassigned or required to share channels, for example, in order to preserve more white space. Then another big issue is in order partly to compensate for the lost white space, the legislation allows, gives the FCC discretion to designate—they're assuming that this will be a paired band plan for LTE that the industry is requesting and so they'll be a duplex gap presumably in the middle between the uplink and downlink channels, and probably a guard band between the bottom and broadcasting. So the gap, duplex gap and the guard bands we presume under the legislation will be unlicensed. But the width, how much continuous unlicensed nationwide has to be technically reasonable.

So we have to figure out what that means. And that's very important, because as I said, you have very little white space in markets like New York, Washington, Los Angeles. And so a contiguous nationwide band will at least allow a continuation of nationwide markets for equipment. A 3550 to 3650 band for a long time it was in the legislation for an auction mandate that was pulled out. So now that can be reallocated for, well, not by auction, possibly unlicensed. And there's also the potential for an additional 195 megahertz of unlicensed in a 5 gigahertz band. A study is mandated on that which NTIA is working on.

There's been TV white space trial deployments. So we know there's no question about a technical feasibility. It's been tested in eight or nine or ten different trials since 2008. In fact, both these gentlemen have been involved in leading those trials for rural broadband, smart grid, mobile health, smart city deployment in Wilmington. Also there was a year-long trial involving fourteen companies in Cambridge, England, that just wrapped up in April. I think you'll hear more about that. And also the New America Foundation and Big U are partnering to do something called Air U where we have a consortium to leverage TV white space for, to bring better connectivity to rural colleges in the surrounding communities that are underserved.

So next I just wanted to, you know, remind everybody why we're so interested in, you know, in this, what you might call the unlicensed economy. So it's not just Wi-Fi offload; there's also going to be implications for things like smart grid. And it's very interesting that right now the U.S. is kind of leading the world in the unlicensed economy. So currently 80 percent of the automated meter infrastructure in the U.S. is using unlicensed mainly 900 megahertz bands, and utilities are very interested in white space, whereas in Europe that's all done over cellular, licensed cellular networks. Something similar in terms of wireless healthcare. Two-thirds currently is Wi-Fi or Bluetooth. Very little is cellular licensed. The M to M networks, smart home, mobile payments inventory, that's mostly unlicensed in the U.S.. And, you know, will take off even more, particularly with the more long distance machine to machine thing like I mentioned that they're doing in Wilmington with monitoring water levels, managing, you know, everything from, you know, parking lots to other public properties, mobile video monitoring and so on.

And then of course there's offload. This was just, you know, a schematic, but it's something that's obviously booming. Ruckus is selling now 100,000 hotspots to Japan's KDDI, which is going to have 125,000 hotspots for offload in Tokyo—I think it's the Tokyo area alone—by the end of this year. Of course where that's been most dramatic in the U.S. is with the iPhone and the iPad. Mainly you see AT&T with 30,000 hotspots offloading almost half of the data traffic over on iPhones on Wi-Fi, 90 percent of iPad traffic because most people don't even purchase a cellular subscription for those.

So now to kind of loop back to close by doing what, you know, what Eric asked us to relate this a little bit to the broader discussion here, to the potential for federal spectrum sharing to the PCAST recommendations. So really there is this is a great disconnect. It also relates to the last presentation about the availability of bands that are, that are in some ways fully occupied, meaning when they're needed they're really needed, but most of the capacity is not used. So we have on the one hand calls, claims that there's a spectrum crisis, a broadband spectrum deficit of 300 megahertz by 2014, and yet less than 20 percent of spectrum below 3.7, even in big cities, that seems to be very much occupied at all on a business day. I know a number of you out here have done those studies.

So I think really the relevance and really importance of the TV bands, of the white space, is the TV bands database more than the actual spectrum, which right now, like I said, there's a cloud of uncertainty, to be honest, over how much TV white space capacity there will be after these incentive auctions. But there's tremendous policy importance because this can be the platform and the proving ground for governance and control mechanisms for other white space, for federal white space, for fallow bands in other areas. So here are some of the advantages I think are useful to think about because it's really apparent, even with the TV white space.

So first of all, there's the thing about the TV database, there's no permanent assignments and so no stranded users. Any band can be listed and then delisted. And the commission did that purposely because they explicitly reserved the ability to assign a new TV station license in a white space channel, and then take that channel out of the database overnight. And the user is not even aware of that because the device is simply getting, you know, a list of available frequencies and using those, and it's not even really a visible thing.

The CSMAC just yesterday was, adopted an unlicensed subcommittee report that said as we open new shared and unlicensed bands, there should be requirement that the devices are connected devices; that they have the ability to, you know, they're required, even if they rely on sensing for transmit permission, that they still connect back to a database for firmware updates or for changes in terms of access to the band. I would say something that was not done in TV white space but you would want to do in any shared federal bands is probably also prohibit single frequency devices, because you always want alternatives to be available that addresses the garage door opener issue.

Access to each band can be subject to unique operating conditions, unique terms of access. That's true in TV white space. As I said, the adjacent channels have entirely different operating conditions than the nonadjacent channels, and that's sometimes on the same frequency. But if you move from DC over the Charleston, West Virginia, the same channel may have different operating conditions based depending on your location, and the database can manage that. Preemption shutdown and priority access can protect primary operations and be managed through the database. Any tragedy that the commons can be avoided, that was always a big argument when we had these debates about property versus common, licensing versus unlicensed. So it was always yin yang, black and white. But there's not necessarily a tragedy to the commons when at any point access to a particular channel frequency can be limited or conditioned on micropayments, for example.

And then finally enhanced features can be added over time as cognitive radio improves. So for example to incorporate sensing data so that the devices can be advised not just, Here's kind of a dumb list of, here's just a static list of the channels you can use but, Here's the best channel for you right now in this place. Other benefits of extending the TV bands database or a version of it to govern shared access, it can be a platform to enable secondary markets. So you can, transparency, automation, and standards can be leveraged to lower transaction cost. So you can imagine something like on a particular band of sort of private commons that's managed through that database. More capacity and efficient use.

We think in general that this promotes a small cell strategy, because relying on low power access to shared spectrum bands and self-provision backhaul should be the most cost effective way to meet high capacity in peak use because you're really using the local infrastructure on the premises or nearby. More competition and innovation obviously because you get low barriers to entry. Some indicators of that are the 2,000 WISPs and a proliferation of unlicensed devices, and a possible, in the commercial band, a possible alternative to the somewhat toothless, Use it or lose it.

So all that's, just to close, all that's led us to be advocating, you know, over the past couple of years a, Use it or share it approach. The nation broadband plan alluded to that about further development and deployment of opportunistic access to unused spectrum across, across other frequencies. As you'll hear tomorrow, PCAST said licenses are for exclusive use, not non-use. So the idea is let's use what we're not using. So the proposal would be to identify and open the most underutilized and useful bands for more opportunistic sharing on a secondary basis, but subject to band—this would have to be done band by band in order to protect incumbent users.

And the three obvious categories, warehoused FCC spectrum setting idle, underutilized federal bands such as the thousand megahertz PCAST is talking about, and fallow licensed bands, you know, where you don't have build out, it can be used in the meantime. And here's obviously from the NTIA's fast track on the right side some of the shared bands that they intend to prioritize for study. And you can see from that where the PCAST was looking at 2.7 and 3.7 because that entire range is on this list with actually 36, 35-36 being on the left side, but hopefully moving to the right side. That's it. Thanks. (Applause.)

### *1.4.9.2 Peter Stanforth: Unlicensed Use of TV White Space*

MR. STANFORTH: Michael took you through the rules and regulations. I want to spend a few minutes and talk about how we actually implemented a solution. I think there are times when I sort of gag a little bit when we talk about a geolocation database, because I think what we're really talking about is a spectrum management solution with a geolocation database in its heart. As you go through what actually happened, how it works, and then you talk about what you would do with it in some of the areas that Michael was talking about, you begin to realize that a database is just the beginning of all of this.

But we are talking about a database where we're talking about frequency, time, and location. And as Michael alluded to the fact that this is reality today. Our database was certified towards the end of last year, closely followed in the spring by Telecordia, which is a subsidiary of Ericson. There are actually three completely certified radios today. And just from the radios that we're working with, we're actually helping five more through that process with the FCC at the moment. I'd be surprised if there weren't another half dozen or more between now and the end of the year. So these things actually are real and actually going into production and being deployed today. It's actually something that's going on around the world. The details of exactly who gets protected and how they get protected differs a little bit as you go from sort of one regulatory environment to the other, but the principles are basically the same.

Using the sort of the FCC model, which is the one on the left—so the one on the left they come out a little bit pink on this slide. But basically what those blobs represent, this is a single channel of operation, channel 9, I believe. So each of those blobs is a defined service contour for a TV station. So as a consumer you have an expectation that you would be able to receive that TV station inside the blob, and that you are protected; you have a right to receive it. Now, that doesn't mean to say that outside that blob you can't receive that TV station, but you don't have a protected right to it.

In the U.S. version of the rules, when we plotted all those little blobs, and each obviously in three dimensions because there's two photographs in one channel, if a white space device shows up inside one of those blobs it's basically not allowed to use that channel. If it's outside, for the most part it can use that channel. I say for the most part because, as Michael alluded, there's certain other things we have to consider in terms of interference mitigation, but the bottom line we're trying to get to a point where there's acceptable interference on both sides so that both can operate. So this is how it actually works in the U.S.

So in the U.S. everyone that transmits at least at high power is licensed, right? So one or other of the licensed databases provides us with the information about where people are, what they are, what they look like, what their antenna structure is and so on, so forth. That information combined with the rules gives us the basic information we need for who to protect and where.

And as Michael said, there's also a second interface to the database. Because when it's a film crew going out making a movie, or it's somebody setting up a concert or they're going to set up a golfing event for the weekend, those temporary reservations are also permitted and protected. So we had to have interfaces to let those people come in and pretty much on the fly say, I'm shooting a movie across the street tonight and I need some protection. You notice that there's more than one database up there. The FCC allowed several databases, which means that in order that these people that are doing temporary protection don't have to come in and register many times, we have a requirement to synchronize between the databases. As a result of gathering all that information doing the calculations against the rules, we can then provide channel maps to radio networks, radio access networks that come and query.

So why multiple databases, and what's going on here? Well, there's two reasons. The more obvious one is competition, the catalyst for innovation and for efficiency and ideally for lowering costs. But there was a second reason why the industry was desiring to have multiple databases, and that is if you look at some of these examples of applications, and I won't go through them in detail because Michael mentioned them, but they're very different. And the requirements they have from this management system can be quite different. So there was always this belief—and we've started to see some possible substantiation of that as we go forward now, that these databases that got authorized might actually end up being optimized for certain kinds of services or certain kinds of vertical markets, and so you wouldn't necessarily have to have a database that did everything for everybody; you could actually have these things customized, so maybe one's a very low cost, simple, and one of them might be fault tolerant and redundant, and obviously the service it offers could change accordingly.

Just in terms of the applications, you know, Wilmington was, and Wilmington was chosen because of—and the irony might not be lost on some of you—that was the place where the first digital TV transition was done. So it was really the place to go to start white space. The bottom line in Wilmington is they're using white space for a lot of enabling applications that they were having trouble getting to work with any other wireless technology. And they're immensely proud of it; it works very well. They got ROIs of these deployments in a matter of weeks and months from these things so they're very happy with what they did.

If you sort of take the generic common themes out there of what's happening in all the places we've been deploying the radios it's physics basically. The UHF spectrum has much better line of sight capabilities than the current bands of 2.4 or .5 gigahertz. What we generally find is that you get about a 3X to 5X improvement in coverage. If you're in a coverage constrained environment, you'll get away with about a tenth of the number of access points if you deploy a white space solution at, say, 500 megahertz compared to a similar solution deployed at 2.4 or .5 gigahertz. So the places where this is really being used very well is in areas with rugged terrain or heavy foliage, lots of non-line-of-sight issues. And it's become, even with first generation equipment, the fact that it's economic because of the coverage constraint that it overcomes compared to the more typical Wi-Fi solutions that are out there.

Coming back to the multi databases for a minute, there were some challenges there. There were essentially ten entities that were designated, nine originally and then a tenth one later, to potentially be database administrators. And as a group we got together and realized that the rules required us to do two things. The first is what I mentioned earlier, which is we had to synchronize so that when somebody registered for protection with one, that same registration was equally shared amongst all of them. And the second thing we had to do is we actually have to end up giving the same answer, right? Both of those things were nontrivial. And it took a great deal of work; probably a year's worth of work by the majority of these folks. And they ended up publishing two standards, both available on the FCC website. Although the FCC is a terrible place to be looking for anything. Most of us actually post them on our own websites if you want to look for them.

But the first one obviously was a database to database synchronization so that was the actual implementation of the set of functions we needed for the rules. The second was the calculation consistency document, which means if you came and queried a database with a location you would get the same answer from every database. And that turned out to be quite complicated because obviously first of all we've got to get the same set of input data from the FCC, and then we have to input a set of complex algorithms in a way that's consistent. And they're sensitive, these algorithms, to terrain databases and to even to the point if you take four points, four pixel points in a terrain database, but the actual location is in the middle, how do you rationalize that? Do you take the average? Do you take the nearest point? All of those things are very sensitive.

But the end results is these specifications are completed now, and we are all very pleased with the outcomes. They turned out to be significantly better than we were required to do, and better in some ways than even we thought we might achieve when we were all done. So we've got levels in consistency in the way this works now that are very very close, very granular, and as I said, those are available to anyone who really wants to get bored and read them.

So changing tacks a little bit, and this is speaking from Spectrum Bridge now as a database provider, there are two sides to this equation. Obviously the first thing that has to get taken care of, and the thing that everybody focused on when they were looking at our database was, Are we adequately protecting the incumbents, right? So everything was fixed on the fact that we knew where they were and we gave them adequate protection, but obviously there's another side to this equation, which is the people that are going to use the spectrum, right? And so you have to be able to take care of them.

Now, because the incumbents were already there, they were doing their own thing, they weren't annoying anybody and they didn't ask for this, there was a presumption, which will probably be true in other bands, that they weren't going to pay for this service; they were going to get protection for free. So the only reason for getting into the business of providing a database is to provide value to the other side of the equation, which is the users of that. And the way we do it at Spectrum Bridge is we provide a whole set of tools and services for people to plan networks, deploy networks, manage networks, and work with coexistence issues.

I'll give you one quick example of how we do that. So on my little chart before where I had the red blobs, like I said, the TV device is not allowed to operate inside that blob because it will interfere with the television, or may interfere with the television reception. But those megawatt TV transmitters don't magically stop transmitting at the edge of those blobs. They keep going. And in some ways they're like the Energizer bunny: Thinking and thinking and thinking, right? So what you end up with is a situation where you get this gray space which is an area where the white space device could operate because it would not interfere with the incumbent, but the incumbent's going to kill it because you're talking about milliwatt devices versus megawatt devices.

So the chart on the right is a bit of an eye candy, but on the left is a list of channels that the rules say for whatever that location was were available because they would not interfere with the incumbent. On the far right is the analysis we did when we took those propagation models out further and we looked at the co-channel and—more importantly for white space devices because they've got a forward front end—adjacent channel blocking. What you end up with is somewhere in the red, which means if you try to operate in that channel there's so much energy from the TV guys that, forget about it, basically. And obviously at the other extreme the green ones are relatively, the noise flow now is so low that they're gray. And in the middle are some sort of yellow and orange ones that if you know what you're doing maybe you can use them, but if you don't you might want to stay away from them. That's one example of a single service where you look at the other side of the equation of what we do in terms of where it goes.

Just to wrap up in terms of where we are here in the U.S., the rules are, quite frankly, fairly rudimentary. The FCC took a position that they were going to be quite conservative, and that they were going to do this in incremental steps. So for instance today there's a lot of white space in my view that's left on the table because we overprotect the incumbents. One of the reasons we do that is because we take channel assignments for 24 hours at a time. There's no reason why we couldn't do channel assignments every minute or every five minutes.

And we protect a station whether it's actually broadcasting or not. If it's licensed and designated as available to operate it gets protection. So in those big city environments that Michael talked about we know, because we also run a secondary marketplace, that a lot of those channels are ratcheting up for sale because they're not operating. But because they're in a ULS or a CDBS database as a white space database we have to protect those channels even though they're actually not operating. So there's a lot of opportunity for us to go around again a couple more times and actually make these rules a lot more granular and make a lot more white space available. With that, I will quit. (Applause.)

#### *1.4.9.3 William Webb: Weightless and White Space in the UK*

MR. WEBB: The last presentation of the day—it's getting late. It's late for you guys, but it's midnight for me. I've only got eight slides, so we'll get through these fairly fast. I was asked to talk about two things. One is a technology that we're working on at standardizing for white space operations for machine to machine white space. I'll take about half the presentation talking about that. And the second is to look at white space rulemaking in the UK and also to a little degree the rest of Europe, which is pretty up to speed around some of the rest of the world.

So there are two names up there. Neul is the company that I work for. And Weightless is the name of the technology we're standardizing for machine operations. So what's going on in this area? Many people for a long time have hypothesized that there are billions of machines out there that will benefit from wireless interconnectivity. And that's been around for 15 or 20 years they've predicted that, and more recently there've been predictions by Ericson and others that 50 billion devices by 2020, CISCO talks about interconnective things.

So it's a well-known concept that machine connectivity will be a good thing. But it hasn't really happened to date, and it hasn't happened to date because there isn't really a suitable standard for what I call wide area machine connectivity. If you want to connect your machine in the house you can use Bluetooth, you can use Wi-Fi; there's many other similar kinds of standards to do that. But if you want to connect it over a wide area, if you want to connect a small meter back to a substation, if you want to connect your car to your dealer then best you can use at the moment is cellular, which kind of works but it's kind of clunky for machine communication standard. So there hasn't been a suitable standard.

And one of the reasons for that is because there hasn't been suitable spectrum to run such a standard in. To do anything wireless you need spectrum, of course. And that changed the gap into the white space spectrum, and that changed because suddenly there's spectrum that is in the right sort of frequency band for this sort of thing because you want pretty good propagation so you can get small meters deep within houses without needing too many base stations. You need a reasonably large chunk of spectrum because you've got 50 billion devices all in one place perhaps you've got to get to them all in a reasonable amount of time, and that means a reasonable capacity.

And quite importantly you want this stuff to be harmonized worldwide for two reasons. One, that's the way you generate economy of scale, and that brings the price point down in many applications that require global roaming, things like astral tracking. Most cars can go around the world, but they get manufactured in one place and sent round the world, and it helps if they can use the same technology wherever thinking.

And white space does all those, takes all those boxes perfectly; at least it has the possibility of global harmonization insomuch as the TV bands are pretty much the same all around the world. So if the regulations to allow white spaces is adopted around world perhaps we can harmonize the spectrum band. But just as Peter was mentioning, it's not easy to use TV white space. There's always interference both from licensed users and potentially from other unlicensed users. And so put all that together and basically you need a new technology, one that's optimized for machine communications and able to handle the environment cooperation in white space.

So what does it need to do for machine communication? It needs to be very low power. Quite a lot of the machine applications require battery operation for on the order of ten years. For example, if you're going to put a sensor on car parking space, you know, whether that car parking space is free or empty, you don't want to be going back and charging that battery once a week. So this has to go for a long time on a simple battery. And it's got to be really cheap. If you're going to put a sensor into every garbage bin, every car packing space, then you put a price point of about two dollars for this set of stuff to make it cheap enough to pretty much put in and forget about. It's got to have really good coverage. I mentioned before, smart meters, you need something like 99.5 percent coverage into homes. Particularly in Europe, many small meters are buried deep inside homes and it needs to be globally available. So that's what we're aiming for.

And with the Weightless technology the approach we took for that was first of all try to be as flexible as possible because frankly we don't know what the breadth of the application in the machine space is going to be. To make use of funds is pretty standard for white space operation because you have no guarantee of a nice, well-spaced frequency duplex pairing. But also we've got no real understanding of what the balance between uplink and downlink traffic is going to be in this system. If it's smart metering it could be mostly uplink. If it's management download to cars it can be mostly downlink. We don't really know. We make use of frequency hopping. That's a good way to overcome unexpected interference from unlicensed users. And I think a really critical point is the use of spreading to extend the dynamic range of the system.

So I talked about the ability to achieve 99.5 percent coverage. And the way we do that is with battery pack devices that are only transmitting at 40 milliwatts or so. It makes use of the direct sequence spread spectrum, which is exactly what GPS satellites do to extend their range. And we can spread from no spreading at all up to a factor of 1,024. If you spread by 1,024 you get about 30 dBs, which is more than enough to get you into the building and into the basement to read the meter. Of course the downside is you lose a thousandfold of the data rate. You take the base rate down from megabits to kilobits. But that's okay. Small meters don't get too flustered about low base rate; in fact, they're actually happier with low base rates because they can run their clocks at that speed and it works just fine. That actually all fits quite neatly with machine communications.

And the whole thing has to be really low cost. And with all the tricks you can play here, for example you can run the entire core network as a Cloud based software service because there's enough time to do that. Cloud based posting has come a long way now, so essentially you have a network that is entirely software based, base stations that are one watt devices and have the same four factors as a Wi-Fi router, and you have chips that cost about two dollars each, base stations providing coverage ranging from about four or five kilometers.

Now, we turn this into a global open standard because only global open standards can do it. I can't think of a single successful wireless system out there that's not a global open standard at the moment and indeed royalty free because that's the only way to get the two dollar chip, the price down. So that's three slides on a specification that's now, we're over 200 pages big. If you want to find out any more about that you can talk to me. There's a book available. And there is a website for the Weightless standards, Weightless SIG, which is Weightless.org. Join that for free if you're interested in doing that.

Okay. Let's change tack now and talk about white space regulation and trials in the UK and the rest of Europe. So you've heard mention about the Cambridge trial. Cambridge trial is being, going to be the biggest in the world for white space application. It was in fact a truly excellent trial particularly because it brought together all sides of the interest groups. So the broadcasters were there—the BBC, broadcast network operators like Archiva—the wireless microphone community was involved, as were a number of manufacturers and database operators, and a really good range of different players. And the system basically consisted of six base stations based around the center of Cambridge, and a couple of broadband links.

Every now and again another bit of it came in and went away, but that was the kind of the core of the trial. And those were running pretty much continuously. And a lot of the focus of the trial was really on: Does it cause interference? For example, we put round leaflets to all the houses that were next to those base stations. The base stations were right in the middle of the city. They weren't on a march down to one side. They were actually in some cases less than five meters away from people's houses. We put round leaflets on their doors saying, If you get interference give this number a call and we'll check it out. It just so happened that one end of the band was pointing straight at my house from ten meters away so I was also able to check that TV interference was not happening; actually I wasn't, but my daughters were. And we did a whole lot of testing as well with wireless microphones.

And the thing that came out of this was it was actually really tough to generate interference. We even ran a base station co-channel on the roof of the theater in which the wireless microphones were running and then took the wireless microphones to the limit of the utility by changing how they transmit and unshielding them and we still couldn't cause interference. It wasn't until we took them outside and pretty much pointed them straight at the base station that we got interference. So it showed essentially that this stuff really does work very well, and quite a lot of data on that sort of stuff and minimum coupling loss. And the key message to take away really is, as we mentioned, this does work in practice. There's no need to carry on trying to determine whether it works in theory; it works in practice.

What's happening in terms of white space regulation. So Ofcom are by far the closest regulated behind the FCC in terms of introducing white space access. They haven't been studying it for quite ten years but it's probably something like seven now. They have gone through three rounds of consultation and they're now working on the fine detail. They are just finalizing a document to go into ETSI, which they call a voluntary national standard that will essentially set out the overarching characteristics of what the white space devices need to look like. And that helps the process of enabling the equipment legislation that has to come up to some European standard for that to work. They're expecting to finish that legislation by the end of 2012, publish a statutory instrument, which is just a legal document that says, White space devices are also allowed to transmit without a license if they fulfill these key characteristics.

They're talking about the database perhaps being enabled in the first quarter of next year. I won't dwell too long on that. They're still trying to work out how to implement that due to some confidentiality issues with the broadcast TV coverage data. The Ofcom rules are actually at the highest level very similar to the FCC rules.

So you have the database, and you can assume that the adjudications are the same. But yet when you look in detail they're quite a lot more flexible. And in particular they don't have a fixed maximum power level. So for every individual location they ask the question, What power could a device transmit at without causing interference, and return that allowed power level. In some cases that may be very low if you're right next to a TV receiver. Other cases it could be really high. So instead of there being channels that work and channels that don't work, you've now got a whole range of channels at different allowed power levels on those particular channels.

And it's predefined rules like you mustn't work in an adjacent channel. Just look at all the characteristics and devices. It also allows for multiple device classes that allows for devices that have, for example, very poor out of band 0 emissions such as might be the case with really cheap devices, and of course they get far less spectrum allowances back to them because they cause much more interference. It doesn't say, You must meet these particular criteria about in-band interference simply because the better you make the device the more white space you'll be able to access. And it allows for narrow band transmissions as well, which the FCC usually measures and allows for. And TV coverage is mapped on a careful pixel by pixel basis based on very detailed and very complex covering models. So that all adds up to quite a lot more flexibility.

And in fact I have a paper on this that's due for publication in the Communication Magazine in the next month so you can get more detail on that if you're interested in that particular space. So that's the good news.

The rest of the EU though is not such good news. There are one or two countries in the EU that are proceeding in various ways, in particular Finland. But most European countries at the moment are basically sitting back and awaiting some kind of more centralized guidance either from the European commission or from bodies that are associated with the European commission, such as CPT. And CPT has been doing a fair amount of technical work. But it does suffer a bit from the work by committee kind of approach, which tends to eventually settle on the worst one possible case from everybody's point of view.

What I don't see from other European regulators is a desire to promote innovation. Instead I'd likely see much more of a desire to be very cautious. And so I suspect Europe is running two to three years behind the UK, something like that. It depends really on whether the European commission decides that's the case and they have the powers to force European members to adopt a particular regulation around this if they get the band, or whether individual countries will just gradually follow suit.

What I did observe, and I think it's an interesting observation, is that if you look at all the companies that are developing white space related products or databases or services, they are almost without exception either from the UK or from the U.S. And I don't think that's an accident. I think regulators that provide testing and innovative rulemaking tend to encourage native companies to be active in working that space. So I think the UK and the U.S. is going to be where we'll see the key rewards being reaped both in terms of end users having access to the spectrum first, but also in terms of countries and organizations within those countries becoming world leaders in that particular space. And I'm done. I managed to stay awake. Thank you. (Applause.)

#### *1.4.9.4 TV White Space Q&A*

MR. CALABRESE: You want us to take a few questions? All right. If there are any questions. Go ahead.

MR PEPPER: Robert Pepper at CISCO. So what William and Peter seemed to be talking about is very exciting. Actually for those of us who were at the FCC in 2002 this was sort of a vision, a concept that this is actually going to be able to work with opportunistically using the allocated but unassigned TV frequencies so it works, which is great. But there seems to be almost two different visions. Michael, you know, you laid out, and we originally started talking about this as supplement or complement to the broadband. But as a practical matter—and you talked about that a little bit, you know, the WISPs. The WISPs were getting their backhaul elsewhere and sort of if you thought about the WISPs. I guess the question is in reality what I'm hearing from Peter and William, that this is more about, you know, machine and machine, the smart grid, industrial applications and usages, and less about broadband. So I'm just kind of curious from the Cambridge test, what did we learn about that? And what do you think about the applicability towards this having anything to do with broadband as opposed to a new way of sharing to create an ecosystem for a completely new set of uses in industries?

MR. WEBB: Yes. So the Cambridge trial had a little bit of broadband like application in that in some cases individual links are set up. They had a Wi-Fi link on the end and you could do that. You could set up one Wi-Fi router and show that in mega seconds or something like that. But I think they were overall there was a scare from the participants on machine to machine and rural broadband. And particularly in the UK it's hard to see quite why you'd want to do broadband in white space given that there's already excellent 3D coverage and increasingly Wi-Fi deployment of four and five gigahertz. So I think that that's why it wasn't really explored in the trial. It's not something that there seemed to be a lot of interest in.

MR. STANFORTH: So here in the U.S. the WISPs are very interested in white space for broadband. The issue for the WISPs is that there are very few radios on the market, and they're relatively expensive, you know. So when they've got a model where they can charge somebody 20 bucks a month for broadband they need pretty inexpensive radios. And we are very early in that cycle. So there are some WISP deployment, more trails or evaluations. But where you do find there's an insensitivity or less sensitivity to the price of the radios is in those for industrial applications. In Wilmington, as Michael mentioned, these water sensors, those things were $35,000 apiece. So I don't have to have a two dollar weightless radio for that, right? I can get a $500 radio and it makes sense. So what you're seeing in the U.S. is driven more by the economics of the first generation radios that are all in this 400 or 500 dollars apiece range more so than it is that there is no interest in broadband.

MR. PEPPER: One of the issues for the WISPs always has been the backhaul. Do you see this in the WISP model backhaul technology or a client's device? If it's a client's device but it's primarily rural, how do you get the manufacturing scale to get the chipsets down to two dollars or less as a broadband versus hundreds of millions of chips for machine and machine? I mean, it's not a technology issue, right? It's more of an economic scaling question. How do you see that?

MR. STANFORTH: There are several technologies and standards that are candidates for deployment in white space. So there's a group that's trying to take 211 and repurpose that through the LNAX so we see them trying to leverage that in the economy of scale. There is actually a whole IEEE working group defined standard for white space 802.22. Then what you're also seeing, interestingly enough, are there are some folks that are building LTE equipment and they're looking at TDLTE and they're saying, I've got to build this stuff that works at 700 megahertz and maybe it's too much of a problem to move it down to work in the 450 to 700 megahertz. So it's early days. I wouldn't like to bet that any of them will actually make it. But that's what people are doing to try to solve that problem.

MR. CALABRESE: You know, one with also the WiMAX alliance, you know, with the 802.16 standards looking to get into this as well. But it's correct I think. This is really the first year of any deployments. And initially the way it's being used for broadband at least, you know—and I've spoken to at least five equipment makers—what they seem all to be doing is creating, is building initially base stations and CPE that will essentially, yes, use the white space as backhaul in a sense to deliver bandwidth. So for example, they can take six channels and deliver 60 megabits per second over one or two miles to a place where it's redistributed by Wi-Fi. Because of course the problem is the consumer, at the end consumer interface isn't white space. The consumers in their laptops and smartphones have Wi-Fi interface. So the CPE will actually retransmit this as Wi-Fi connectivity, but it brings the bandwidth into a place where there's not good, there's not higher capacity wireline right now. That itself is going to be, it would change the economics for some of these up served and underserved areas including even places that, you know, only have, you know, low rate DSL. And then the market, you know, will develop, and we'll see there is tremendous potential for machine and machine as well.

MR. BIRCHLER: Hi. Mark Birchler from Roberson and Associations. Three of you have practical experience developing business cases for companies that are using spectrum as a secondary user. Can you draw on some of that experience to talk to us about the challenges and opportunities in the more general future where different types of operators in different areas of spectrum are being used on a secondary basis for commercial use, and how that might play out?

MR. STANFORTH: So we run a secondary marketplace for spectrum. There are two reasons why that is not a wild success. One is because there's a lot of spectrum that sits there because nobody's got the incentive to either use it or lose it or use it or share it. But the second reason is that, as you get into these ideas of more dynamic use of spectrum, the piece of spectrum they can use today may not be the piece of spectrum they can use tomorrow. So frequency intel radios become an issue as well. And so on any given day we might have hundreds of megahertz of spectrum literally on some locations available. But unless someone can pair that with a radio, you know, it doesn't make sense. So part of the issue with these bands that we're talking about is the availability of equipment period, and then availability at a reasonable cost. In terms of the demand, what we've seen if you go back—and I know you know this, Mark—the old two-way radio days and the commercial and industrial bands that were identified and all the businesses from taxis to concrete trucks that ran around and ran their business using 25 bits of millihertz channel, as they've gone from those push to talk applications to these Internet applications, their problem is where do they get the bandwidth from, right? And there isn't a separate industrial commercial broadband space for them to work with. So generally they look at opportunistic use, either unlicensed or secondary access to spectrum in order to serve their needs. So there's definitely a demand for them. And they are desperately short of spectrum and the radios that will serve them.

MR. WEBB: People just need to realize that that doesn't have to be like that. If you lose one licensed spectrum then you have to cope with much less confident access which you get spectrum for free or for much less cost, and that's when you've got some more money to go do certain things. And of course it depends on application. So machine to machine it's actually quite tolerant of delay in many applications. So if you had a temporary spectrum outage that might not be a big issue. But like sometimes my analogy sometimes companies like UPS saying, Well, we can't possibly start with one. We don't have a dedicated road network, and there might be congestion on the road. But no, they don't. And they accept that there could be congestion on the road and the parcel may not get there time and there's going to be some issues. But you kind of feel that you operate it and you live with it.

MR. KHAYRALLAH: Ali Khayrallah. I think I want to sort of bring the discussion back to a dollars and cents kind of argument. I think you mentioned you are going to sell the device at two dollars. Everybody is talking about using white space at Wi-Fi. I think the key thing that differentiates Wi-Fi and the white space spectrum satisfied. And if you are saying that you can do at two dollars, even at 40 milliwatts a selected filter that can span and calculate megahertz and sell it at two dollars I would be very intrigued. You have an answer to that?

MR. WEBB: Absolutely we have. We have designed a chip that's going on this application shortly.

MR. KHAYRALLAH: RF filter.

MR. WEBB: RF as well. I mean, it's made—there's a number of ways we achieved it. One was we were able to take the modulation speed, because it varies, we could keep with very severe filtering we got single carry modulation much much simpler to filter. It only uses about 70 percent of the actual channels, so we've got plenty of space for the filtering side of the channel then we're able to run it at low power so we can afford to have it slightly efficient. So you add in all those kinds of things and absolutely we can do it.

MR. KHAYRALLAH: If you test it and try four watt devices filtering doesn't add up that easily.

MR. WEBB: Yes. But we're running four watts but they're not two dollars.

MR. KHAYRALLAH: Not the two dollar. Wi-Fi access point price I think is going to be.

MR. WEBB: Yes, it's going to be a lot more expensive to run that amplifier with a very high power ratio to get a much more powerful para amp then you actually need to use to make it work.

MR. KHAYRALLAH: The corollary question is are we overpromising, and likely run the danger of under-delivering the promise of white spaces?

MR. WEBB: Depends on what promises are made.

MR. STANFORTH: The mask that we have today is very challenging. The rules that we have are very challenging. But there's no reason why you couldn't change the formula for protection to accommodate a simpler mask like a Wi-Fi mask. I mean, what you might do in simplest form is take whatever white place is available in its location today and maybe divide it by two. Then if that simple mask works then you can get there. So the mask is an issue. But, you know, it's kind of like a plate of spaghetti. You know, you have to sort of be careful because if you move one thing and everything else moves. But I don't think that it is an issue exactly the way you said today, but I don't think it has to be an issue in this band or necessarily other bands.

MR. DEATON: Hi. I'm Juan Deaton, Idaho National Labs. I just wanted to thank the panelists for coming up here and talking about TV white space because I think the progress you guys talked about is really great. It's just another step forward in making sure DSA technologies make way into the industry. I have one question, kind of two parts. The first part is you talked briefly about protection areas. I wanted to know how much of an impact you think that has on people actually making devices and things like that in terms of equipment manufacturers actually wanting to move into the space. And I know Mr. Webb had talked about contours versus the different propagation models. I don't know if you can comment on that issue. Also there's the incentive auctions coming up pretty soon. I wanted to know what potential impact that might have to TV white space. Is there a potential for it to actually just make it go away, and so on. If the panel could go ahead and answer that question.

MR. WEBB: So we're in a somewhat simpler position in that with the technology that we're running we only actually need one channel as a minimum in any one location. So as long as we can access one white space channel we can use the system. There's like two or three. So actually things like the incentive auction, which might make one or two channels available bands would actually be an improvement on the current situation in the U.S. where there are some parts of the

U.S. where there are no channels available. So actually some of these things have unexpected consequences. Sure, I'd like to sit here and say everywhere in the U.S. has got at least ten channels. It's going to be absolutely fantastic. That's not the case, but I think there's enough number of places out there to make it a very interesting market already. And my suspicion is that over time either rules will change or more spectrum become available perhaps through PCAST type approach or whatever to be able to solve some of those problems. So I think we have to have a bit of faith as well as working on the numbers.

MR. STANFORTH: Until it happens it's hard to say, but William got it right in the sense that in New York, LA, Chicago, there's not much white space today. But if a guard band and an, you know, an uplink and downlink gap was created nationwide you might find out at the end of the day there's a lot more spectrum at the end of the day in those big cities than there are given the current way that we use white space. And what you end up with is, as Michael alluded to earlier in the rules, anyplace, whether it's in New York or Kansas where they don't sell the spectrum or it's not being used, then obviously that's still available. And the other thing that we can do is the rules today are the same in Manhattan as they are in a cornfield in Iowa. There's no reason why they have to be the same. There's no reason why from 6 o'clock to midnight on a weeknight in the area around Broadway we can't have different rules than we have in, I don't know, downtown DC when nobody's around. We can do a lot with granularity and affecting the rules and probably find a lot more white space. But I do still believe that here in the U.S. in the major cities the biggest issue is the low power stations that are designated for protection that are all silent; that if we can get them to that sort of use it or share it approach that Michael wants to then there's enough for this incentive auction as well as for white space devices as well.

MR. CALABRESE: As Peter said way in the beginning when he spoke that we're leaving a lot of white space on the table. So the incentive auctions themselves will be some sort of trade-off between having new contiguous unlicensed in the gap and guard bands hopefully which will be an improvement in some respects versus, you know, losing obviously some white space overall depending on the take-up rate among broadcasters, what the participation is, which personally I don't think is going to be huge. But a bigger issue in the sum of longer terms is to revisit these overly conservative mechanical rules which just, you know, threw an arbitrary contour around every license. So you've got things like, you know, Michael markets—usually here; not here today I don't think. He's done filings where he showed for example in Santa Cruz, California, there's hardly any white place in Santa Cruz because they've locked out all the TV stations from Sacramento down through San Jose even though none of them are visible because of the mountains in between. So unlike UK, our white space rules aren't based on reality; they're based on drawing circles. So hopefully we'll be revisiting, you know, a lot of that, and the situation will improve even as the technology matures.

MR. LUBAR: I want to thank you for your presentation. This is Dan Lubar of the White Space Alliance. I wanted to sort of throw the softballs since you guys were sort of talking around it. William and Peter, if you could talk for a minute about what's happening outside of the U.S. regulatory domain in the context of, you know, they have a little more degrees of freedom than, you know, the developed world where there's so many encumbrances. Do you want to speak to that at all? Maybe Peter, as a database guy, is the database relevant in developing nations, or is that not something that you guys are even looking at? William, is your company interested in developing nations as a marketplace? Do you think there's upside potential there especially because of the look of regulatory encumbrances?

MR. STANFORTH: I think the developing countries are equally opportunistic. One example was the folks in South Africa, who had a conversation with me, and believed that they couldn't deploy white space because they hadn't done a digital transition. And my response was, We'll just track your analog TV stations as you turn them off and turn on digital, you know. The actual channels that are blocked in any given location may change from day to day but you don't have to. So the beauty of it is that it's somewhat dynamic. So they could actually start today. And even if they have plans for 4G cellular or digital transition for TV, they don't need to wait until that happened. If you're using this sort of spectrum delocation database concept then you start with where they are today, and then as they migrate you keep track of it. And the devices will be, you know, almost ignorant of it. Here in the U.S. we had a set of rules. We certified two databases, certified two radios, put them in operation. And then in April the FCC brought out another set of rules for the recon. Thirty days later the database is flipped, and the radios kept blissfully working and nobody knew any better. So the opportunity's there. And, you know, again quite frankly it comes down to is there, you know, an incentive for someone to take on the economic, you know, investment to do something. But they're easily as worthwhile and fruitful.

MR. WEBB: Yes. I pretty much agree with all of that. We've done a fair amount of work out in the Asia Pacific region. There's quite a lot of interest out there. But by and large they all follow the database approach. One thing you sometimes spot in some other countries is that they can move much faster because they don't have the same kind of consultation type work always that we do in the developed countries.

MR. CALABRESE: There's an analogy there as well, you know, for federal band sharing. Because I'm sure we'll hear more about in the morning from Mark Gorenberg from PCAST for example, yes, there is a notion that if the, if the devices are required to be connected, if you use a, if you use a database management system the devices are required to be connected and multiple band frequency hopping, then the federal system can also evolve. It's not just a question of one time, you know, snapshot or sharing decision. Because if you change the, if the need for the primary licensee change, the database can adapt and the devices can change their usage without the consumer necessarily even being aware of it. So it's a nice, it's a nice model.

THE FLOOR: I wanted to agree with what you were saying about the flexibility of the database approach. And I want to make an analogy. If you are aware of what's going on in the Cloud computing and software service world with the database approach to regulation, one of the things that for example you might've experienced on things like Amazon or Google is they don't necessarily go through the same old-fashioned software release cycle where you have, Okay, here's version 2. Then you have a big rollout for version 2. Then, you know, you collect bugs and you have another goal release of version 3 like two years later. Instead they do incremental updates, and not just incremental updates, but also experimentation where you can imagine regulatory experimentation when you say, You know what? Let's try a slightly different set of rules over here and see what happens. And you can just take half the users and give them this rule and the other half let's give the other rule, and then let's see if there's like a difference in performance and you control the experiments in systematic ways. If you think about regulation as entering a continuous improvement kind of model it's very different from the old-fashioned, publish this in the federal register, and that’s when it takes effect. What I want know is, is there kind of an appetite to sort of think that through? This is a lot more revolutionary, it can be a lot more revolutionary as a technology than this very forward thinking group is thinking about.

MR. STANFORTH: I was looking for an FCC person. I can’t see one. I mean, it’s really from the technology side I think William and I, we’d love to start doing that. But the regulation doesn’t generally, in a lot of cases won’t let us do that. I think in some cases in some bands we might be able to try some of those things. But we do need to convince ourselves that we should regulate spectrum differently.

MR. WEBB: In fact, I’m giving a paper tomorrow as well that’s actually kind of along those lines. But I think that’s what we all really want.

MR. LUBAR: Let me toss up one more softball for Peter and William. Since neither of you were involved in PCAST, this will sort of bridge us to tomorrow. Since the PCAST Report in this area of database really did center in on that as an approach, you alluded to this as an extension. But what is your view of the PCAST proposal, PCAST Report insofar as I presume you both read it? I think that would interesting for the group to hear. I know where Michael is since he’s part of it.

MR. STANFORTH: I get to tell you the full story at 9 tomorrow morning in the PCAST panel. But the short answer is absolutely we’re convinced that it’s the right way to go. Again, if you look at what we’ve done in TV white space, we have allowed for secondary unlicensed access to the band. But when this spectrum management solution with a geolocation database at the core, you can start to consider access based on who is willing to pay for it, who needs priority, what kind of quality of service. So the short answer is absolutely, the whole point of this is because of what we can do in those other places that PCAST is proposing.

MR. WEBB: Some of you know, I used to work for Ofcom. And part of my time there I worked with Martin Kaye and others on studies about moving access to spectrum and I think we all came to the conclusion that the only way to get spectrum access to military spectrum was through some kind of shared database access approach. I think you are spot on. (Applause.)

MR. WEBB: We’re done. Thank you

# 2. JULY 26, 2012

## 2.1 Session III: Fresh Approaches to Spectrum Sharing

### 2.1.1 Eric Nelson: Introductory Remarks

MR. NELSON: Good morning. So we're going to be changing gears a little bit today. Yesterday we had an opportunity to kind of look at the current state of things. We took a look at what the existing federal spectrum ecosystem is. Got a chance to look at some spectrum surveys, how the federal government agencies are working to share with each other. And at the end of the day we looked a little bit on the commercial side action taken by the FCC for commercial sharing with FCC managed spectrum TV white spaces Today we're going to be changing gears and looking at commercial sharing with federal agencies. And, you know, we'll also, the next session after this one we'll be looking at some regulatory approaches. I noticed a little bit of a change. If you look at your program you've got a slight change in the title. This session was a bit of a challenge. Working with our moderator we had some, a lot of discussions about the topic. There was possibility that the PCAST Report would be out in time for the conference. And the amount of material we thought we were, we'd thought we'd be able to present increased dramatically since the report came out on Friday so we can talk more in depth about the PCAST Report. So we've gone, the title changed from fresh approaches to PCAST and the Future in Spectrum Sharing. Preston Marshall, who is kind of a sage of ISART has been very much a familiar face, will be moderating this panel.

### 2.1.2 Preston Marshall: Moderator

MR. MARSHALL: Thank you. I'm actually standing in for Milo Medin who has a big Google announcement today and couldn't come here. But we have the back and forth. We thought PCAST would be out for weeks before this panel came up, but then it didn't look like it could be. But we're really pleased to be able to add Mark Gorenberg to the list. Somewhat different from the format of the other panels. What we thought would be good would be to walk through the PCAST report. Mark's going to present essentially the same material that he did during the kickoff, and really annotate it for the community that believes in this, whereas I think most of the time the audience were, Mark's thinking were people who didn't necessarily get religion quite yet. So we're going to do an extended discussion by Mark.

Then we're kind of going to walk from the PCAST Report in the media so I'm going to do some technical parts of it, Peter Stanforth on white space and then kind of look to where it needs to go in the future because the PCAST Report really only defines the beginning of a much larger campaign to do more and more spectrum sharing. And so the panelists are kind of walking out in time and in generality looking towards the future of this.

So I want to introduce my panel. I won't do too much detail because I think pretty much everyone knows them. Mark is a venture capitalist, and has probably been the hardest working person in spectrum that I've ever met. Every other week he's in DC seeing 15 people. He's really made this a personal cause. Pete Stanforth, of course from Spectrum British talking about the white space. White space, as you'll see, is really key to the initial implementation of PCAST. Apurva is going to talk about spectrum sharing moving out again—he's also my competitor in DARPA Comics. John Stine is going to talk on really generalizing the interference management. We've done a lot of work on interference on case by case; that's how we've done business. PCAST presumes we can think about any possible system against any possible system, so it really requires an extension. Lastly, Lynn Grande is going to talk about the standardization effort in P1900. She walked up to me and introduced herself to me once. And, you know, I should be very interested what they're doing. And I felt really good because I started P1900 with Ted Berger at DARPA. We couldn't have a DOD connection to it because that was the middle of the Iraq war, and if DOD was connected no one else in the world would play so I really felt like we did a really covert job in getting that going. So with that, Mark?

### 2.1.3 Mark Gorenberg: PCAST Report

MR. GORENBERG: Preston, thank you. I got to meet Preston last August. I'm not a spectrum expert. I've been on the steepest learning curve that you can imagine over the last eight months. He's been, you know, we've leaned on him a tremendous amount as part of this study. And I'm sure his wife is, Is that another phone call from Mark Gorenberg? In any event, he's absolutely brilliant. He's done some phenomenal work. You've probably seen a lot of his books, though he's not going to talk about them himself. But this was his latest work on that he was the raconteur for the Aspens program. He does a number of these. He has another, he has a book out. He has another book that he's editing that's coming out and you can go on and on about his expertise in this field and his expertise in wireless.

It was both an honor and humbling experience to be the chair of the PCAST Report over the past, really over the past eight months. My day job is in venture capital as Preston was saying, so we look for large marketing opportunities. We invest in software companies. As, you know, we follow through this, we realize that we had hoped this would be the very big market. But with the way that policy has been, it's really been—and I think ISART is probably the great example of this—it's more the small market of true believers. So we're hoping to really turn spectrum from scarcity to abundance so that we can create that innovative virtuous cycle so we'll really have the opportunity to create a lot of companies as we saw in the Internet in the mid '90s. If that turns out to be our goal and if we're even together close to making that happen, that would be the thing that really turns the tide for this country and for the world in moving forward in its use of spectrum and the great products that would come out as a result.

I feel very honored to be here also because we've put together, besides PCAST itself, we put together if you want to call it sort of a working group of 20 technical experts out of many people that we talked to. And a lot of them are actually here today, which gives me a lot of comfort that if anybody asks any hard questions there's at least somebody here who probably wrote the work in the report who can answer it and go on from there. But rather than list through all the people that are here—and I know some of them are probably working—I'm wondering if the people who worked on this, would you please be willing to stand up so everybody can see and we can recognize you? You are really the true workers of this great report. Thank you. (Applause.)

I saw Tom Powers here. Tom has been an adjunct member certainly of our committee and a true backbone in terms of thought process, as were people like John Neuwith, from the FCC, and Doug Sicker, who was with the NTIA at the time who worked as sort of a sounding board, Does this make sense? Not make sense? The work that we did I think really was much of adding on top of a lot of great work that's been done through the industry. And, you know, let me mention a few things. And I apologize in advance for some of the work that perhaps would be left out of this list that is great work as well from people who are here. But certainly starting with the many years of receiver work from Dale Hatfield, who I know is here.

And I think Dale, as many people on this committee typified, the greatest thing that I heard on the honor of being on this list was people who spent so many years on this and have written so much about this basically to now come to that point basically where they say, Okay, we can start to get all this together and try to move this forward, sort of almost a lifetime of work. Some people, this was very emotional to kind of put all this together. The Spectrum Policy Task Force obviously that was chaired by Paul Callase, the National Academy Study that was chaired by David Lydell, recap work that Ben Cerf did last year, the FCC Technology Advisory Council, the Commerce Spectrum Management Advisory Council, a lot of the DARPA studies that have been done, and the ongoing evolution of work with a number of the agencies. We really piggybacked on a lot of that, and some of the panels you'll hear later on today such as a lot of the receiver work that went into that; Pierre DeVries, for example, that's here, did a lot of the, moved forward on that chapter. And perhaps most importantly piggybacked on the FCC national broadband plan of 2010 that sort of envisioned this new world we saw as our sort of work point, the idea.

We talked about going from scarcity to abundance, the idea of supporting economic growth, the idea of ensuring U.S. competitiveness and leadership. And also we were pushed constantly to try to see, even though you want to try to grow the economy are there ways to create new revenue streams for the U.S. treasury? Can we go beyond the current ways that we grow through that? You know, this is preaching to the choir so there's really no reason to go through this. I think the thing that, the point that I would drive out of this, it's interesting that the reality has always been ahead of the forecast, larger than the forecast. No matter what we forecast this at, it seems to be larger than we expected and will continue to be larger. And more than that, we talked to a number of people that believe by 2020 or beyond that the greater part of this will be machine to machine and not just, you know, in the way that we see cellular being used today.

And the other thing that was true, which many people in this audience know very well, it's not just the commercial sector that needs more spectrum. The federal government continues to use and will continue to use more and more spectrum for its work. For example, one idea we talked about in, you know, in unmanned aerial flights going just eight years ago from about 67 flights to 7,500 just last year in this continued sort of extreme work, extreme movement forward. And so these sort of were part of the background of what we were doing.

Clearly we've piggybacked on top of a great report that came out this year by the NTIA looking at the 1755 band. If you haven't looked at that report, I definitely recommend that you do. A lot of good engineering work that went behind it. And you know, if you sort of read through that as a conclusion, you know—and we're not weighing in in the fight over what to do over the 1755, particularly the 1755 to 1780. I think that’s going to be continued work in Washington, and hopefully will come to a conclusion that works best for everybody.

But in the sort of general case going beyond that let’s just say that there’s a more efficient and immediate use of federal spectrum through sharing. And particularly we looked a lot at the higher frequency bands. We looked at the, you know, the 2700 and above. So particularly the 2700 to 3700 there was opportunity to try to create a gigahertz of spectrum. We started with the notion of could you create one big contiguous highway out of that with lots and lots of exclusion zones, but really move just towards the idea of backing away from the word “contiguous” to the idea of just creating a superhighway. And that superhighway became sort of the metaphor. This, of course is the map as you know it today. The people who live with this most of their life like Karl Nebbia, Karl Nebbia probably has this memorized in his sleep at this point. And has done a lot of great spectrum work for the agencies for, Karl, I think it’s what, 20,30 years?

MR. NEBBIA: Since ’83.

MR. GORENBERG: ’83? There you go. You guys can do the math. This is the map we all live with today. You know, this sort of the vision that we had of the metaphor that came out of the report, which is the idea of saying that the U.S. policy, policy of the U.S. government should be to share underutilized federal spectrum. And then we came out with a notion of working, piggybacking on the NTIA reports to say that we should immediately identify basically a gigahertz of federal spectrum for sharing and start to analyze that. And we talked, you know, the basic theme of the report is to obviously move away from small area use of spectrum to the sort of wide, wide range of spectrum for large blocks that can be shared by devices that can coexist together, whether that is by frequency, by geography, by time, by code, by modulation or other sorts of dimensions with the idea that I know we do that that heuristically today but the idea that that could be more automated over time. And we can envision perhaps in the future computer systems that look at that and change how things are packed together over time almost automatically, of course many years out, but we’re hoping to start.

And we also looked at the idea of talking about effectiveness metrics. Some of this was piggybacked off work that’s in Preston’s newest book. But the idea is not just to look at how people are using the spectrum, but also to measure how they’re stopping other people from using that spectrum; in other words, who they would actually, you know, preclude from using that spectrum. And we came up with some measurements that say that because of that you could sort of effectively increase capacity a thousand times by combinations of small cell, really looking at how to pack things better in terms of receiver performance limits, and also sort of relaxing perhaps some of the ways that people work with each other in terms of interference.

You know, we, our cornerstone was to sort of look more at existing technologies today, which are more databases and small cell oriented with the idea that over time the newer technologies that are being developed and progressed year by year would come into that mix, and actually this would create the backbone that would allow that to work on a more virtuous cycle to go forward.

So one of the cornerstones of the report was the creation of, we ended up quoting it as spectrum access system, which at its heart is the geolocation database, but the marketing powers at the PCAST decided that geolocation database was a little bit too techy to go forward with. So like spectrum superhighways, we'd hope that things like spectrum access system become part of the lexicon.

It was the idea that you would have a hierarchy of users. You would have, you know, primary access. We were only looking at federal spectrum as well, so primary access which would obviously be the federal government. Secondary exclusive access which could be LTE systems as is sort of talked about in the ASA system that's being talked about in Europe by Nokia and Qualcomm, or could be, you know, more generalized for people that were looking for quality of service and particularly, you know, even people in some geographies are saying, you know, they may have run effectively unlicensed, but for a period of time want a quality of use and could effectively pay for that and get that sort of exclusive use in that area.

And the other was the idea of a tertiary user which we, which in fact is it's unlicensed, and we ended up coining as generalized access. And that's the idea that you would have some sort of registration, whether that's registration, automatic registration, or at least the federal agencies would have an idea, a better idea what's out there. And that was very important to them. And then of course the system would also allow sensing options, you know, for federal systems that would be too sensitive to put into a database, and other options like that.

But our main cornerstone of trying to come up with this was to have the notion of an open system that other systems could tie into so you could allow access to unused spectrum, and basically perfect that effectiveness over time. There's a lot in the report about receiver management. I know you're going to have more sessions on that today. There's also work going on at the FCC TAC I know Dennis Roberson is chairing. And, you know, I think this is a topic du jour now. Obviously particularly there's been a number of different instances of things that are happening. You know, GPS LightSquared sort of put a moniker on that even the general public started to read in general magazines and just daily newspapers to understand it. So we looked at how do you start defining with things like super protection limits and how do you, you know, how do you potentially move that forward over time, and perhaps in some areas you'll want to put in reasonable standards; hopefully not that often.

In terms of some of the core recommendations, we talk about creating a spectrum management team. We have a CTO today. I mean, you go back to the '70s where there was a director of this in the Whitehouse, and you had part of it, he had part of what was in commerce that was called the office of technology. And in some sense today we have a CTO. So one logical thing is under the office of the CTO to start to look at this responsibility again as well with other people, other agencies, other parts of the Whitehouse associated with the Whitehouse, you know, such as, such as the NEC, such as the Office of Management and Budget, to work together with the agencies and with the NTIA to put more of a spotlight on this, and the spotlight frankly that it deserves and needs today.

The other we talked about is trying to come up with some sort of incentive system for the federal agencies. You know, in Europe they tried spectrum fees, more of a stick. We said, There should be a system that's more of a carrot. So how do you move forward with that? We said, you know, the spectrum bill that congress passed early this year started to talk about starting to do an accounting of federal systems. And in talking with OMB it became logical to take one more step to see if we can start to come up with ways to put a cursory measurement against how this is being used. And so we came up with the notion of a synthetic currency. We called it spectrum currency, the idea that you can start to measure these, and look ahead two, three years at the plans of the agencies that may need more spectrum for new things, but can lower their, could probably lower their footprint from efficiencies of the things they're working on.

So at the lower end of that footprint they would basically lower their amount of spectrum currency. And with that you can start saying, Okay, if you put these plans forward then people could basically bid on hopefully on real dollars. This would then let the early adopters of the agencies be rewarded for making their system more efficient, particularly more efficient with the idea of sharing. And working hand in hand with that was the redefinition of the spectrum relocation fund to more of a spectrum efficiency fund. And, you know, from the very first discussion that I had with Michael Calabrese, this was very top of mind. And I think it's been talked about by him and others in Washington for a while. But it became obviously very important to think about if you want to move from the idea of reallocating to sharing.

And we said we need to take that one more step because if you believe—and not make it band specific. Because if you believe you're moving towards a world with very very wide bands basically, or very very open blocks for people to coexist together, then it doesn't make sense to say that you'd collect fees for an auction here, but only use it within that small sliver. It should be open for basically the federal agencies who want to then make the systems more efficient for the common good because we have no idea 20, 30 years from now where all these systems really will be.

And another cornerstone point of the report, and there's a chapter on that, is the idea of starting to look beyond a licensed model of, you know, long-term licenses. Effectively we don't use the word "ownership," but effectively we all know there is an expectation important to the people who bid on these auctions early that there's sort of a lifetime renewal as long as they want to use it because of the capital expenditures that they put in place. Same token, opposite end you have unlicensed. So what about the notion of medium term and short term licenses that match the capital investment that people will want to put forward particularly around small cell, and also then let people have quality of services?

So for example if a hospital that's doing medical applications said, We want to have an exclusive secondary in that geography, they should be able to bid on that in a very small auction, let's say. And they probably don't want to bid on that in that particular place for more than, let's say, one to three years because we're actually talking more about access than we are about owning hard allocations of spectrum. And our assumption is that over time that this cycle, you know, frankly like apartments there will be a lot of them there to bid on; people will build devices that will have multiple frequencies associated with them. So it's an easy thing to move around, and once you can get this cycle of people sort of being on spectrum allowing to go back into the pool in terms of access amounts that you get a truly much faster innovation system going.

By the same token, a model like this could be used for a small cell systems that are used almost, local carrier like in the WISPs and people like that. There's a number of applications that we talked about that may want quality of service, smart grids and others that may want quality of service and not just working unlicensed, which a number of people are doing today. We had a number of economists on our panel. One of them, Bill Lehr, who is here, a number of them who sort of looked at this idea and started to move forward, the idea that we should be experimenting with these licenses over time, and this allowed the federal government to also, the NEC to have a way to say, there is a way beyond the sort of auctions in federal spectrum that we know today to look at revenue streams that may be further out.

Some of the immediate actions that we talked about, we talked about creating a partnership steering committee of industry, effectively industry CEOs. PCAST did this more recently with the advanced manufacturing partnerships steering committee, which was chaired by the CEO of Dow Chemicals, CEO, and the president of MIT. And they put that report out last week. And it was a very positive report to help move a number of people forward. The idea of creating a real world test city, scalable test city and mobile test services to use for sharing, testing of federal and also of public safety, and then also the idea of immediately moving towards sharing in a couple of federal bands.

And I think a number of us, including ourselves, started to converge around the idea of immediate sharing in the 550, which the NTIA put forward a year ago and I think now people are starting to say with sort of the mental evolution of use of small cells that that can be used, exclusion zones can be smaller than originally envisioned when we're thinking more of the existing world. And this could be very useful in sort of the sharing environment. And we can use things such as white space technology today to help move that forward and put it to use. Those are really the core comments that I had.

But just to be clear on a few points, one is we were only talking about federal spectrum. The entire report is about how this can be done in federal spectrum. In terms of technology we look at starting with existing technology. We think that we can have something up and running within three years for use. And if you look at the notion of clearing versus sharing, you know, it's been on average about eight years to put federal spectrum to use if you go through a clearing reallocation practices. And clearly in the 1755 report, that talked about more of a framework of about ten years. We think that it's not just the idea of doing this for the cycle; we think we can get people spectrum faster actually by going to a method like this, which is really important.

We think that this can go to—and in terms of clearing versus sharing, I think everybody actually has agreed that sharing is important. What they don't necessarily agree on is when, how, and how fast—and that is really what the debate is—to go to dynamic sharing. We think that we have come up with some ideas for revenue generation. And most importantly as touched on, we hope this work and a number of the other pieces of work that we've done in the last few months—and this has been an amazing time. I think it's going it be a golden era for reports and work going forward on the next 100 years of spectrum—that we can get an innovation cycle going. That is—venture capital, that's the most important thing—to us, I think to the folks in this room who are looking at creating new companies, the most important thing to them as well, and frankly to the industry itself, the most important thing to them.

So with that I'm going to sit down and move forward. The report is up on line. We haven't printed many hard copies, because as everyone in this room has probably noticed, the government is not trying to spend a lot of money on things that aren't important. But this is what it would look like if you actually like printed it double-sided, and put it together. Thank you very much for your time. (Applause.)

MR. MARSHALL: I went to university so I could get rid of PCs from the government. Mark asked me to talk a little bit about the metric. If you saw the public announcement John quoted, A thousand times improvement in bandwidth. Which is actually better, because there was a number 40,000 in one of the PCAST reports. And that would've been really really hard to defend. But one of the key things I think in this report was to go back and try to form a metric, not a spectrum efficiency but a spectrum effectiveness. Efficiency is between zero and … there's no cap; we can put as many bids as we want. But effectiveness is really what we're after in delivering broadband. We created a metric on that. It's in Appendix B. It's totally stolen from Cambridge University Press.

One of the keys to that is it really focuses on not how transmitters use spectrum, but on how systems and architectures allows spectrum to be reused. So what it measures is how one use of spectrum precludes another use of spectrum. That means receivers in many cases dominate that metric rather than transmitters. We really we had one of those questions you'd just kill for when we were in the gulf of, Would this have avoided LightSquared? And can you quantify it? And in fact, this metric very much quantifies, we have in the report how we quantify what's the real spectrum usage of GPS versus what the transmitted signal of GPS looks like.

So receiver performance is in there. It talks about it reflects systems' interference tolerance for exclusion zones and the range over which the system operates or requires exclusive use. The whole U.S., if you think about this, the whole U.S. government was tasked to go find 500 megahertz of spectrum. That essentially doubles the amount of spectrum for CMRS. Our arguments are things like receivers' interference tolerance and all are much more powerful tools to get use out of spectrum than going and trying to cannibalize federal systems and moving people's around. Don't search for spectrum; search for efficiencies in how people use spectrum.

And that was the purpose of this metric, to quantify ideas like receiver standards, which otherwise look like infringements on people's rights to build lousy equipment. So this is really fundamental. I think when Mark presented this there was a lot of positive reaction at PCAST that this report could really quantify the impact of the recommendations. I think a key assumption in this was to say that the search for 500 megahertz is certainly a reasonable goal, but 500 megahertz essentially doubles CMRS spectrum. LTE is perhaps five times more efficient. So if we had done nothing more than say, This is how we think you get 500 megahertz, we would've potentially added ten times the capacity of CMRS in a decade away when the broadband plan said you need 50 times six years before that. So the metric really became important in trying to visualize how physics and information theory would force the evolution of CMRS, and how we could look at spectrum sharing in the context of where CMRS was going rather than necessarily where it was today.

So this is a science and technology report so we had two equations. And this is a general one. And this is the capacity of a collection of devices. The important thing is that interference range squared, if you cut interference range by two you get four times the capacity. If you get spectrum you only get double the capacity. So we really are arguing we're going to focus on different terms in that equation. Ultimately we came up with this. The architectures are going to have to evolve with this kind of effectiveness, which is, well, *C* over assets, but the real important term was $I^2$, the interference radius.

How do we get more and more systems into the spectrum? CMRS capacity or capacity of any of these broadband systems is not a function of spectrum; it's a function of how many times you can repopulate the infrastructure within an area. So they had a lot of implications in the NTIA report. A lot of bands were looked at and said, Well, you can't really use high power LTE in these bands. True. But the PCAST argument was, That's really not where you have to go. You have to go to lots and lots of spectrum in use; so even if you can't run a 50 watt 6 sector LTE tower, you could run hundreds of cells where Wi-Fi like devices or unlicensed equipment's in that band. And so we should look at federal sharing not against towers, but against a large innovative infrastructure that also fits with Mark's model of venture capital, because small cheap things are much easier to innovate than big, tall towers that take ten years of building and populating and all.

So it fits with the idea that if we want to encourage innovation then we want to look at these very small Wi-Fi-like ecosystems, which is constantly innovating and recreating itself every year. So from the point of view of innovation, it turns out lots of small things is really good. From the point of view of bandwidth, lots of small things is good. And that opened up a lot of opportunities for federal spectrum sharing that really aren't apparent when a large carrier comes to NTIA or DOD and wants to share spectrum. It's a very long process. What we do now is argue, That's not the target for federal spectrum sharing. It should be more like, as Mark mentioned, a hospital wanting to put in a body area network, someone wanting to invent like LightSquared but wanting to do it with thousands and thousands of cable boxes.

And so our, take a look at this metric. If I go from the 1.2 kilometer range tower to 60 meter photocell or Wi-Fi, and that with just 60 feet of interference tolerance in my systems and I've gotten 600 times improvement in my architecture effectiveness without adding any spectrum to it; therefore, our conclusion was the best use of federal spectrum is not clearing it and just giving 500 megahertz of CMRS, but to find lots of these opportunities where people can build fairly dense, lower power infrastructures in areas where federal systems weren't heavily populated.

So essentially the vision that this report assumes CMRS will have to go—we're not saying they'll have to do it—but we're envisioning that they will have to go to that emerging infrastructure. And federal sharing against that emerging infrastructure is a fundamentally different and much more tractable problem than sharing against the existing one.

So this is the slide I was building for Milo before. Milo is not going to come. So if you read the report and if you're a geek, so I was the biggest, one of the biggest advocates for DSA. DSA is not in the report. This report is terribly unbalanced technologically towards incumbents. We require mandatory database use. Incumbents assert interference criteria. There's not really a process to challenge that. We have static exclusion zones that require registration. I believe that's a requirement to get the sharing regime through.

I think the rest of this panel's focus is on the other half of that. How do we rebalance the sharing practices and bring other technologies into play? Interference tolerance, much heavier engineering on the general case of interference criteria, how do we do that and make exclusion zones selective registration so that everything doesn't have to be registered? For spectrum sharers we need IQ tunable filters. The fundamental, if you look on the blogosphere attacks on this report, in large part they are, We don't have tunable filters. If there's an engine for innovation it's the guy who figures out how to make a tunable filter at the cost of five or ten soft filters. That's the enabler for this thing.

And of course, DSA, as far as I know there's been one large field trial DSA, which is the one DARPA did. I wouldn't want to say—it's certainly the—we did not do a broad class of all possible users. We did a single case and proved it can be done. We certainly didn't prove it was ready for prime time. So we have to go and do that. We're going to have to invest a lot more money in doing DSA.

I think there's also a tendency to think about unlicensed. I think this is an opportunity for innovation right between the two. We really have two ecosystems today. And this really opens up a whole technical rationale for a third ecosystem. Equipment that can be licensed and unlicensed, equipment that can be initially deployed unlicensed and convert. It can convert nationally. It can convert locally. It can be or 3 watts rather than 50 watts or 100 milliwatts.

And the whole offload architecture really has been done pretty ad hoc. The technologies that have been brought to offload have been two existing ones. Either they make LTE in small boxes or they try to make Wi-Fi integrated into the CMRS architectures. It's hard to believe that either of those was the optimal answer. But they really didn't have spectrum homes to be developed and to emerge as a third candidate. Perhaps a primary carrier is CMRS. This whole framework provides an opportunity to develop a whole third ecosystem of devices.

So technology shortfalls. We don't have good interference models. I know John Stine's going to talk about that. This isn't a circuits consortia, but very clearly the filter work, I always try to, like, to tax two percent of my DARPA program to do something on filters. I never published on it, so you can see how successful I was. I believe they got something—it's unexciting and somewhere where we have to put in work.

And we need to take DSA and do a lot of large-scale experiments. People playing around with Wi-Fi is not going to create confidence in the community DFS, we need to take it to federal agencies is kind of a mixed experience. And so we need to really think—Tom Kidd and I were talking today about really thinking about DSA as a recourse device rather than as a primary. It allows me to be sloppier in a lot of my other interference modeling. Maybe DSA in interference modeling we should think about as one trade space. But we have a long way to go before anyone would let DSA in. If you read the blogosphere between when the PCAST Telecom—Mark, when was that that you did the PCAST approval?

MR. GORENBERG: End of May

MR. MARSHALL: End of May and before the report came out everyone assumed it was DSA. And if you just look at how they all landed on the report as being premature you can get a sense of what would have happened if we had put that forward. I think the other thing in here is the receiver technology requirement. I think our report, with all due respect to Mark, is unduly cautious. I think we did the community a massive disservice when Spectrum Policy Task Force came out and said, We can have flexible use of spectrum, and didn't mention that the cost of that was you had to have things like receiver standards. The person who paid the cost of that were investors in LightSquared, who actually believed you could be flexible in your use for spectrum, and went and put a lot of money in.

I think as an engineer we ridiculed who could think you can do that, but I think as policy we really led them along because we didn't do—and we were on the Hill, I forget which one of us, Mark or I, sort of characterized this as we let people have dessert without eating their vegetables. The dessert was spectrum, spectrum, flexible spectrum use. The vegetables was you have to be to receiver standards. And I believe it would be a big mistake if we let the sharing recommendations in this report go forward without being coupled with the idea of receiver standards. We will just have a whole lot of lousy devices. If we're going to let computers decide who can enter an adjacent band then we have to understand what those receivers look like, everyone has to have reasonable expectations about who can enter the band adjacently and they can't be having to go to the FCC or NTIA or congress to litigate it. I'm not a venture capitalist, but I can't imagine a venture capitalist wanting to invest money in this field after watching LightSquared.

So with that we're going to sort of start with Peter. I've been delaying for you, Peter. With Peter talking about some of the more, the white space technologies is based on, and then kind of walk out looking at more general and more forward looking approaches.

### 2.1.4 Peter Stanforth: Spectrum Sharing Using a Database Management System

MR. STANFORTH: I feel like the kid that got locked into the toy store the night before Christmas when this came out. It's really cool stuff. The bad news is Preston gave me five minutes to explain --

MR. MARSHALL: Seven.

MR. STANFORTH: Oh, seven, sorry. So to explain how we take white space technology and we make this happen tomorrow as opposed to ten years. The only way I can do that, some of those slides are very similar to what you saw yesterday on white space but be careful because the message is different.

The first slide is very easy. White space technology is real; we made that point yesterday. The rules are in place, the databases are in place. They're certified. The radios have been certified. They're operational. And so we have a baseline; we have a foundation with which to work on. So the rest of the next six and a half minutes I'm going to try to talk a little bit about what's missing and what we have to do in order to make this happen. If I get my way we'll do it in much less than three years, but, you know, that never happens.

So back to the slide we saw yesterday. Two things I wanted to bring back up on the slide. The first is that in white space, TV white space we have to deal with thousands and thousands of incumbents that range from high power television stations to translators to the microphone that pops up in this room for an hour a year, and everything in between. So when we looked at the 1750 report from NTIA and they identified I think it was 3,500 things that had to be protected, compared to what we currently do that was like a walk in the park, right? So scale of what we got to protect, you know, keeping track and then protecting them, that really shouldn't be an issue because in the TV land we already deal with an order of magnitude more things that we protect today.

The other thing that's interesting is that we have these sort of multiple databases, two in the slide, and they're syncing up. And if you think about it, these databases in TV white space appears. But what they're doing is when the program-making equipment comes in and registers for protection in one database, the first database, the top one, tells the second one to sort of protect that, put that reservation in place. So I tend to think of myself as a reasonably trustworthy person, but a lot of the three letter agencies take exception to my style of dress and usually my haircut, so they don't like that idea.

But here's a way you can get around that particular issue. Take that slide and rotate it around by 90 degrees. Instead of having two databases that appears, take our database and put it in two places so let the three letter agency make their own reservation. So the database which would now be on the right, which is the public database, starts with the assumption that all the spectrum is available. They will simply get told that there's a reason why you can't, you can't use this piece, you can't use that piece. Doesn't need to know why; doesn't need to know what; it just needs to know it can't use that piece. So if you really are very sensitive there are ways of actually taking the basic constructs of what we do and the synchronization today and solving that problem.

Now, when we started out, I would be in presentations—I think I actually came to one here a couple of years ago—and the broadcasters would put pictures up like the top right. They were convinced that white space was going to be a train wreck. How can you trust the industry? They'll screw it up. They couldn't be—you know, look at this guy standing here. How can you trust him to do anything? They've gone from that level to something a little bit like the bottom left picture now. Let's call it detente. We've got them to the point that they're not convinced we will create Armageddon, but they're not necessarily all the way there. I'll come back to that in a minute.

The way we got them there was through having all the participants involved in the process. What the FCC did, and to give them credit, was after they wrote out the rules, after they had brought out the definition or decided I should say who the database providers were going to be, they put the incumbents, the database providers and radio vendors into a series of workshops. And we went through the rules; we went through how and what and where. And over the process of time and listening to both sides of the arguments, consensus was come to on a lot of these issues to the point now that the broadcasters may not be totally happy, but at least they're reasonably comfortable that we're not going to go crazy and that we'll do the right things.

Simple example of that was that the rule requires us to synchronize databases every 24 hours. A broadcasters say, you know, That's very—there's a lot of latency if you do it every 24 hours. When the group of database providers got together and said, How are we going to sync? When are we going to do it? We said, You know, we can probably do it in near real-time. So let's tell the broadcasters we'll do it every 15 minutes. That issue went away. So the key to this is when you're defining the rules, the last piece of this slide is make sure that you focus on the what, and then let industry and bright people in this room and other places figure out the how it actually gets done.

Now, there's still a lot to do in white space, in TV white space. I don't want to make it sound like we're in the rose garden yet. And part of the reason for the incumbents' I would describe as detente rather than being really happy is that we still have to, we've got limited actual use. There's not millions of radios out there today, so we've still got to work on that. There are still some areas in the way that the protection is defined and utilized that they would like see tightened up. They would like to see less time of a particular registration. As an industry we'd like to see the protection tightened up so that in a trade-off for that we get more access to more spectrum. At the same time if we can get harmonization with international regulators and get some standards in place, that obviously works in everybody's favor. We've still got work to do, but doesn't mean we can't get going.

Now, I used this slide yesterday to explain a problem. And the only thing I want to talk about today is the picture on the right-hand side. Because remember two slides ago my picture of the train wreck. Today the biggest users of our white space solution and the people actually paying us money to use the white space solution are the broadcasters, right? Nobody really thought about that when we started out, but there's two sides to this as I said yesterday. But one of the things that came out of this is in order to protect incumbents, we have to build a very high fidelity database, and we have to build all sorts of GUIs and UIs to prove to them we are protecting them. And it turns out that information with all those UIs becomes very useful to them. So this screen shot on the right is actually for a tool we sell to the broadcasters so when they go out and they're doing their news events or they're doing their whatever and they want to power up the wireless microphones, they can use their Smart Phone; it's got their location. And it simply tells them, Forget all the stuff on the left. Just look on the right and try and use the channels that are in the green, right?

So as we go through this process, the other thing that again should be considered is that there are trade-offs and benefits and issues on both sides and in some cases there are some that we didn't really anticipate but turned out to be real benefits which the broadcasters are now leveraging.

So lastly, in terms of where the database is today, so we already keep track of radios coming to us, they're registered so we know who they are, where they are. They ask for spectrum. We give them access to spectrum. So all the things that we need in order to create effectively clearinghouse function so that you can actually charge for use are already inherently in there. We don't do any white space because it's unlicensed, but you could do it.

So that gets you to do these things that Mark and Preston talked about, these alternate models. We have a world where we view today as exclusive licensed use, nonexclusive unlicensed use. Once you've got this idea of a spectrum management database, all the shades of gray in between become realistic. And the last piece of it is where we believe that, you know, we can manage priority, we can manage the quality of service, and quite frankly where we'd like to see this go is this spectrum management system is sitting out there almost like the air traffic controller, and he's dealing with, just like the air traffic does, military jets, private jets, you know commercial jets and everything in between, and basically making sure everyone they're going to, everyone lives nicely and cohabits together. With that, I think my seven minutes is up.

### 2.1.5 Apurva Mody: Fresh Approaches to Spectrum Sharing and Emerging Regulatory Rules in the TV Band White Spaces

MR. MODY: All right. Thank you very much. First of all, I'd like to thank the organizers, NTIA, Eric Nelson, who I've been working with at NTIA and many other people at NTIA who have given me the opportunity to speak today. So my name is Apurva Mody. I'm the chair of IEEE working group, which is a published standard that, which is cognitive radio base standard in TV white spaces. And recently won the IEEE Standards Association emerging technology award.

We also started the White Space Alliance. The White Space Alliance itself is not just about 822. It's about a wide variety of technologies and service providers and to bring the whole ecosystem together. I'd like to recognize some of the people. First of all Bruce Kraemer, who is out there. He's the chairman of IEEE working group. And also some of the folks from like Rich Kennedy and Peter Ecclesine who are representing, you know, their companies and their working groups. From White Space Alliance we have Dan Lubar, who's the service provider right here in the Denver area as well as Darrin Mylet from Adaptrum who's part of the White Space Alliance now, and they're building a pre-822 system.

I'm very happy to be here and explain. In fact, the PCAST Report mentions white spaces 55 times. And we could be in the right place at the right time, so thank you very much for that, Mark. One of the things that I want to, you know, we've all talked about how this is a priority as far as the United States is concerned. But this is even a bigger priority if you just look at the world as a whole. So say for example there was a recent report that said, you know, that the population of the world has become seven billion people and 73 percent of the world population still doesn't have Internet access. Many people have cellphones, but they don't have a qualified Internet access, so that's 5.1 billion people. That's a big market.

And then 49.5 percent live in rural areas. In rural areas we don't have a technology that can go far, reach far, and provide the services that people need. So this really makes it a very very big market. And if you then look at machine to machine applications, you know, this is really going to explode and become a 10 to 24 market. I've been getting requests from all over the world, for example farmers in Argentina and people in Brazil. You know, farmers in Argentina, for example, have to travel 0 kilometers to turn on the tap so that their animals get fed. Folks in Brazil, they have this big rain forest that they want to protect from illegal deforestation, drug trafficking, human trafficking. The United States has got a big border. In fact, if you just think of the Arab spring. The Arab spring couldn't have happened if people didn't have access to Internet or be able to communicate. I think these are great enablers. And the more people have access to information I think many many things can happen, not just in terms of revolutionary technologies, but the enablement of people, I mean, people's rights and things like that. So I think that that's what we would like to do. I mean, we would like to take the technologies, bring the whole ecosystem together, and provide it in such a way that we can make a difference in the world today.

So White Space Alliance was formed in December of last year. We had a technology organization and we would like to be a catalyst in shaping the worldwide white space ecosystem. We will be simplifying the standards, but it's not just a standards organization. You know, it's the standards that we will be looking for are IEEE. One of the standards that we are going to start working on, or are working on, is 822 to simplify the standards so that people can implement it. GPP, as Peter suggested, there's some interest from GPP folks to come and also ITF. So, you know, really speaking we would like to bring a wide variety of people to come and be part of this bigger umbrella. And at the same time to create a body that can educate and create awareness in the marketplace as to what are the benefits of white spaces. And also, of course report and certification programs.

So moving this a little bit and changing directions, as we all talked about, you know, different things and a wide variety of spectrum sharing domains and enablers, we've been investigating this, my company just wanting to come here and doing a lot of cognitive radio research. We have a lot of companies, for example, Shared Spectrum, you know, this does a lot of cognitive radio research. And Dr. Marshall, who has done some pioneering work at DARPA. But as we all know, space, time, code, frequency, these are all different domains that you can share. You know, and even if you might be in the same location at the same time but maybe in different frequency or code space or some other, you know, domain that you can share the spectrum and still get the services.

White spaces. We have been talking to a lot of people about that, but, you know, white spaces as well as gray spaces is not just a possibility but it is also a reality if you carefully craft the problem and the system design steps, so really speaking, I mean, the next generation, the next step is going to be not just white space but the gray space. Coexistence in spectrum sharing can be done many ways, like avoidance, tolerance, suppression. Dr. Marshall talked about that. I completely agree with him. Filtered design is the main thing. I mean, I think one of the key things here is the analog filter design.

And the other thing, that I really want to echo Mr. Hersey's sentiment yesterday, which is spectrum sharing is a two-way process. You know, I mean, it's really like a marriage. Just as Peter said that, you know, broadcasters have become their biggest customers. I mean, we've been trying to tell broadcasters who have been part of the 822 working group that, Why didn't you adopt this technology? Because they have a problem that they are directional flow, they can only provide, you know, access in one direction. And they really need the customer feedback. And in fact, they can adopt the white space technologies to enhance the content and service that they are providing. Same thing goes for the maybe the Coast Guard or the DOD that just as once the spectrum becomes available maybe you can come back and start using it, right? So my comment would be to you guys that, Make the spectrum available faster so in fact you guys can come in and start using it, right? So that's one of the things I would like to propose.

Now, coexistence enablers. We all talked about spectrum sensing and—oh, I don't have much time—sensing database beaconing. One of the things that we proposed here in this is to create a beacon based solution. And in fact we're working with the Department of the Navy to create a beaconing based solution. The idea is that the beaconing based solution will be making hundreds of megahertz of spectrum available throughout the United States and it really resolves a very important problem of the U.S. Navy. And there are things on how it will work, how it will not work, the pros and cons of using it.

The last thing I really want to talk about is the emerging white space ecosystem around the world. We talked about the United States. Canada, one of the key things to look for, you know, so there are common things here but there are also differentiators. For example, U.S. was the first one. You know, I really admire FCC's, you know, innovative spirit to make available the spectrum. Obviously they were the first ones and, as Mark said, the rules of the FCC are pretty conservative. But at the same time, FCC went first, you know, so obviously it leaves room for other people to come and innovate. For example, in Canada you can transmit up to 00 watts of power, right? So you can really reach very far. And they already have light keying which is in place. In UK, you know, just as the United States we only have pull mechanism; in UK we have also a push mechanism.

And one other thing. You know, Singapore, for example, there are trials going on in Singapore. And even a small country like Singapore is really innovating and creating rules that are tougher. What they are envisioning is that they intend to have a big market, but if they can create technologies then they can sell the technologies all over the world. My time is up. Let me just conclude my talk. I had some more cites.

But, you know, White Space Alliance is formed. We are actively seeking members and your participation. We would be very happy to talk to you. We propose advanced beaconing for 3500 to 3650 band and hopefully the FCC will allow us to form a group and continue the work. White space as well as gray space operation is not just a possibility but reality. Worldwide spectrum sharing rules are being developed we need to accelerate the process so that we can create a market. Small countries like Singapore and Japan are really innovating, so I think that that's something that we need to be worried about; that, you know, we don't want to be left behind. And that's it for now. Thank you. (Applause.)

### 2.1.6 John Stine: Model-Based Spectrum Management: Enabling Dynamic Spectrum Sharing

MR. STINE: So when I was asked to speak, the Mitre Spectrum Management does a lot of different things. When we talk about the PCAST Report and what is demanded from the PCAST to do it as database based spectrum management across very different organizations it is ideal for supporting that particular solution. This particular presentation was designed to answer a question that Eric asked me to kind of emphasize is how do you do the sharing between government and commercial, especially when you have databases where you do not want to share the information that's in that database. But hopefully in this presentation you'll get more than that particular story.

So what is model based spectrum management? Well, it's spectrum management based on the creation and exchange of models. And those models are trying to capture balance of spectrum so we're modeling transmitters, and what we're trying to convey in those models is how to do that. The transmitters emit radiation. And we model receivers, and in those models we are trying to convey what is interference to those receivers.

Now, in our research we developed 13 different constructs that are used to build these different models. And they're going to capture the temporal, the spatial, the spectral variations that occur as a result of their operational use and environment. Those are all contained within the models. What's nice about those models is that they do not reveal the details of the systems, what type of modulation, what type of radio, what type of antennas that they're using.

Together with the models there are attendant computations for assessing compatibility among the models. So once you model something then all the computations for interference and whether or not two different uses are compatible is based on the models themselves, not on any of the data that was used to create the models. If you look down at the bottom I have some diagrams that sort of show the difference here. If you look at the legacy right now, that's on the left, that's where you collect lots of data. Yesterday we heard about the federal spectrum management system where they have data that have thousands of entries of each individual system that's out there. And normally you'll have some user that sits there with his tool with very powerful capabilities, sitting there and studying that problem, and ultimately they come up with a decision. And that decision is what is the spectrum assignment is going to be.

The problem there is it is a lot of effort even with the tools, and it's going to cause a very slow process to occur. It's going to take a long time to make those decisions because there's always a study that's kind of involved with that in making your decision. What we're saying is being difficult in here is that you will use those tools to first create a model. That model then allows other tools to be able to do computations against all other models of the system that are out there. These models are what then you can exchange between what the government does and you don't want to tell them about. You just tell the models about what the spectrum is that's available, or they can convey what spectrum is available.

Let's look at another way of looking at these models. It's that these models sit at the center of a number of different things. In the system of spectrum management it can serve the same function that IP serves for the Internet. It becomes a way for different spectrum management systems to convey to each other what spectrum is available and what spectrum is being used. The very act of doing spectrum management by creating these models in effect creates spectrum policy. The models themselves are machine readable, and they can be conveyed directly to the RF systems so the RF systems can know what spectrum they can use. Also, the RF systems communicate back and forth with these models to be able to deconflict their use of spectrum.

And within this model by just standardizing the modeling approach we anticipate there can be innovation, all those different layers as you see on the left. Also the models can serve as a central definition of spectrum use for many different communities that are involved in spectrum management. Regulators could define what a user or a spectrum usage right for a particular user with the spectrum consumption models.

Remember what I said? Part of these models contain a receiver model. Those receiver models will serve the function as being the specification or the limit of what those receivers are supposed to perform in order to get the protection that is in the spectrum management policy. They are to be able to be used from the commercial users. I'll point out the brokers in my next slide. It provides a great opportunity for first of all the communication between different communities of interest of the spectrum where the government can convey to a white space administrator what spectrum is available dynamically, but also these models provide a means that multiple different white space administrators can collaborate in dealing with the coexistence issues that are present with doing a sharing system. So that's what I'm showing here.

So what I envision happening is a spectrum owner, and let's just use as an example let's say the government has spectrum and they're willing to share it. They go to their favorite database administrator, and together they work together, put together some models which they think will allow a marketable presentation of that particular spectrum, it's introduced into the market using these models, and then I would say any one of these database administrators can use those models and identify what their customers need for spectrum. And if they find that there's some spectrum that is suitable for their customers then they can do the negotiation between the original database administrator that listed the spectrum and come up with a model of what that use is going to be. So it becomes a foundation, a way to quantify the quantity of spectrum that is traded within the market.

So now, (what) these models look like. Now, we're looking into the part of that story about how do you convey models that are going to hide—create models that is going to hide what the government is actually using with the spectrum. And these are abstract. I think you can see the general intent. First of all, you can have permissive models. That's kind of what the NTIA report did is it said, You can use spectrum as long as you're outside this particular boundary. So you can use a spectrum here; this is where you can use it. Of course, there's some definition or descriptions of how much power and other things that constrain your use. The other way you can do it is you can use a permissive/restrictive model. You can say, You can use all the spectrum in this space so long as you don't interfere with these other uses. Now, of course we're doing this with models and models can be very abstract and not give you too much detail about what those uses are.

Let's look at a simple system. I have a radar on the coast. I'm going to give you a number of different models that could potentially be built, all to protect that radar on the coast, but then to allow sharing. Very simple model. This is a permissive model. You can use a spectrum here, just some stage that's outside the area where that radar is operating. We can go to something else. We can go to a permissive/restrictive. We can, you can use a model spectrum anywhere so long as you don't interfere with the use we have modeled here. Don't forget, the models provide the means of computation of whether or not you're compatible or not. We can go and try to get into greater detail about the particular radar in this case. We can try to put some models that identify the directivity of the antennas that they're using, where it's normally pointing, and with the antenna, trying to provide additional sharing opportunities. In this type of model we can get, also get into the temporal type of things, how fast an antenna is rotating, or how—even into the details of the pulsing if that is something you would want to share.

And final one I have here is permissive model. In this case you can give a model and you could specify some type of policy or protocol that will allow you to use a spectrum. The perfect example of using a beaconing signal would be here. You can use a spectrum so long as your radio or your system is monitoring and responding to the beacon however that beacon system has been developed.

In conclusion, what I want you to come away with is that all base spectrum management can enable dynamic sharing of spectrum, rapid interference analysis, the management of coexistence, and the abstract presentation of sharing opportunities without revealing the sensitive details of spectrum use. I believe it will support an evolution of the spectrum management system. In the beginning you can model the existing uses very conservatively if you can keep the other users far away. But over time you can make them more and more liberal, less conservative, and allow more sharing to occur.

Last thing. I've already said this. I want to make spectrum consumption modeling the equivalent to the Internet protocol for spectrum management. To do that you have to standardize it. Well, this week it was brought into IEEE standards commission 1900.5. We'll talk a little bit more about this. It is in the process, in the process of being standardized. There's a lot of technical detail I haven't explained to you already. I have up here a link where you can go and find more data about this particular model and technique. I've already received lots of feedback, so that manual is being updated and I'll certainly make that available, publicly available when it's done.

Also we want people to participate in the standardization effort. So in order to participate you need to know something about it. So I've sent two tutorials, one in DySPAN, one in Milcom, both occur in October, with the intent of training people or teaching people what we've already developed so they can contribute to make this, this whole concept better through the standardization process. Finally, I have a public collaboration site which you can join. All you have to do is send me an email and I'll give you an invitation. Thank you. (Applause.)

MR. MARSHALL: John reminded me that I can never speak and not plug come to DySPAN 12. It's my last year as chair. I'd like to break the attendance record. And I'm looking for a new chair for DySPAN if someone wants to take this over.

### 2.1.7 Lynn Grande: Supporting Standards for DSA

MS. GRANDE: I'm the last one on the list holding you up from a break. I'm going it be --

MR. MARSHALL: And the questions if there's time.

MS. GRANDE: I'm going to be the Bruce Washington of today. I'm excited about standards. That is probably why I don't have many Facebook friends. IEEE DySPAN Standards Committee is a vehicle for us to standardize everything related to dynamic spectrum access. I'm not going to go through the detail on these slides because there's a lot of detail. But I want you to know what we're doing currently, and more importantly what we can do.

These are the current active working groups. Actually, I should say these are current working groups. 1900.2 is not currently active; it's already been published. There is no work being done on that currently. 1900.1 is really, you have to begin with what's the technology that we're using. 1900.2 was recommended practice for interference and coexistence analysis; .4 is building blocks of architecture; .5 is the group that I'm chair of, policy language and architectures. We're just trying to determine how to do policy transfer for cognitive radio dynamic spectrum access. 900.6, this is your spectrum sensing standards group; and 1900.7 is a recently formed group dealing with white space dynamic spectrum access. These are, I put the people involved on these slides as well.

And these are the scopes of each of these working groups. 1900.1 has just gone through an amendment process and is going out for recirculation. And this should be published again probably late this year. And as I said, 1900.2 was published in 2008. And there's some details here. All of these standards are available through IEEE. 1900.4 has a published standard, and it also has an amendment. The original standard was published in 2009. This is the usage model for 1900.4 and they described an entire system architecture. Four "a" is an amendment that was published last year. And they're currently working—this added white space to the system architecture. And .1 is currently ongoing. And that's a standard for the interfaces and protocols to make the 1900.4 system work.

The 1900.5 standard we have published in January. The standard that gives us the requirements for policy languages and architectures and describes an architecture. That's kind of like the first line in what we're trying to do. We envision a suite of standards that will take us in a full thread from the policy management. In our group we call it the big P and little p, the big P being, you know the regulatory policy, and the little p being policies that were transferring information throughout the cognitive networks. And this is just a real benign sort of architecture diagram of some of the things that are in the 1900.5 standard. 1900.5.1, as John said we have had some discussions.

We actually had a face-to-face meeting here prior to the ISART meeting. We do occasionally we have face-to-face meetings on our own sometimes, about once a year. We also have face-to-face meetings during all the plenary activity. Those meetings are typically three times a year. And all the rest is done through teleconferences. John's work, as he said, is we're going to bring in some of the model-based spectrum management work that's been done there because it fits well into what we're trying to do for 1900.5, so we have actually just submitted a par modification so that we can bring that work in. 1900.6 standard, spectrum sensing interfaces, that was published in 2011. And 6a is ongoing, and that's an amendment for procedures, protocols, and enhanced interfaces.

If you, you can kind of tell what we do is we try to get kind of basic standards published, and then we amend and add to them to put more information in just so we can get the information out there. 1900.7 is our newest working group. And they are working on a standard for white space dynamic spectrum access radio systems. This includes MC and PHY layers. And that's ongoing.

Some of the DySPAN meetings, this is the list of some of the meetings. Our next plenary is in January of 2013. That's in conjunction with the WN forum. Many of the IEEE groups have liaisons, like my 1900.5 has a liaison to the TM forum that you, that Howard talked about yesterday. And the wireless innovation forum. At our website you can get much more information, dyspan-sc.org, and if you just Google IEEE DySPAN you'll find probably more information than you wanted to know. We encourage everyone to come in, propose new working groups, or come in and work on some of the existing standards because this is your, you know, this is a vehicle for dynamic spectrum access standardization. And that's it.

MR. MARSHALL: Thank you. (Applause.)

MR. GORENBERG: I think the normal format is I ask you a few questions, but I think I'm perfectly happy to defer to the audience if people want to line up. Don't trip. There's probably a whole lot of questions here, but I do want to say one thing. I think that the PCAST Report speculated that all this stuff was around. And I think it's really clear there's a lot of work on the modeling, there's a lot of work on the standards. So we're not starting afresh. I think some people said this is an all new effort and ought to take three years. To be really clear, it's not a whole new effort, and that there was an incredible body of work that's gone on. 1900 I kind of worried about. It kind of like took off. But Lynn's really been driving it up the last couple of years. All right.

### 2.1.8 Session III Q&A

**MR**. REASER: Hi. I'm Rick Reaser from Raytheon. First I want to commend your comments about receiver standards. Receivers—

MR. MARSHALL: GPS program manager. Your equipment caused all this.

MR. REESER: Not my equipment. The commercial private sector equipment that has no standards that causes problems like that. Actually the military has lots of standards. I won't get into that. We can talk about lying about LightSquared, but it was very important that we have receiver standards so you are not going to be able to share spectrum if you have no idea the people who are listening into your band. So I think that's very very important and I'm glad you brought that out. So what I wanted to just sort of focus on is this business about the spectrum fund stuff. I think there's a great misunderstanding. I'm a defense contractor now. And nothing is going to happen on the federal side—because we do contract with NASA, DOD, and FAA—unless the money is put into the programs to go do this spectrum stuff. I think we're going to have maybe a broader announcement on spectrum stuff. We're not doing anything in the real programs. We build lots of programs that could be improved in terms of spectrum utilization efficiency and all the things that Preston pointed out on his little model there. Until that happens, until there's money to do it on the federal side in our contracts that we bid on and compete for, this is just not going to happen. In the last round of the CSMAC we had a great debate about this. We called it the spectrum innovation fund and a lot of argument about things being revenue neutral and stuff. If there was a way for program managers in the federal side to tap into funds to go in and then actually implement and tell people, tell potential bidders or incumbents that I want you to go off and implement these new technologies, or come up with a demo and do it on a real system, this is just not going to happen; you got to go do it. And what's interesting about it is many of the things we build in this industry are extremely adaptable in these kinds of things. I'll take exception to Preston's comments about those radars. We build radars. I'm going to make this comment. Our radars are basically computers hooked to receiver exciters on TR modules. We can reprogram any waveform you want. And typically our TR modules—I'm serious. We can do it today. We do it all the time 'cause the device we have on the front end in terms of the TR modules they're fairly broadband and they can do lots of things. And so the issue is if somebody wanted to go put forward the money to go put together a demo program to just go do it, because I think a lot of this stuff we can just go off and do if somebody would want to put the money into the program.

MR. GORENBERG: Well, beyond, beyond the sort of sources that are out here today, the DARPA sources, et cetera, what we envisioned was, if you want to put this in perspective was the AWS auction was the large, last large federal auction that happened in 2006. It was a $13.7 billion auction. About half of it was considered associated with federal spectrum. So—and about a billion and a half was used by the agencies to repurpose their system—so that's $5.35 billion left after that. In the world that we're proposing, rather than that go back to the Treasury automatically, it would be considered to stay in, and that would stay in the spectrum efficiency fund and a number of ideas that you talked about help systems become more efficient, more effective for sharing in the future. That pot would be available to work with. Program managers and the government, folks like yourself to work with them, figure out how to make that available, that is the world that we hope to envision. That will require one more rev by congress. I will say that we went to talk about, Preston and I actually went to talk with the new house working group last week. Eight members of congress, bipartisan, four Republicans, four Democrats. It was a very positive meeting. This area is, despite sort of what you sort of read about in the daily press this area seems to be one where people are moving up the curve to get much more enlightened and much more knowledgeable. And it feels very bipartisan in the idea of trying to move forward innovation. There are in the diagram about what people agreed and disagreed on in congress, but it feels like there's a good middle ground for a number of things agreed upon. So it would be helpful actually that something like this would be a possibility in future sessions of congress moving forward.

MR. MARSHALL: Check the rear microphone.

MR. GARBLE: Peter, CISCO Systems. One way to bootstrap the receiver standards is continuous improvement in order—to put a time limit on the grants of like five years and say, When you come back in five years your performance has to be at least as good as the best things on the market, the top 20 percent from five years ago. Continuous improvement process could fly across all of the products. Rather than have receiver zoos where you go try to measure everything everywhere, just start now with the measuring campaign on interference acceptability, and store those results and say the grants are good for five years. That way, everybody knows five years from now their designs are going to have to be more spectrally efficient with reduced interference diameters.

MR. MARSHALL: That was a comment more than a question. So we'll go to the front microphone.

MR. FRITZ: Hi. Dave Fritz from Mitre Corporation. So yesterday we heard Howard McDonald talk about what DSO was doing in terms of improving and evolving spectrum management. A lot of it involves the kinds of standards Lynn is working on where we have policy-based radios, and then begin developing an infrastructure and an ecosystem in the spectrum management domain to feed digital policies to those devices. So looking at the PCAST Report getting the sense that the commercial world is, you know, leveraging the concept of databases, and that would probably be a focus near term in terms of commercial product development. So I'm curious about the thoughts on the panel about this. Certainly the military has a lot of interest in leveraging the kinds of investments that the commercial world makes in new devices and new technology. So is the concept of a policy-based radio kind of divergent from this concept of getting increased sharing through database mechanisms? Or, you know, where should the military be focusing the investments that it's making, or at least the research and thinking that it's done in terms of policy-based radios, and how best to—sorry, I—

MR. MARSHALL: We'll start with Lynn on that.

MS. GRANDE: I think policy-based radios is the way to go regardless of whether it's, you know, a DOD contract or not because it doesn't matter necessarily what you're interfacing with, but that information has to be driven through the network to the devices and the policy, digital policy is the best way to do that. So, you know, I still, I still believe clearly that that's the approach. Anybody else?

MR. MODY: I just have one comment. We all agree policy-based radios is the way to go. I think the architecture is very important in my opinion because, I mean, in commercial world we are talking about database service. We have a need for a coexistence manager. So where does the policy fit? Where is the decision made? I think that's something that needs to be thought about.

MR. MARSHALL: We did not talk about policy based in PCAST because by and large the PCAST Report over the next three years is driven by incumbent systems. And so incumbent systems are clearly not policy based; they're lucky to be solid state in some cases. I think we did the work. I think we impregnated those ideas into JTRS RIP. But very clearly the bulk of federal systems for the next 20 to 30 years will be legacy. And so to get this going immediately we discounted policy as an immediate enabler and then sort of viewed that as the things would come on to more tip the balance back to fairness. But the lifecycle of the federal systems being typically 10 to 20 times longer than the average home Wi-Fi box really changes the time scale for that to happen.

MR. FRITZ: Quick follow-up to Peter if he has some particular thoughts. So, you know, concept of policy-based radios fit well with your, how databases work and interact with the devices?

MR. STANFORTH: The short answer is yes. The pragmatic answer is what Preston just said, which is we've got to live with what's out there for the foreseeable future. But going back to what Peter Ikelstein said, you know, the commercial world spins at a very fast rate and it's very reasonable that concept-wise reports that are being done today, we use about 20 percent of the spectrum under gigahertz. If we start today with a simple sharing with terrible receivers, maybe you'll eke out another 10 or so percent, which doesn't sound great, but it doubles the effectiveness of what we're using. Over the next 10 years those receivers will only get better and smarter, and not only the receivers but also the policy. I'm a big believer in the fact what we have today is a top down cognitive network with these databases. Where things get really interesting is when you start to integrate with the bottom up, and take advantage of the things that you do. And a real simple experiment we did last year with some Goggle Android phones, with doing that, simply having a balance we improve the battery life by 25 percent; nothing but a piece of software, right? I think that the longwinded answer is that yes, we need to get there. We aren't there today, but that shouldn't be a reason not to start. We should start and get there as soon as we can.

MR. MARSHALL: Peter, I hope you'll note the source code for that. I'll take 25 percent. Rear microphone, and then we'll come to John.

MR. BIRCHLER: Mark Birchler of Roberson and Associates. I was struck by the discussion about the beaconing for the naval system. And yesterday I talked to some of my colleagues on the DOD side who kind of cocked their eyebrow at the idea of agencies' cruisers floating around sending out signals that say, Here I am. Here's what I'm doing. And so—but my thought was that there must be an obfuscation element to the beacon. And John spoke to that in some of his model based spectrum management discussion. So I was wondering if we can expand this out and talk a little bit more about how these issues relate to each other in practically bringing to market beaconing systems and the systems that allow this trade-off between commercial users being able to have enough information to use the spectrum while protecting our national security secrets that are critical as well.

MR. MODY: I guess this question is for me. I completely agree with that question in the sense that security is a very big issue. We've been talking with Navy and trying to figure out how this would be done. In fact, the word that I got from the Navy is that a lot of this data is already out there. In fact when the 3550 to 3650 band was commercialized all over the world ITU was making a database on what kind of systems that are out there. And a lot of this information like PRI and PRF and pulse pieces of radar systems is out there. What we are proposing is two mechanisms, two things, peacetime and emergency modes. And in peacetime you keep sending the beacon. In the emergency mode, all you have to do is tell everybody to shut down. And I think the problem exists today because the 3550 to 3650 band was commercialized all over the world, the naval ships are going at other places in the world and they are being made to shut down their radars because they can't really operate in these bands because these bands have been licensed off. So they have to shut down the radars. The fact is if we create a worldwide standard, which everybody has to obey, I think it will be much better because, you know, the U.S. Navy ships can even go to Australia or some other countries and at least use their radars for some threats. So I think that's what we proposed.

MR. MARSHALL: One thing it points out, I think, on that one is that we are chasing after something that's been employed for, now how many years ago did we lose 3.6? Tom, you must remember.

MR. KIDD: '79.

MR. MARSHALL: Yeah. So we lost—'79?

MR. KIDD: Yes. The world was basically told to move radio location out by '85. Excuse me, they were urged to relocate, relocation out by '85. They weren't told to; they were urged to.

MR. MARSHALL: Forced people to put in like what's essentially DFS ten years after they've already relicensed it. I think we've always been overconfident in our ability to dominate in ITU, and then we end up chasing our tails like we are in 3.6. John?

MR. CHAPIN: Sure. John Chapin, DARPA. Speaking for myself, this was a point I was going to raise with John Stine off line but after hearing some of the discussion I think I'm going to pull it out for the public record here. Which is that we're talking about interference simply in terms of energy leaking into a receiver. But modern systems tolerate various amounts of energy for various amounts of time. So if it's a brief burst you overcome it with—for error correction. If it's a moderate burst you overcome it with active retransmission. If it's a long-term burst you overcome it with rerouting with a different link. And I think it's very important if we're setting the basis for potentially decades of approach to spectrum management higher efficiency, which is what the SCM, I really hope they'll do. I think it's great work. But we really need to figure out how to include in our models and in our management plans the ability to specify different levels of tolerance and maybe at different amounts of cost. Maybe the databases should start being able to say, Yes, you can use it if you have a certain duty cycle in that operating band, something like that. We need to think about those level mechanisms for interacting between systems, not just low level physical layer, Is your energy coming into my receiver or not.

**MR**. STINE: In response to that, I do have mechanisms that are very definitely trying to look at things like narrow band signals and the presence of a wide band signal or frequency hopping. We also have areas for behaviors where we know that there are particular behaviors that going to be very compatible with other systems and you can adjust how you do your underlay masses, what we use to find interference because of those other methods. Certainly spectrum consumption modeling is a modeling technique. It's not a fixed model. And we try to use as many different methods that are available to convey that type of ability to share it.

MR. MARSHALL: Maybe one topic that we ought to think about for next year's ISART should an out channel—Mike Marcus is not here—but, you know, Mike would point out, How in the world can you do interference management when you've never defined harmful interference in any legal framework. At layer—we assume it's energy at layer one, but as John points out it really should be the hacker error rates, bit error rate, something that's measurable at layer two or three. There has been no work by the regulatory community to do this. We're going to start a whole new sharing regime without defining what we're trying to avoid. That would be a great topic for a panel next year. Bring the lawyers from FCC to come here and talk about what in the world are we trying to avoid. We are using quantifying methods to achieve something that we've never quantified.

MR. LUBAR: I'm David Lubar from Raytheon. Speaking for myself I think in general concepts that we are espousing we all know will get placed into standards or in regulations. And I think we should be, we've had some references here in the conference that we should try to point out the exceptions. In other words, you're conveying a concept, and it's clear that there are certain types of technologies or certain services that fit one concept, but clearly don't fit another. The example would be in the report of the data yesterday, that excellent set of data that was taken by ITS, Chriss made a very short comment, We can't see any satellite data. We spacecraft people realize that, a) we have systems getting launched and put up there for many years. There isn't an obsolescence policy or replacement when a new model comes out because it takes a long time, and it's an expensive system. And b) you're not going to see it with conventional techniques. So those kinds of caveats are very important to go in reports, go in recommendations. If you're going to database something, that's great. And John, I loved your approach because you're taking externals, and that may really solve a lot of things. I think it's important to go along that these documents are going to provide a pathway to people that there's a section, a caveat, an appendix, a preface that says, This is what we believe this can be used for, but this is things that this won't help with. I think you have to look at it from all the angles; technically you have to look at it, financial. But right now as we're setting a path it's very important to say what it will do and also what it won't do.

MR. STANFORTH: I think there's two sides to that. One is we have systems that are in place today and will go up in place very shortly that there's nothing we can do about. We have to live with them, we have to work around them and deal with them for the foreseeable future. Then we have to talk about what we're going to start to deploy and put out there across all these in the future. And I think the time has come to change the way we think about how we do it and the technologies that do it. I mean, today when the FCC licenses radios they license them for the same operation across the entire country everywhere. But once you start to have a database and you take a white space radio as we said yesterday, you can have a different set of rules in Manhattan as you have in Iowa. You can change the rules from midnight till 6:00 in the morning. You can change it. And what happens is that every time those radios come in and say, Look, this is who I am, what can I do, they get an answer. They can be oblivious to why that answer changed over time. So the way that we've done things not only in the assignment of the spectrum but the way we consider the design and license of radios, we've got to start thinking about that and starting to implement these things to enable us to get past it. We'll always have to deal with the legacy until they find another way. But we can make, take advantage of a completely different way of thinking about how we design and deploy networks and what we do with them going forward.

MR. GORENBERG: A few points to make. First of all, we totally agree. And in the report, the PCAST Report we talked about different timeframes starting at a year, starting at three years, three to ten years, ten years or more which really is code for it's going to take 20 to 30 years to fully implement a new architecture because you have federal systems that are out there that are very hard to get to that are not easily replaceable who'll go through another technology cycle and that's probably the right kind of timeframe to be thinking about—the technology cycle. And the good news is that the technology from commercial systems and other federal systems along the way is going to be so advanced by then that I'm very excited what those systems will look like when they're replaced 20 or 30 years from now. The second point, in terms of having a database system, more of a spectrum access system is the idea that there will be many different ideas put in place to try to figure out how to work the federal systems. I think we're going to learn that, whether it's sensing, whether it's beaconing, whether it's DFCN concepts or whether it's concepts even beyond that. But the notion—and I really liked John's words in his presentation, which was, rang true of exactly what our thought process was about starting conservatively but sort of saying, Okay, get the effectiveness up so far, but over time you're going to learn to be able to pack more, you'll be able to understand that more, you'll be able to work around systems more. In those SEM like concepts you'll be able to be more liberal over time. I think that was—so we said, Let's start with a harness, something that will be very conservative but allow the idea of air traffic control, to coin Pierre's words, early and take that into much more compacted skies so to speak. So David, what you talked about really was the cornerstone of what drove us in all of our thoughts from the beginning.

MR. MARSHALL: We'll take questions now. I'm going to ask a couple of people in the audience to come to the microphone and comment on some things.

MR. HERSEY: Joe Hersey from the Coast Guard. In reading the PCAST Report, to me, the most difficult problem to solve and probably even a showstopper from a viewpoint of federal agencies may be the federal access system and what it actually consists of. Two constraints that we're under. One is obtaining the data necessary for it, particularly from moving platforms, but the second problem is even the releasability of the data. We're constrained by regulations, the statute regarding releasability of certain things like antenna power locations not designating them classified, but for official use only. So I guess not seeing in the IEEE 1900 series a spectrum management structure up there yet, could you describe a little bit what you expect the spectrum access system to look like, and what you expect the agencies to populate, what kind of data do you expect the agencies to populate the databases with?

MR. GORENBERG: I'm going to hand the mic over to Preston in a second. But the basic idea was again to start with something very conservative that didn't really reveal that; if you want to say cloak it. We'll have to, whether it is large and multiple exclusion zones of information not to give specific locations away, or whether it is some combination of sensing, et cetera, to try to figure that out. The thought process was early on the zones that you could not use. It could be very big, very conservative. And that would fit in that structure where you wouldn't be giving information away. And we didn't expect that data to be in a spectrum access system either. We also did put in the report the notion that we are going to have to find money for both the NTIA and agencies to sort of data process, the data cleansing process, the data retrieval process, the number of people that would be needed to be added to that to help with that process. That's a big problem. That though is a combination of a data issue, but also frankly it's a money issue of getting the resources because this has not been an area that has been resourced as well as it needs to be. We're in agreement with that, not necessarily to make the data public, but so that you, the agencies, and the NTIA have that data basically to figure out how to set the early contour maps and things like that so that we can make those better over time. I'm going to hand this over to more of an expert.

MR. MARSHALL: I think there's two answers to that. Some of our release policies need to be rethought. I was chastised when I was a federal employee of putting the name of a particular Air Force operation in something that wasn't marked FYEO, and I took a picture on the outside of that base where it had that name. So we tend to have very broad policies for what we mark FYEO. Part what we did here in this spectrum management team in making the report into the Whitehouse was NTIA is in no position to put pressures on agencies about release, but the Whitehouse is. There's an opportunity for some adult supervision where it's commonly available material. I've done a lot of time out on Navy ships. And when I came back, everybody knew that their husband was coming off that ship, even nuclear submarines. You know, so a lot of this stuff we treat as protected and confidential but in fact it's really well-known. So we have to use some common sense on this. But in the end, the big efficiency of this framework we recognize is the lack of releasability of this information would mean that we overprotect in some bands, and that's just going to be a fact of life. No secret that at Schriever Air Force Base we have lots of satellite downlinks. We really don't need to cloak that. What bands are on, we might. So I think it's adult supervision. One of the changes in this I think was to bring the political appointees that respond to a broad agenda including innovation and economic activity to help people make some of these decisions and apply the horsepower to deal with policies that are in place, but perhaps don't make the most sense when applied. So I think it's a two part answer. We don't solve it in some, and we really, if it's not common sense, we go after it and fix it. Between the two we'll solve them all. Next?

MR. BACKUS I'm Beau Backus, Aerospace Corporation. Speaking for myself, I have an observation and question first. With all of these spectrum sharing devices needing to communicate with each other should we start looking at spectrum needed in order for them to talk to each other? It may be getting large. The question that I have is one of the things on the federal side for spectrum sharing that's worked extremely well has been the ability for these mission orientated spectrum managers to communicate with each other and do quite a bit of real-time or near real-time sharing between each other's spectrum resources from one location to another. One of the difficulties in spectrum sharing in a shared band between commercial and federal has been the inability to really talk to point of contact or to work with commercial counterparts in the spectrum management community. There's not been a means or a channel established to allow for that. I was going to ask the board if you had thoughts along those lines for the ability to work more as a unified spectrum management community rather than a bifurcated one.

MR. MARSHALL: Mark, I'll let you start with the process that PCAST proposed. We'll go down the panel.

MR. GORENBERG: Okay. There's a number of things in the report. I'll take the highest level. One of our immediate actions is the idea of creating a spectrum sharing partnership committee really in name starting with CEOs of major corporations that would start off immediately for the next year to talk specifically about issues like these, which are much more high level policy issues rather than technology issues as to how you actually work with the federal government to make sharing work. So that was one of the cornerstones that we saw, put that together and say PCAST did that in their manufacturing report. And that worked out really well in terms of its phase two study of involving industry.

MR. GORENBERG: Anyone else want to talk for the industry?

MR. STANFORTH: I think it's, again, it's a double-edged sword. It certainly can be done better. But just like the broadcasters realized that things were in their benefit once it had been done I think a lot of federal agencies will find that they can do things better, faster, quicker when they do that. From a separate process that, the reason why is not material, but I was involved in a project where we sent folks from the west coast—I mean, the east coast to the west coast to do their military training before they go out to Iraq and Afghanistan. And they spent—of three weeks of basically battle preparedness—they spent five days tuning radios. That was something that some of these technologies could almost completely automate. I think it's time for us to look at a combination of what goes on in the military and the federal side of things and the commercial side. I think Don said it yesterday: DARPA is really good at proving things as possible that the commercial world tends to not have the patience to do, that but they know how to make things better very fast. I think if we were to actually do some of the things you are suggesting I think we could make life a lot better a lot quicker.

MR. GORENBERG: I'd like to make one point. I think we're trying to change that coordination process, fundamentally change it. Right now there's veritably few players who understand how to come and interact with the federal government on the industry side, largely the large carriers. Point to point microwave, they do a lot of coordination with federal agencies. In effect we're trying to get rid of that closed little community, and open it up to an automated process so a hospital in the middle of Iowa can go and look in the database and see they can get spectrum without having to know who to call in the Navy or whatever, and not having to spend $100,000 on interference consultants like me, and just go and have this process automated because we can't have innovation until there's some predictability and liquidity. So by carrying a predictable process isn't dependent on knowing someone who knows someone and how to get paperwork through DSO or JSC we'll open up and create something that's so much more transparent that we won't have to have a lot of the lower level interactions. So I think there's also an attempt here to fundamentally change those relationships from essentially a very clubby environment to something that is totally open to anyone, and I could go do a business plan and say, Look at all the spectrum that's there with some confidence so when I need it I can get it whereas today no one has any confidence that they can get and share federal spectrum until they go through the process. I think it's also intended to fundamentally change it as well as just accelerate it to top. Okay. I'm going to take one more question, and then I'm going to have one for Tom Kidd and Tom Powers.

MR. KHAYRALLAH: I'm Ali Khayrallah from Eson Research. In the cellular industry we've been dealing with something called carrier activation, which was a very simple version of the kind of dynamic spectrum capabilities you're talking about. Even with that the design of transmitters and receivers turns outs to be very complicated especially in the terminals. But the examples that I have heard from various people are about machine type communications or maybe rural access or whatever, which we tend to associate with very cheap terminals. So I wonder if you can comment on that.

MR. MODY: So, you know, everything is driven by market forces, right? And if there is a market for it I'm pretty sure people will come up with new technologies which will allow things to do. I mean, I'm talking to a couple of carriers, a couple of companies which are designing the base stations. And for them they find that it's very easy to reconfigure the base stations but they need the support from the vendors who are making the cellular terminals that can do the same thing. And once again it's the cost of the RF, it's the cost of the filters, the ability to talk in multiple bands. I think that these issues need to be solved, and I agree with you that needs to be done. It's happening; we're getting towards that.

MR. KAYALA: The tough part is in the terminals, not in infrastructure—

MR. MODY: I agree. It's cheap terminals.

MR. MARSHALL: Tom, lumber up to the mic. When we walked in here Tom mentioned to me he just published a paper about how to do frequency assignments or moving toward doing frequency assignments in milliseconds. And it occurs to me that's pretty much what the last half of our panel talked about, and it really is the assumption behind the PCAST Report. So Tom, what's been said looking at PCAST, are we on a path to doing frequency assignments in milliseconds?

MR. KIDD: No. I realize that's kind of a smartass short answer. We are heading down that path. But if we follow the same level of innovation the way that we're looking at it now we're never going to get there. It will take us to the end of the century to get there. We don't have till the end of the century.

MR. MARSHALL: Does Stine's model thing do it for you? It's a starting point?

MR. KIDD: It's a starting point. The challenge, we have a couple of challenges. One of course is any new innovation that comes out today makes everything else legacy, okay? So it all has to fit in. I'm looking at the models and I'm looking at everything and my mind is turning how would we address all of this.

MR. MARSHALL: I should say Tom Kidd is Navy.

MR. KIDD: Yes, I'm sorry. I'm the IRAC rep for the Department of the Navy. And I'm speaking probably 80 to 0 percent here for myself. But to go from our current process we can argue about the numbers. I rounded it off to make it easier so we could talk orders of magnitude. Today we do dynamic spectrum access. I'll advertise it. It's not really a paper; it's an article. There's no peer review. There's advantage on that so it's sort of an op-ed piece. Basically dynamic spectrum access today. The dynamic is roughly 100 days, okay? When we decide to move frequency A to frequency B and give up frequency A we're basically giving up one license and moving on to another license. To do that we heard that the NTIA's internal process is nine days, and that's assuming nobody objects; there's no tabling of the process and slowing of the process. But when you do consider tabling objections, you know, the coordination that's required, the internal processes of the agencies, I went back and took a look over the last year or so at how long a term, I came up with total time to assignment. In the time somebody decided they needed a frequency for a radio until that frequency was assigned for that radio. And then for the sake of doing the math, I rounded it off to an order of magnitude. It's about a hundred days. The question is, you take a process in 2012 that takes 100 days and reduce it by seven order of magnitude to 00 milliseconds, sub one second. How do you do that? The article breaks it into three areas to try to give just an idea of how you would do that. You'd find it in Chips Magazine, go to the DON CIO website there's a link or you can Google Chips Magazine. Feel free to criticize me all you want for it; it was just an idea. But the thought is that we can't be on an evolutionary process. We have to basically set ourselves chunks that we're going to bite off that are evolutionary or revolutionary. So what I propose in the article—and then I'll give up the mic—is that we try, we do this. We go from 100 days to one day, okay? We can do that with a lot of this innovation. We can turn things. We do turn some assignments around in one day right now. A forest fire occurs. A disaster occurs someplace. We are able to turn the process on one day and it's roughly the same process. Why can't we do that with everything? Then we have to take things from one day down to let's say one minute. One minute means basically automating all those decision processes. We've talked about it today. I'm going to quote a good friend of mine, Tom Taylor, who is back from Afghanistan working up at OSC. And he basically said that the process we have today is still a people-centric, manual process. It's all about present information to a person to make a decision, and it's all about me presenting that information, so a very manual process. We need to automate that. Machines need to make the decision. Moving from a one day, which we can still do, people centered manual process in one day because we do it. Moving from one day to one minute we now have to automate all of that. Machines have to be making the decisions. But it can still be done in the Cloud, it can still be done with models, et cetera. The challenge is then going to be moving it from the one minute to the subsecond. Then the Cloud is no longer fast enough. We're going to have to move all this decision- making process inside the machine. The machine is going to have to have the knowledge, have the understanding to alter its behavior, whatever is necessary, without consulting with databases and stuff because there just won't be enough time. And as we heard earlier, there won't be enough spectrum for the spectrum to manage itself because all these devices obviously are wireless. If they're going to communicate back to the Cloud overhead is just going to crush us. Thanks for the mic.

MR. MARSHALL: Comments?

MR. STANFORTH: So let's go the other way around. TV white space today we talk about minutes for channel assignment. So that leap to get to the minutes is pretty straightforward. As someone that's spent a lot of time designing radio networks I'm not sure I want to get to the millisecond and let me tell you why. Take your laptop out and see how long it takes to get Wi-Fi, right? Just the retuning time of the radio, the synchronization, the overhead of, Hey, I'm moving from here to here typically is in hundreds of milliseconds, right? So I think the realistic—we can definitely get to minutes and less than minutes. We can probably get down to seconds. With what we've got today the retuning time, the resynchronization, the process the radio goes through to move from one channel to another probably says that milliseconds is not reasonable. But we can get pretty close to it I think—

MR. KIDD: So not seven orders of magnitude, maybe six. If not six, maybe five.

MR. STANFORTH: Five or six.

MR. KIDD: We're still talking about when typical processing improvement schemes that are out there address something they expect improvements on the order of 60 to 0 percent improvement, not six orders of magnitude improvement.

MR. STANFORTH: Five or six is good. That would work fine too.

MR. MARSHALL: I want one more topic on this panel and we'll be looking towards the next time we meet. We've all talked about sharing for decades. I think there's now an actionable document sitting in front of the administration. As a geek I feel like I've done my job. I get a sense that you're kind of the action officer to go and sell this to the vast organization or whatever it is to the United States government. So how has the technical community by and large represented here met its obligation to support you in selling that, and what haven't we done what we should be focused on to give you the ammunition you need to win, and maybe win in seven.

**MR**. POWERS: I didn't realize you were allowed to call on me.

MR. MARSHALL: If we had more time we'd call CRS up here on why congress isn't giving us the right language.

MR. POWERS: This hasn't happened to me since law school.

MR. MARSHALL: I'm nicer than the panel.

MR. POWERS: Well, let's see. First, so I'm Tom Powers. I work in the Whitehouse Office of Science and Technology. We are sort of the home to the PCAST although the PCAST is independent of the administration and is made up of a bunch of really bright folks. And Mark Gorenberg has just done an unbelievable service to the country, frankly, and it's been a great pleasure working with him. And this report, as we discussed at the event last Friday, is really I think is going it be instrumental in moving the ball. That being said, the way things work in Washington, it does tend to be sort of incremental, and there are obviously a lot of stakeholders, folks coming at this from completely different directions. And it's not just binary; it's not just black and white. There's like shades of gray and all sorts of different folks. I was interested in on the one hand some of the carriers were a little apprehensive I think about the concept of sharing.

They're still very bullish on clearing. My sense was there were folks on the hill who reacted very positively to the report as, Let's get more spectrum from the federal agencies, and in standing up and supporting your effort in that regard and in pushing on the agencies probably thought they were on the side of the carriers but they weren't exactly because the carriers were actually somewhat apprehensive about it. So you have these pressures coming from a million different directions. It's really important to have all the stakeholders kind of at the table getting a buy-in as opposed to trying to think that we can just sort of decree action. I will point out a few things. That some of these efforts are under way and have been under way. I'm the telecom guy in the Whitehouse. I could be spending the majority of my time on universal service or media ownership or the end of POTS, right? There's lots of things I could be spending the majority of my time on. I'm spending the majority of my time on spectrum because it's a priority of this President. So the report talks about spectrum management team. We don't quite have that formally. But we do have emphasis that doesn't have to be there. And would not necessarily be there in prior or future administrations. The 3550 band you've heard a lot about, that was in 2010 that the NTIA said, Here's some spectrum we can work with or the FCC can work with there. And there have been discussions even since the report between me and Don Lieberwith and others to really get down to brass tacks on that. So a lot of these things are under way. You know, in terms of your specific question I couldn't ask for more in the report. I mean, this was a Herculean effort from folks who essentially have day jobs. I don't know if Mark's partners are feeling about him over the last year for the amount of time as you know he's been in Washington. But this report has been great. I think, you know, as I said before, things like this move the ball in ways that you might not see it today or tomorrow, but up we know that it's getting visibility and the reaction from the Hill folks that you guys got last week, the fact that this Hill group has formed, right? On spectrum, right? On a bipartisan basis. Folks really do understand it. I'm not giving you a real specific answer. All I can say is that elevating the dialogue and giving this exposure is—

MR. MARSHALL: We can't bring politics to it, but is there science or evidence that you need that are gaping holes you think people ought to be worried about in presenting here in this year?

**MR**. POWERS: Yeah. You know, I think there's almost an inevitability to some of this. Like those questions will be exposed. I mean, one of the big debates that people disagree on these, as Mark said, the amount of the talk it's not a question of if but when. And so are you talking about cognizant radios and more of the advanced technologies or are you talking white space, which is here today. I think, you know, as the prior discussion just revealed, advances that we make are going to be much more aggressive as the technology advances. We're going to see. But as I said there's an inevitability about this. But in Washington we sort of move incrementally along the way. I don't have specific assignments for you. You called on me, remember?

MR. MARSHALL: All right. We'll let you off the hook. And with that we'll let the panelists off. Thank you very much. (Applause.)

## 2.2 Session IV: Validating and Regulating New Sharing Schemes

MR. NELSON: Let's go ahead and take our seats. The next session following in the progression of the various panels that we've put together starts to take a look at the trust issue that has been raised here a number of times. And you build trust by having stakeholders get together, work out the rules, and ultimately they begin to validate the models and assumptions to show that the sharing can work. As a part of that validation then it needs to somehow be expressed in regulation. Hence, the title for this session is, Validating and regulating new sharing schemes. I'd like to introduce the moderator for this panel John Chapin.

### 2.2.1 John Chapin: Introductory Remarks

MR. CHAPIN: Thank you. I think my job is to fill enough time for everyone out in the hall to come in. Maybe, Eric, you can get the hook out. We'll try to bring in the audience. Because we have a wonderful panel today, folks who have thought a lot about the questions of regulation over the years, and about ancillary issues related to building trust, whether that is things like test laboratories or actual test facilities, test beds, test procedures.

So we feel that it's very very hard to consider moving forward with the sharing schemes that have been talked about without putting a lot of effort, attention, and indeed investments into the questions of validation and regulation. So I will say just a word or two about our speakers in advance so you know who they are. And then you can read the full biographies in the brochure that you have.

- William Webb, formally of UK Ofcom
- Professor William Webb, now CTO of Nuel
- Dale Hatfield who really needs no introduction but has held many major roles in spectrum regulation over the years and spectrum policy
- Peter Tenhula who was at the FCC then was at Shared Spectrum Corporation for a number of years trying to make this stuff work in the private sector side and is now back at the NTIA
- We have Stephen Berger, who was really one of the founding leaders behind the 1900 and FCC 41 effort in addition to his work with the certification community and with a number of different efforts.
- And finally Dennis Roberson, former CCO of Motorola—is that correct? Yes—and currently at IIT, and a major contributor currently on the receiver standard work being done at the FCC.

With that very brief introduction I'll ask William Webb to start us off. We'll give each speaker ten minutes to present their ideas and then we'll go into I think directly into questions by the audience, although I have a few seed questions if things get slow. I think it is unlikely.

### 2.2.2 William Webb: Why DSA is Better Deployed and Modified Rather Than Modelled in Detail

MR. WEBB: Thanks, John. And good spooling. I think we've got a fair number of people in now. I spoke to you yesterday about the technology and machine to machine technology that I'm working on, about regulation in the UK. This is quite different. This is a personal viewpoint that is looking ahead, trying to learn a bit from the experience to date of deployment of white space systems, and trying to understand from that experience what's the best way ahead in the future in terms of deploying and validating that I'm expecting the mechanics of white space might be. I've actually written a short paper that's available on the ISART website in the download area. So if I'm not coherent enough in speaking you can always take a look at the paper and see if that's more helpful.

So the basic idea that I want to throw out there for discussion today is that we can try and design sharing to the nth degree of detail, but actually that may be wasted effort because there may be many unanticipated things that actually turn up that dominate the effect of interference. Let's take a step back. If we're looking at any kind of a dynamic spectrum access system we're looking at sharing the spectrum. And basically sharing means not causing excessive interference between the different users of the system. So the sharing is done on the basis of the amount of interference of course.

Of course, that actual amount could be what varies between different technologies and different systems. And we know from the past that defining interference caused to other spectrum users is a really difficult problem. We've had proxies for it over many years in terms of transmission towers, but a transmission tower is almost irrelevant in terms of interference cause because it's actually transmitting density, an overall aspect of key criteria. And we've seen many issues in the past caused by trying to define interference through transmitted power where it's as much as the NexTel issue and the LightSquared that led to all sorts of problems.

So the UK, for many years Ofcom studied this problem. They came up with a concept for protection usage rights, which did attempt to define a spectrum license in terms of the interference that could be caused to other users. Now, it was actually based around other licensed users but the concepts are entirely transferable to unlicensed or shared users. And if you want to go down the route of defining interference caused to others then that's one way you can go.

But what we've learned from white space access is that that may not tell the whole story. So there's been a lot of very detailed studies of how much interference a white space might cause a TV. And then only about a year or so ago in the UK it was posited that actually that was almost totally irrelevant because the white space device happened to have a burst of transmission come in, and then it caused about 20 dBs more interference to the TV than a continuous waveform. And the reason that was happening was because the automatic gain control in the CD receiver front end was not set up to handle a burst of interference; it was set up to handle continuous transmission because that was the path of interference in TV bands. It was other TV transmissions. And it tended to go a bit screwy through some bursts at it and caused all sort of unanticipated problems. So actually you could have spent years defining interference in immense detail down to the last dB and discover you were 20 dBs out because of some unanticipated factor out there.

I'm not sure defining sharing to a great degree is effort that's worth doing. And if you're not going to define it, then perhaps the other option is just to throw stuff out there and see what happens, maybe measuring interference or even noticing interference. And that is the solution I'm actually going to propose in the next slide. It's worth understanding that that in itself is really problematic.

If you want to actually measure interference with some kind of a test receiver that's really tough to do. You've got a system where there's enormous time variance of devices particularly if they're laptops or personal devices that are popping up and disappearing all the time, they're moving around, they're relatively low power, they don't have base stations typically with low power transmissions and indeed if you're just measuring signal are you measuring the primary user or the secondary user? That in itself may be a problem.

You can start to dig into the signal characteristics to understand that in more detail. There's all sorts of issues in terms of going out and understanding what level of interference it is. Another option is just to say, Well, it isn't interference unless it causes a problem. And it only causes a problem if someone notices it's a problem and therefore we can just wait for the users, the primary users to spot if there's a problem and tell us if there's interference and then we can do something about it. And yes, that can work.

But if we take a look at for example the TV bands there's a number of immediate issues. First of all, many users may not realize there's interference. They just notice that the TV isn't working properly. But they don't link that to interference going on. It may be they think the TV transmitter is not working correctly or there's some kind of strange weather pattern affecting what signal they get or something else. If they do know there's interference, what are they going to do about it? Not everyone knows of the FCC or Ofcom and they may not realize that they need to go to their website and report. They just tell their neighbors or whatever. And if it is very sporadic interference then sending someone out to resolve the problem may not work because the interference may not occur on the day they go out to resolve the particular problem so there is a lot of issues there.

So I suspect there is a way ahead with some kind of discussion forum Internet approach where you can set something up so if somebody does type into Google, I've got TV interference, they get taken to a webpage where they can type in their location, the kind of problem they're suffering, and that can be aggregated up over a large number of users and you can start to form a pattern of what's going on and whether it's actually white space interference or not.

So it seems to me we've got two different approaches we can adopt to implementing shared users in licensed bands. The first is an exhaustive test approach where you take a new technology and you test it to death against all the existing receivers, you try to block out some minimum accompanying loss and aggregate interference models, and you build detailed scenarios, you build in plenty of margins for error because there's all sorts of unknowns and variables out there, and then you derive what should be allowed. That's basically the approach that was adopted in TV white space and the approach that we're using today.

The other approach is to be more lighter on those sort of tests; to do some, but not to spend too much time and effort on that, and then to get stuff out there and to monitor what happens and adjust quickly accordingly to change the rules. So between those two approaches we've basically got a risk-reward balance.

The exhaustive test approach should be the lower risk because it's conservative and therefore the chances that you get something wrong are less; therefore, the chances of interference to the primary user are lower and the chances of needing a rule change for the secondary user are also lower. But because it's conservative, the amount of spectrum you can access is lower so the reward is fairly low. The second approach is the converse. You have the higher risk there may be some kind of interference, the result of which would be a rule change to tighten up the access rules which would fall on the dynamic spectrum user. You would then find that they now have to have slower transmit power, and all that spectrum availability would then be the case but it should allow more spectrum access because there's less conservatism in there.

And what the right approach is, of course, will depend on what the primary user is, whether any interference is tolerable or not, and what second degree there is, the politics of the situation, and to some degree the experience that we've gained in knowing how these things will ultimately work. As we gain more experience we can measure the risk better.

But my underlying rationale for proposing the second approach is that I suspect once you've got some rules out there it's very much easier to tighten the rules than it is to relax them. If we put out some rules and we think that conservatively no interference is being spotted it's very hard to say, Great. No interference. Let's have another dB, please. We have to go through a full consultation process and modeling process. The incumbents don't like it. It takes years and years and may end up changing the rules a bit. If you have rules that need tightening because there's interference, you can do that in seconds or at least within a few days. It's a much much faster process, a much simpler process.

If we want to get to the optimum, and we want to get to the optimum as quickly as possible, then we're better off adopting the second approach, the more generic. And then if we need to tighten the rules we can move in fairly quickly to tighten them because we're going for a very detailed approach. That's basically the thesis that I'm proposing to you today is that in this kind of sharing approach we should concentrate much more on a mechanism where we can get stuff out there, understand whether there is interference and address it very quickly, rather than one where we spend an awfully long time modeling every kind of interference in the first place, which is unlikely to have full result and likely to lead to something that's very conservative. Thank you.

MR. CHAPIN: Thank you. (Applause.)

### 2.2.3 Dale Hatfield: Self-enforcement through Multi Stakeholder Groups

MR. HATFIELD: I'm local. Welcome to Boulder. I hope you're enjoying your time here. I oftentimes when I speak, in the past I've always started out by saying I have a warm place in my heart for ITS. And indeed I do. I started at a predecessor organization of ITS 49 years ago. It was called Central Radio Propagation Lab. And I have a couple of hopes. One, I hope there will be an ISART next year. And then secondly I hope maybe you'll invite me back at least for some sort of token appearance so I can then say it's been 50 years, five decades.

While I'm being sort of personal here, I'm just gratified to see the focus on the issue of receiver performance. It's something that's bothered me for so many years. I'm not claiming that's exclusive with me at all, of course, but I'm so pleased for the attention that it's getting. I have my affiliations up there. And in the interest of full disclosure I should probably say I'm on the board of directors of Crown Castle, the tower company, doing small cell stuff, and also a company called Mobile Pulse here in the Denver area.

The purpose of my talk here is to identify and perhaps clarify some of the enforcement issues in the possible role of multi stakeholder organizations in this very different environment that we're talking about. I've been somewhat surprised, having been here most of yesterday and today, that the word "enforcement" has not come up as often and as strongly as perhaps it might. So what I was going to do is first I was going to sort of outline on some of the interference and mitigation and enforcement in the traditional historical sense, showing my age, I'll talk a little bit about the challenges and opportunity of interference management in the more dynamic environment that we've been discussing here, and then touch a little bit on the possible role with multi stakeholder organizations in enforcement and perhaps a little bit broader context, and then maybe offer some concluding comments.

When I started all those years ago, boy, life was simple. Limited. What did we have? Modulation formats? What, AM-FM and maybe frequency shift keying on the radio teletype was about it. Maybe it's over-exaggerating it a little bit. A limited number of, limited numbers of channels, static rather than dynamic assignment techniques. Trunking was still on the horizon; hadn't been—which is a former dynamic, of course, and it was still—high power high antenna height noise limited systems, licensed stations and transmitters. Even the, even the, there was old IMTS, which was the mobile telephone predecessor to cellular that we have today. And you actually got a license for the device in your car from the FCC.

I can't help but tell an anecdote about the people on the processing line who did that terrible routine job. There always seemed to be a buzz of excitement. Something was going on. And it was because they got, you know, John Wayne's license, license application to operate the phone that took up most of the trunk of his car in those days. We personally had licensed operators and technicians. We had unique identification call letters, equipment certification. And the signals were often, of course, in the clear or easily decipherable.

When you look at the enforcement and that whole environment—and I won't spend any time on it because you all know it very well—you had a receiver and you kind of knew where to look. You had spectrum analyzers to help you. And then if you couldn't identify just from the call letters for example and give the person a call, you might haul out the direction finding gear, find the person. And if it was causing interference to some critical service maybe send the field, FCC field engineer on the FCC side, send an FCC field engineer out to take a look. Then if it was really a serious thing the field engineer would go out with a U.S. Marshal. The FCC person had a badge. The Marshal had a gun if it was a real serious problem, so that sort of describes the tools and the methods we had. And of course there were some incentives along with it.

But what's interesting to me who's interested in the multi stakeholder organization, there were several voluntary organizations that grew up. I don't have time to talk about them much. One was frequency coordinators. As some of you may know frequency coordinators grew up in certain services without any official recognition by the FCC but they started doing their thing, it proved useful, and eventually legislature was entered so that they became, they'd become, they became more recognized. But here again, it was the example of these sort of multi stakeholder groups. Site management, where you've got local interference issues, you can't do that from a central location so you resolve some of those issues locally.

One example, one of my favorites, the amateur radio service where you had people—still do—called official observers who actually monitored what people were doing. And they'll send you a nice little card saying, you know, You were observed operating out of your band. You shouldn't do that. And over time, in other words, the amateurs wanted to, you know, police their own services and maintain good relationships with the FCC. And then eventually I believe it's correct—Peter, you can probably tell me—I think there's actually an MOU now between the ARRL and the FCC governance relationship between the multi stakeholder group and the commission.

Now, when I sit here and listen this year, past areas, we talk about this new environment, boy, does it look different. Virtually unlimited modulation formats, waveforms, multiple broadband channels scattered over a wide range, dynamic rather than static access, low power, low antenna heights, interference limited, increase in unlicensed or licensed by rule, far away from what we had back in those days. Minimal licensing of operators and technicians. In fact it sort of sounds crazy today to operate, talk in those terms. Of course we still have equipment certification. Signals are often encrypted or not easily decipherable. And of course now we have increasingly we have underlying devices in networks as well, and of course even intentional jammers because the equipment is so widely available people can build up stuff to do it intentionally so very very different, very very different environment today. And I guess the thrust of where I'm going is we need to do something on the enforcement side that really recognizes and takes into account that new environment.

Let me say just a little bit about multi stakeholder organizations. The sort of formal definition of a multi stakeholder organization is one which does not operate under or pursuant to any formal government authority. Its authority generates, is derived from the consent of those who choose to be governed and the power that they have comes from the respect for the processes, for example, the openness, fairness, inclusiveness, transparency, flexibility, indeed the quality of their output, be it standards or best practices, recommendations, or codes of conduct. And when you think about it of course, much of the governance of today's Internet is carried out by such organizations. The Internet Society, including the IETF and the Internet architecture of the Worldwide Web Consortium, NANOG here and so forth, those all fit my definition of that multi stakeholder organization. And of course we've heard a lot about those here during the talks today. IEEE, P1900, the 802 series, the standards, all these come through this multi stakeholder type organization.

I happen to be affiliated with a relatively new one called the Broadband Internet Technical Advisory Group. I won't take the time to describe it very much. But we're a group of engineers representing all facets of the parts of the Internet ecosystem, if you will, including public interest groups. What we're trying to deal with is issues that relate to net neutrality, network management particularly in net neutrality. And the example I would give is you're an ISP and you do something in the network management area and it breaks somebody else's application. And immediately of course you can get into litigation because you've broken the application or whatever.

And it's especially challenging when it's, you're an ISP, for example, and you're providing a news service and then somebody is providing also a competitive news service using your facilities. And then there's the issue, When you break my application, you know, did you intend to do it? And that gets into lawyers involved and so forth. What we try to do is try to look at some of those sort of things and get the engineers in the room together and work those things out before essentially they blow up and the lawyers get involved.

I'm getting the two minute high sign. I think I can do it pretty close to two minutes.

So clearly multiple stakeholder organizations, albeit some with more formal ties to leverage can indeed, and indeed already are playing an important role in designing sharing arrangements. We've heard that repeatedly in the last day and a half. But how about the role in enforcement?

I've tried to say that the role is important. While certainly multi stakeholder organizations like those represented here today can play a key role in deciding tools, for example, that prohibit devices from even transmitting in some unauthorized manner or locating misbehaving devices and actually shutting them off automatically. Of course I think we touched just a bit on it, and Dan Stancil, who's on the CSMAC, the Commerce Spectrum Management Advisory Committee, has proposed a multiple stakeholder type organization, could be a multiple stakeholder type organization for collecting long-term information on the interference environment, and then based upon that sort of crowd sourcing notion, based upon the information collected, say, Oh, there's problems, there's problems of this type of device in this particular area and so forth that will allow you then to take some remedial action that I think William was touching on.

Let me just conclude then by saying I'm personally convinced that multi stakeholder organization's based heavily on the engineering problem solving. I mean, what I like to do in the BITAG is, when the engineer's in the room, We're here in the problem-solving mode. We're here to work out problems and not represent, not get tied up in all the sort of legal and policy stuff. Let's get as far as we can to resolving the technical issues. Maybe even the example that I give where you break somebody's application, let's sit down and talk about it. Maybe there's another way of doing it that doesn't break the application. Or if there's very good reason that you need to sort of hurt the application, do it in a way that minimizes that, and does it in a way that doesn't differentially impact, advantage one particular group over another.

So I think that engineering, that engineering culture of problem solving can go a long way. And we've heard talks about that. Of course government is still needed. There's normative issues that we engineers don't have a better opinion on than anybody else that you need to resolve how much, purely normative things like how much risk you're willing to take and so forth. That becomes something. And of course you oftentimes get people who won't cooperate voluntarily. If the incentives are not there for voluntary cooperation then you need the government to step in if the cooperation is inadequate.

I still have, having sat here, I still think just a final personal thought, I still have concerns that a very dynamic spectrum sharing environment coupled with receiver inadequacies—and I think the comment this morning, you got to take that receiver stuff into account here or we're not going to make progress—vastly increased number of transmitters in close proximity and the interference from unintended radiators such as switching power supplies and so forth, and intentional interferers may lead to a potentially dramatic increase in the noise floor.

I'm not talking about people we can get to that we realize they're doing something wrong and shutting them down; I'm talking about all the other transient sorts of interference that you might get. You've got a receiver has linearity problem, you get intermod, and because you're jumping around a lot that intermod may only exist for a short period of time. At the same time of course there may be multiple interferences. You can do this. We can do it for a single interferer but what do you do when you have multiple interferers, and what do you do when there's multiple interferers plus, plus some other unintended radiation, switching power supply in there, that causes you harmful, now there's interference that's harmful. But who do we go after? Basically the three people causing it say, It's not me because I'm operating things. So we need to think a little more about the example where we have multiple interference and a little bit more about some of the unintended interference sources that I don't think that we normally talk too much about in conferences like this. Thank you very much. (Applause.)

**MR**. CHAPIN: Peter?

### 2.2.4 Peter Tenhula: Regulatory Framework(s) for Facilitating New Sharing Schemes

MR. TENHULA: Thank you. It's really hard following Dale. Plus this is going to be my first speaking engagement in my new role at NTIA so I'm also really scared about that and I hope I don't get in trouble.

THE FLOOR: We're watching you.

MR. TENHULA: I was told I'm not allowed to make disclaimers but, you know, whatever. But, you know, I'm here to focus on the regulatory issue. I'm only one of a handful. And I got a confession. I'm a lawyer, if you haven't read my bio. You know, I went to law school. Sorry about that. I know there's a handful of us in the room. Tom, our deputy CTO, lawyer. Mike Calabrese, sorry to out you, but you're a lawyer too. Bruce Jacobs in the room, he's a lawyer. You know, Mary Brown. Raise your hand if you're a lawyer. Okay, raise your hand if you ever read, interpreted, or implemented a regulation or a law. Thank you. Welcome to the practice of law.

So now that I'm talking to a roomful of lawyers, you guys can understand what I'm saying. Because for lawyers words matter. Little parentheticals like that S there matter. And the fact that this is, you know, ISART with a T and not ISARP with a P, you know, matters because it's important. It's important that we have interdisciplinary and multi-disciplinary like Dale was talking about approach, but for us who speak legalese, you know, to talk to you guys who mostly speak in techno-speak so it's important. I can maybe count on maybe two fingers how many economists are here who have been able to teach me econobabble. So I want to focus on the regulatory aspects which are not necessarily all legalese, but are very important I think off the disappoints, and I hope that gets across.

So what I hope to do in the short time I have is to do a quick survey going back on some regulatory efforts to promote, quote, unquote, shared access to spectrum resources and various prospective, regulatory, quote, unquote, frameworks. Regulatory frameworks are not always established by regulators. At the very last slide if you're able to pull this down from the portal, or if you'll give me your card afterwards I can email this slide. There's a Word document with some references where they're available that I have listed. And, you know, being a lawyer and a policy wonk, you know, one of my things that I've done over the last few years working in this area is I collect kind of proposed policy of regulatory frameworks, you know, like some people collect stamps, coins and art. If you're interested in joining my collectors club, please let me know. But those references are some of those, and I'd be interested in hearing more.

But the key questions to consider here, you know, as I'm talking, I don't think they have answers necessarily. But the ones I've been struggling with, this is just a few of them, you know, what do we mean, words matter? What do we mean by shared access? What do we, you know, how do we keep, you know, long-term visions from become clouded with a short-term reality, and what are the nearer term opportunities that we can take in the incremental steps? Some folks talked about the nature, Tom did earlier about incrementalism really being the way you get to a paradigm shift. And, you know, a key question is are regulators trying to fit, you know, DSA, dynamic spectrum access, you know, round pegs into square holes of legacy, you now, that we had for the last hundred or so years. And also this is the question I maybe get to and, you know, and maybe discuss, you know. The last one is, you know, What are the missing ingredients for effective sharing coexistence models?

So quickly over kind of the recent, this is recent years, recent regulatory efforts, if you want to go back in the last decade we did an NPEG with Dale and a bunch of his CU colleagues, Phil Weiser, Tim Brown, who is in the audience, and Derr Bergenthal, went back and looked at other regulatory precedents, including automatic link establishment in HF. Lots of precedents for sharing. Assistant Secretary Strickling yesterday talked about the original radio act of 1912, how that included some basic sharing arrangement in it. These are the recent ones obviously.

The offer to find radio, cognitive radio proceedings at the FCC and secondary markets which was my baby when I was there. And obviously we've been talking about TV white space. I'd add the medical network things as kind of the most recent effort. The broadband plan, the DSA notice inquiry that the FCC did. Obviously we talked a lot about the President's initiative of late and NTIA's implementation of that 500 megahertz goal. One thing I'll talk about in more detail in one second is probably you never heard about the Redbook changes that are going into the NTIA manual regarding SDR cognitive DSA.

In the international efforts, primarily in Europe, and William espoused a lot of this effort in his two talks, you know, with Ofcom taking the lead and a lot of that, you know, because of his initiatives. And as we were working on the spectrum policy task force Ofcom was right along with us with Martin Kaye. Then I'll talk about some interesting ideas coming out of the radio spectrum policy group in Europe in a second. Actually, there's a lot of investment going on in Europe, you know, like COSTERA, which is an economic—I don't remember what COSTERA all stands for, but economics is in there. So you got the economists and engineers and I think some lawyers in the room together working on frameworks for cognitive radio. And luckily there's a recent agenda item in the World Radio Conference that did not result in any regulations per se on kinds of radio, software defined radio. Industry Canada is involved in TV white spaces. They're kind of the third after U.S. and UK. And I know there's been some trials in Asia and the Pacific Rim as well.

Let me take a slightly deeper dive into—how many folks here are aware that the NTIA manual specifically authorizes cognitive radio and dynamic spectrum access? A few hands. Probably all IRAC members that voted on this, right? Or pushed it? Thank you. You'll see there's a definition of cognitive radio system and definition of designing spectrum access, very broad, you know, wide open definitions. And then this other section 8.4. This is actually not in the currently published version, but I understand from Eddie Davidson it'll be coming out in a few weeks.

The most recent update will have this, you know, provision in it which, you know, I think is a wonderful start. And I actually had absolutely nothing to do with this. So it's—and I'm sure—I thank the people that did. You know, it basically authorizes DSA cognitive radio if they operate in accordance with the NTIA rules, right? The governing services. So you can basically have a DSA cognitive system that takes those rules that are in the manual and implements them so that this automation Tom was talking about is possible at least under the framework in the Redbook.

So ideally personally maybe the rule will ultimately read something like this: Radio communication systems using cognitive radio dynamic spectrum access software defined techniques in any rated communication service shall, notwithstanding the provisions of NTIA rules that govern those services, operate without causing harmful interference to protected services and systems. Very flexible rule. Basically, okay, forget the rules, operate in a way that meets that one basic rule, Thou shalt not cause harmful interference. Remember the word "harmful," a key component to that word, to that element. So you can do whatever you want so long as you do not cause harmful interference. We'll talk about that at another three-day conference.

So in the EU what's going on with RSPG—and I believe you were at this meeting when they launched this effort in May, and they came up with the draft request for opinion on increasing the shared use of spectrum. They actually originally called it collective use of spectrum and other sharing approaches. Tell me if you think this is why words matter, especially in policy readers. You think we'd get away in the U.S. if the PCAST had the words "collective use" in it? I don't think so. So, but Europeans are trying to increase opportunities for shared use of spectrum which is great. And they're focusing on rights. Very legal concept, right? And this notion of licensed shared access or authorized shared access which has been promoted by Siemens Nokia now. And there, you know, they've got an ongoing initiative that I think may be worth paying attention to.

So let me just talk about quickly some perspectives and my collection of frameworks that have developed with, you know, those that were, that came out of the original collective use of spectrum cognitive radio reports at the EU on the Peha sharing model. John Peha in the front row credit him. One that came out of Berkeley with several folks there about what's called opportunistic shared access, something I was involved with a little bit involving interference temperature at the Spectrum Policy Task Force. Some guy's interdisciplinary cross regulatory approach. And Tom had talked, or I mean Howard had talked, about this as spectrum management access transformation already so I won't get into that. The one that has the new model smell to it, the PCAST three tier hierarchy, which Mark talked about already so, and of course these are not necessarily endorsed by the presenter except maybe one. I'm not sure which one it is.

So of course in the EU the first focus is on terminology. And here is where I think a lot of these models and stuff start to emerge. We figure out talking about vertical sharing where cognitive radios, for example, you're sharing with existing users in the white spaces. It's all the other unlicensed like horizontal sharing. Cognitive, we're having, cognitive radios will have the same rights to access spectrum as existing uses, you know. That's one way. This is the EU's approach to make up the definitions of what the spectrum was. But again, definitions, terminology matters.

This is kind of the framework that was envisioned originally in that, one of those cognitive radio reports about vertical sharing and how the, where regulatory intervention comes in. You know, license exempt use which we call unlicensed here. Light licensing, which is somewhere between licensing and license exempt, or private common, which is actually a concept I hadn't heard since I, or we came up with it thanks to Stu Benjamin, a law professor, who came up with that in a paper that then the FCC took and incorporated into its secondary market policies.

So I'm going to wrap up here with the overview of the other rest of the models. But you can pull down the slide and take a look at the text and the references. Another reference in there—this might give me a little more time. I put in there as recommended reading and it doesn't really talk about regulatory framework, more kind of the market framework for this. And this is the paper that John Malyar and Bill Lehr did, you know, in the IEEE and DySPAN in Dublin few years ago about the success, market success. And I would suggest take a look at this.

And John's, I kind of annotated a little bit, how does it match up with EU, you know, terminology like the horizontal, you know, called the sharing among equals or primary secondary sharing, vertical, looks more like the vertical approach. And you've got these different concepts of code systems versus cooperation. And there's some examples of how that, my work in reality and how it fits within. And I drew these, specifically cut and pasted almost directly from his papers, which are cited in there, so thank you very much. The other taxonomy that's in there, which I think it's very implemented, but that one's driven by technology. But it has a regular—here's the spectrum interference.

The interference temperature model that, you know, probably two papers could be written about why that kind of blew up. And then this is my approach, which I won't go into because it's really an eyesore. But it's based on, you know, aggregating and implementing all these various models on top of each other and shrinking that rule book down to size. And then we already talked about Howard's model. I'm not going to tell you where those came from. But it came, you know, like negotiated opportunistic, cooperative, collaborative, opportunistic or non-cooperative type sharing, these are the things that are coming out of these models. Taxonomy, here's this brand-new one. Mark already talked about it but this is more detail on it. So maybe we can talk about in the discussion what are the missing ingredients for effective coexistence models. Here's a reference. Thank you. (Applause.)

### 2.2.5 Stephen Berger: Conformity Assessment as a Risk Management Tool

MR. BERGER: Peter, if you think you had a hard act to follow, try following William, Dale, and yourself, and then with Dennis to come afterwards. Maybe I'll make everyone else look good. I'm kind of going to talk about cleaning the room and taking out the trash, things that are necessary but pedestrian to have a successful deployment.

There's kind of a normal system that rolls out where we do interference analysis looking at some proposal. If it's successful there's a rulemaking and following the rulemaking service rules have to be written, then standards with test methods to show compliance or noncompliance to those service rules. And there have to be lab tests to show that an individual device does or doesn't meet the requirements. Get to field performance. If life is good, that's boring; just everything works as intended. That never happens in my experience. And the cycle repeats. So what really happens? And the question I'm kind of asking and suggesting some answers to is, do we have a system that's ready to carry the water that the technology will deliver? And as I thought about it, where I'm headed is I believe ultimately what we're about here is risk management. So the question is, Do we have a deployment management system that's ready to take this family of technologies and ensure that the risk remains at acceptable levels?

So there's new sharing schemes. We've heard a lot about them. And a lot more could be said. Obviously to be successful they've got to provide a compelling value, and as I've suggested, risk has to be known and be manageable. Regulators use conformity assessment systems, primarily product certification to manage risks that impact public interests and ensure that they remain below acceptable levels. And so I think the question deserves asking, and in the circles I move in I've seen pieces of what we're doing getting implemented. And I don't like what I see happening out of the system that's out there. I don't believe it's ready to carry dynamic spectrum shared access. It could be, but there's some separate work that's needed.

So what are the public interest concerns? Wireless systems must coexist; we've talked about that a lot. We need noninterference with what I'll call the technological infrastructure, hearing aids, control systems, personal electronics. And the problem is we're having enough problems with interference now as the system becomes very dynamic, changing characteristics. Are we engaged in a way that not only will we coexist with other radio systems but with the technological infrastructure?

Then looking further, and it gets even more complex, will we support ongoing innovation? And a lot's been said about LightSquared, and I'm not going to say much more except one way to analyze that whole thing is you had a collision of two technologies, both of which were innovating. If you look at GPS it was not at all what it was originally designed to be. In fact, it's probably 30 or 40 distinct flavors with the different kind of augmentation and implementation. A lot of innovation. Good. We like innovation as engineers. Another set of innovation in the adjoining band and there's a collision. Will we support ongoing innovation and allow unforeseen adaptations?

And there I'm thinking about something that comes along and is intended for one purpose, and someone for an entirely different use case says, Great idea. I think I'll pull it in. And all of a sudden now what maybe have been, was designed to support an entertainment function is being used in a highly high reliability kind of application. So going back through the sort of ecosystem, interference analysis, you don't have to look many places to see 0 to 20 dB of variation in the assessment of how much interference will take place. And that is an impediment to moving forward.

When you get into these things, and I know most in the room have, you get these situations where one conversation I had I was asking why in a particular assessment of a highly credible organization they were giving no account to the interference mitigation measures that were in the proposal. And the answer was, We don't know how to quantify them so we're not going to consider them. Okay. The alternative to not even considering the possibility of mitigating interference and doing many of the creative things comes from an unlikely place, but I'd like to point to it for a minute, in the hearing aide comparability standard C-6319. The first three versions of the standard—and it was started in 1996—simply said, Cellphones have to keep the RF under a certain level, and hearing aides have to have a matching immunity. And the FCC adopted that in their hearing aide comparability rules.

In the fourth version the group had learned enough to do something very interesting. They realized that we now could model the interference to hearing aids. And it basically comes down to how much of the energy demodulates into the audio band and is there long enough to pass through essentially a quasi-peak detector. So there's a spectral filtering aspect and a temporal filter. In the latest version they say, We're only going to assess a radio to the degree it has a potential for interference. So you can radiate as much or as little as you want, but the assessment is going to be, How much energy demodulates into the audio band, and is it there long enough to pass through a waiting filter at the far end? Simple concept.

The committee had a request for interpretation recently. And some results were brought in from LTE. Twenty dB of variation possible in the interference potential of LTE within its various operating modes and configurations. It's huge. The first three versions of the standard didn't even consider that, but at exactly the same power, on the order of two orders of magnitude difference in the interference potential. I think that's a forward looking sort of if we know enough about the victim to model the interference we can start bringing in the time and waveform aspect, and not do sort of brute force regulation but nuanced regulation.

And what's really interesting in that whole thing is some devices, if their waveform is benign enough, can now fall through, fall into a second feature of the latest version of the standard, which the FCC has adopted by the way, where no testing is even required; that the interference potential is so low it can be accomplished by, primarily by waveform that the standard says you don't even need to test because you're not going to have a problem.

Okay. So basically looking at risk you can think of these four quadrants. And the two most important are those that have a high severity and a significant probability of occurrence. The ones we have to deal with are those that occur regularly, and have a high severity, significant consequences. But the ones that perhaps we ought to worry about more, because they won't hit us every day, are those that are low probability, high severity.

And a problem here—I'm going to bring in certification programs—they tend to—and this would be my prediction for this one—start off as checkbox activities. Just people are insecure about how to assess a new device, so they tend to want to just follow the rules and do the recipe. As we get more experience with technology we tend to go to experience based. And sometimes in a really good certification program we get to design based certification where we start to protect against the most difficult and often overlooked issues, the black swans. And the problem with low probability high impact events is they're assured to happen; it's just a question of when, just when the probability.

The issues that led to Bush v Gore were well known. What happened is a national election got within the measurement window of the election. But hanging chads, dimples, those are regular occurring events, well-known. They finally linked up. Some similar things could be said about Fukushima. So black swan events are often created by well-known risks that combine in rare events to create dramatic impact. The concern I have for our field is if we start to go out with certification programs that are checkbook, and that's—not checkbook, checkbox activities—and that tends to be the way they start, we're going to have a problem separating deficient from really good designs. And if we start having bad field issues it could really hinder the program, which is why I'm basically saying this whole area of conformity assessment, we have a system that will make sure only good designs that are going to do the technology as it's intended to get out into the field.

Okay, and one last point, and I think that leads to the field performance issue, have we designed the systems that will let us know what level of problems we're having out there, and then is that information going to flow through to the right levels so it can be analyzed as has been mentioned by several people. (Applause.)

MR. CHAPIN: Last but not least, we have Dennis. And in addition to your talk you're going to show separate slides. Are you going to do that from here?

### 2.2.6 Dennis Roberson: Understanding Spectrum Sharing through Spectrum Observatories, Test Cities, COWS and Service Provider Testing

MR. ROBERSON: Greetings. Are you still awake? That's the key question. A few people nodded their heads. The rest of you are glazed over. We will move on. The title slide for this presentation is a combination title slide and agenda. We are actually going to be talking about the whole notion of dynamic spectrum sharing, which is a term that is heavily used in the PCAST Report, as those of you who have had an opportunity to look at that report will note. We're going to look at this from the aspect of the measurement capability. We had a great introduction to that from the panel last afternoon talking about the great measurement efforts that have been undertaken here. But there are a whole set of things that need to be done in this space. And what we'll conclude on is talking about the test city site. But in the meantime we'll wander through the rest of the topics on the agenda slide.

To begin with, I'll give a little bit of the background of what we do at IIT. Some of you are quite familiar with this. Apologies to you. I found quite a few of you are not familiar with this, so I'll do a little bit of background setting through this. We've been at the task of measuring spectrum utilization for quite some time, five years for our main system continuous operation. That gives us a wealth of data that's quite useful as you're examining this notion of finding places where people can share and share productively in the time domain. What we'll talk about is how this is progressing. Obviously the motivation you understand. The opportunity though is quite significant.

There have been a lot of naysayers on this since the days when Mark McHenry did some of his early studies and certainly a lot of the others over the years. But we are building up a wealth of knowledge that we can apply to allow us to be better equipped to perform this sharing that is now the time to proceed with. For our own systems we've evolved from a single system that's been running for five years to now seven systems that are all running continuously at this point.

And this addresses some of the points that have been made already from the microphone and from the front as well. Measuring spectrum utilization is not a simple task. There are all sorts of caveats that go with this. This was represented earlier from one of the question slash comments. There are all of the challenges of the frequency, how narrow are the buckets, the time resolution, the repetition rate in looking at it, the power levels. Are you at the right place to be able to see this? Are you looking the right direction to see it? The modulation scheme itself, as Steve talked about some of the modulation schemes will inhibit the interference, harmful interference by their own nature. But you need to look at all of those things.

As we have proceeded down that path we've evolved and added a new system every time we come up with a new thing we want to look at. But it's important as we do this examination of the opportunity to be able to have the data at our fingertips that will represent all of these dimensions so we really understand what's there, and understand what we've not been able to measure, have not been able to grab.

The focus of a lot of our work of late has been around public safety. Public safety will have a lot of focus within the context of the presentation I'm providing. But there are a lot of near term opportunities for public safety with the allocations of the D block to public safety, the advent of the FirstNet organization that will be overseeing the national public safety broadband network across the country. There are tremendous opportunities for us to use that sea change as an opportunity for dynamic, the insertion of dynamic spectrum sharing. We'll be talking about that.

But this gives an example of a system that gives us information around that and shows us nice pretty pictures of the top of our roof which now is cluttered with a lot more antennas than are shown here. The big challenge of this whole area of establishing understanding of the spectrum is actually much less a measurement activity than it is a data storage and analysis activity. And this is something that most people that get into the game neglect, especially if you're doing long-term activity and maintaining the data, you know, in manner that is safe, secure, and free from impact and making it available to others as well. One of the bottlenecks for us was the years of data that we now have is the amount of time that it takes to analyze that data, and yet at the same time making the data available to others is not always so easy either because as you make it available it has to be digestible.

Doug Sicker I don't think is in the room now. But this early on opportunity to work with one of his graduate students, provide him with data in his pursuit of a Ph.D., it was a tremendously painful experience on both sides to share the data and to make it understandable. But transforming the data into a real database that can be utilized and has the performance characteristics to allow a variety of people to utilize that information is not a trivial problem, but one of the plumbing elements that we need in our pursuit of dynamic spectrum sharing.

This is a showoff chart to give an example of this. This is public safety information, the 850 megahertz. National public safety public advisory committee band. I believe that's right. Taking things down to 47 hertz buckets. Sometimes you have to do that in order to really understand what's going on so you can see the detail fine structure of what you're looking at.

So illustrating one of those important elements. What do you see when you are looking for a long time? You see events that are macroscopic events. This is the snowstorm, the blizzard of 2011 for Chicago. For those of you familiar with Chicago, this is Lake Shore Drive that you're looking at. It was a parking lot. Many people had the opportunity to ride home in a snowmobile that was driven by a fire officer. But it lasted for a couple of days. So what was the effect that this kind of event has from a spectral standpoint? Here you can see it.

The middle of the chart labeled "blizzard" at the bottom shows the irregularity that is created versus the normal trend. And fortunately this gives it to you in a very nice way. Wednesday, Thursday, Friday, Saturday, blue line shows you public safety, police in this case specifically. The green shows all land mobile used. And you can see the Saturday, Sunday where the non-police users go home and do things with their family, where the police have not much sleep on Friday night and Saturday night, fairly heavy days of work. But the real irregularity comes with the Tuesday afternoon at 2 o'clock when the blizzard hit and you see the spike of police utilization where all of the commercial users of the band all went home.

But it illustrates a great opportunity for sharing, event driven sharing because obviously police needed the spectrum whereas the normal community did not need it. Having the mechanisms to allow for that transfer is very useful. If you collect data for a long time you get to see neat events like the transition to digital television. And that's the video that I'll show you. You can watch long-term history that show you that you can actually see Thanksgiving, Christmas, and New Year's. Don't look at the one on the right. I will be showing you this, but one of the nice things, we've even gone to the extent of producing YouTube video. As we finish the session I'll put the YouTube video up and let it run through and you can watch the history of 700 megahertz like time lapsed photography where you get to watch a flower bloom or these sorts of things.

But it's great when you have the data to be able to really understand as an academic to share with your students how it all really works, but also to truly understand how things operate. Moving beyond the specific work at IIT and turning to some of the other critical measurement activities that are going forward, one that has been referenced a couple of times already in this week of activities between WSRD and CSMAC and now ISART, the TMobile on behalf of the CTIA did in fact pursue a special authority with the FCC. Tom Powers introduced a couple of times now that that has moved to the point of actually citing the places where that investigation might be undertaken to understand both 1755 to 1780 and 2155 to 2180 bands.

First understanding and doing the kinds of measurements that I've described at IIT and were described yesterday here at ITS, but there are a lot of other activities that need to be undertaken as well beyond data time collection also looking at the true opportunity to share, and inserting signals to understand both geographic and temporal based sharing though not, at this point, the opportunity to take the technology based sharing. In the PCAST Report public safety was highlighted as one of the areas, in particular the, acknowledging the D block transfer, the $7 billion that was transferred with in the face of an estimated $30 billion, pick your estimate; some number much larger than $7 billion.

The opportunity that the PCAST Report cites is to use the spectrum access system as a means of implementing secondary access generating revenue that would fill the gap that is created by the limited $7 billion to create the full public safety broadband network. And the neat aspect of this in the red at the bottom is that this sharing could in fact be done even before the public safety network is established in order to generate revenue for the implementation of the public safety network. So key opportunity out of the PCAST Report.

The second aspect of this from a public safety standpoint is the T band which the bill has suggested—not suggested, required—that the T band be transferred. This is an opportunity to mitigate that using the sharing approach as opposed to the transfer approach. Putting this together, as you understand the opportunity, there's a sequence of events that take you down the line of better understanding the dynamic sharing opportunity. Ultimately though you've got to test this. And this is straight out of the PCAST Report as well, with one addition.

And those here at NTIA I guess you will note that your truck has been inserted in addition to the illustration in the PCAST Report. This is a picture I took in the parking lot a couple of days ago. But this opportunity to both establish a test city, a place where you can fully and richly test out things that have gone through the cycle on the past slide that have been moved to a place where you have some confidence that they will actually work. And now use a city to be the test bed environment; not some remote place but right in the heart of a city to be able to test that, and augment that with a mobile test system not unlike what ITS does today in running around and what has been proposed and is under way presumably with the STA that TMobile will be undertaking.

This capability is something that has been proposed through the PCAST Report again to be administered through NTIA, and this, and there is an opportunity to actually fund this. And that is what's listed there at the bottom. So there are places to move forward on this. And I will tell you just referencing the city that I am attached to, this has caught the attention of some of the city fathers in Chicago. There's great enthusiasm about proceeding forward on this. I know Boston and Washington DC are also interested. So there's a lot moving on that, and with that I'll close out since I'm the final one to the transition. This is my address. Use this one as the transition slide to the questions that you may have for the full group. While John's taking over I'll go ahead and get this set up and we'll do that in parallel with the questions.

MR. CHAPIN: Okay, thanks. (Applause.)

### 2.2.7 Session IV Q&A

MR. CHAPIN: Thank you, everybody. So we'll certainly start with questions from the audience. If things flag I have a few queued up here. Is there anybody that would like to ask questions? Pierre, thanks for starting us.

MR. DEVRIES: Pierre Devries, Silicon Flatiron here at CU. Question for William. Fascinating idea of starting flexible and then tightening up. There's a paradox that I'd like help understanding. And the paradox is you've got this notion of we'll start permissive and then tighten if there's interference. On the other hand you also said it's really really hard to see interference, so how do you do that?

MR. WEBB: Yeah. I think we need to put in place mechanisms where users can report the interference. So my thesis would be if there's any problem is it actually causing a problem? If it's just a raised signal level that doesn't affect anyone it's not something we should necessarily want to go address because it's not causing any economic harm. So we need a mechanism whereby users can effectively say, I've suffered interference. And I think some kind of online discussion forum type system that can collect the information from users may be the way to do that in this day and age, and then process that using some sort of algorithms that will kind of strip out what seems to be likely will be the SA effects and perhaps even automatically start changes to databases to make the process very fast.

MR. CHAPIN: Let me interrupt you because there's a video on the screen and anything we say will being ignored. Will you say a few words about the video, Dennis?

MR. ROBERSON: This video is in fact you can see in the upper right hand corner the timeline. So you're looking at analog television at this point. And you just saw the transition from analog to digital. There was the remainder, Qualcomm—you can see the band plan at the bottom, future band plan. What you're going to see is the transition as first Verizon and then AT&T pop up their 4G LTE. It's pretty self-explanatory as you go through it, but it's a nice way to be able to literally watch the spectrum as it proceeds with the time, something that we rarely have the opportunity to do. We talk about it a great deal, but this gives a true opportunity to visualize it.

MR. CHAPIN: Dennis, I think for the sake of respecting questions and answers going on here, why don't you pause that and we'll maybe turn it on when we break for lunch.

MR. TENHULA: Watch the Qualcomm thing get turned off. It goes down right when AT&T bought it they turn it off. When was that? Last year?

MR. ROBERSON: Waiting for the great event, which is about to occur right now.

MR. CHAPIN: Okay. I have a follow-up question for William to what Pierre just asked. If you start with looser restrictions that can potentially be tightened in the future, how do you justify the investment in equipment? How do you build a business case if the rules might get tightened on you downstream?

MR. WEBB: So that becomes one of the risk issues that are involved. There may be some people who see it as a risk too far and others are prepared to take on the risk. But we talked yesterday about the risk that you might have with TV white space and that the amount of white space might change because of the auction or something like that. So those kinds of risks are already there to anyone entering that white space environment. That's something that they, you have to be prepared to take. But as I looked at this from the point of view of the company I'm with, that kind of risk is actually one of the least significant risks compared to risks such as will we get funding in the next round and many other things like that. I don't see it as insurmountable, but it's certainly there.

MR. CHAPIN: Peter, next question.

MR. KIDD: Not to keep it focused on you, William, but something that was mentioned a couple of times in the conference is something that we struggle with right now within the Department of the Navy, of the kind of inference that causes desensitization of a system. I didn't hear you mention that. We have a challenge of certain kinds of interference to some of our radar systems for example that would prevent the radar from detecting objects at the distance designed. The challenge though is the operator doesn't know this. The operator still sees the—detected it, but it's detected sooner than the specifications for the equipment were. So using your model—and I could honestly see this for example over the air, over the air digital TV. I hit the little button and it runs through the X number of channels and it pops up and populates my little thing and tells me where I happen to live I can receive 11 channels, when reality is the TV that I purchased and the broadcasters in the area perhaps are expecting me to be able to receive 18 channels. But some interference is causing a desensitization. I as the customer will never know that so I'll never report the interference. How does that fit into your model?

MR. WEBB: I'm not thoroughly prepared for every case in detail, but something like the radar approach it strikes me that actually you want to check the radar from time to time anyway. In the UK when we looked into this we had a target set up, where we basically set a known target on the limit of the radar range and then turned on the interferer to check whether you can still see that known target, and did some measurement like that. I can imagine a ship comes back to dock, it then checks if it can see some fixed target that it knows about, some building some distance away on the horizon. Does it every time it's back in the dock just to check that the whole system is working.

MR. KIDD: That's really not my—I'm talking about when in actual operation. So the system bench tests okay. Then when it's in real operation the operator doesn't realize that they can't see 80 miles; they can only see 60 miles.

MR. CHAPIN: I'm going to repeat the question for the sake of the record. His point is in actual operation, say, a radar range might go down, whereas in the bench test situation it would have been fine.

MR. WEBB: I think that's something that people need to look at ways that potentially can the receiver itself understand the noise it's seeing in its front end and report back on the noise, that kind of thing. And it seems to me, you know, that's going to be good practice. It's going to take the stuff in arenas where the interference involved such as a war zone or whatever you should be checking that sort of stuff anyway.

MR. CHAPIN: All right. Open for other questions.

MR. BUDDHIKOT: Bring it back to the dollars and cents questions I think because I think it's easier to deal with this than to look for the black swan events. So if you allow for permissive behavior in the devices at the end of the day it has an implication on the costs of the devices in the event as it does to the cost of the system you are trying to put in place. So is there a way to somehow do some sort of a trade-off analysis with less conservative versus if I'm more conservative, and then try to articulate the cost of systems, not just a device for a certain thing? So how do we bring in the systems prospect in the decisions of the economy in the business and the cost prospect in the decision, not just the technology, but whether they should be permissive and non-permissive? Any thoughts on that?

MR. CHAPIN: I think Steve will have something to say.

MR. BERGER: One of the things I see commonly is dislocation of cost and benefit. And that becomes a difficult problem. You should spend more on your receiver so I have a business opportunity. What sense does that make? Unless we can figure out—I guess the two mechanisms are if we can quantify that in some way then maybe there's a business arrangement or a political solution, a regulation require issue for the public interest to bear that cost. It's difficult though.

MR. WEBB: So the only real way to get numbers is if you take specific examples that you can work through. For example, I've run some numbers that show in the UK how if you change the white space access rules I mentioned in the UK the base gets back to a maximum amount of power level. So if you change the rules that power can go up and down. For every dB that power changes if you've got a system, say it's a base system then the ranges of your cell shrinks so you need more cells, and you can work out the increased cost of that. But actually I can quantify for specific systems in the country. For every dB change it effectively allows white space power. It's what the cost of that actual access, what the cost of that is. And that's the only way to go about the analysis.

MR. BUDDHIKOT: We can look at it from—

MR. WEBB: I'm trying to think if it's published. It has been.

MR. ROBERSON: Add maybe a word on this because it's just so fundamental in the work we're doing with the FCC in the receiver working group. It is very clear that receivers are actually getting worse now because there are ways to cut costs by making them worse even though the componentry would allow you to make them much better. So there are, there are opportunities to make the overall spectrum utilization much more efficient. But the costs are usually borne by other than the people who are deriving the benefit. And getting that disconnect resolved is very very challenging because it's often very complex. There are piecewise ways of analyzing the issue. But how to reassign those costs in a way that, at least in this country, that winners and losers are not being selected by big brother in federal government, that's a human challenge.

MR. BUDDHIKOT: It will—

MR. CHAPIN: We can't hear you, Milind. I'm sorry.

MR. BUDDHIKOT: I think any concrete service standards, I think, there's none, I think, at least as of today. So the whole point about having good receiver standards is increasingly paramount as we go forward.

MR. CHAPIN: Please state your name.

CISCO: Cisco Systems. I think inherent in this is that the license exempt bands have been interference limited. And the licensed bands have been noise limited. And as we come to share we're effectively, Your environment is now interference limited, not noise limited like the radar being impaired by blockage or anything. And it's fundamental because when we say, What's the risk and what's the return, the 20th Century had it as noise limited, and we knew boatsman cox and we can measure the weather and figure it out. But when it's interference limited we don't understand the basis of the bands that we're operating in. And that's fundamental to everything that follows.

MR. CHAPIN: Very interesting point. Anyone like to respond to that? Dale, is that part of the change you saw?

MR. HATFIELD: No, I agree. I agree completely. To try to say to a certain circumstance, of course you would hope negotiating and bargaining would work where the person who's going to get the game pays off, and the person who is going to have some costs works it out in the marketplace. In some ways of course that would be, that would be the idea, recognized right away. But oftentimes that can't happen because one side is the government and can't negotiate or whatever. But at least in principle we ought to keep it going.

MR. ROBERSON: I just would agree with your point as well. There are still many many cases where geographically it is noise limited. But the problems that are most vexing and most challenging, most in front of us in urban environments and so on, it is an interference limited growth.

MR. CHAPIN: Great. Before we go on to Dan's question I'd just like to ask a follow-up question related to that. As we look at an interference limited world does that perhaps drive us more towards Williams' style approach of changing the regulations, starting loose and going tighter? Is that a better fit to that world? I'm looking at Peter also. Does that drive us towards one or other of the regulatory regimes that you identified and others if it is indeed as fundamental as folks seem to be agreeing?

MR. TENHULA: Yeah. I'm very intrigued by that because I always thought we would start conservative and go liberal. You know, start with a baseline—you know, this is kind of the worst case scenario but it's true what Dale said. And since we're all speaking econobabble here, I would see bargaining, you know, that would then allow parties to think that they're on the same playing field to start there, the fallback regulation, but then negotiate around that and say, Well, I'll allow more access, you know, under these circumstances. But William's starting with kind of the more liberal and then adding conservative. My issue with that, you know, living the reality of the regulatory process is that you, when you start with a loose regulation and then, you know, after a while somebody then proposes, Oh, God, we need to tighten this regulation, I don't think I've ever seen that in my entire career, you know, but, you know, unless there's, you know, a real a mutual agreement on that. So I'd like to see that in practice. If we are talking about regulation with a small R in the sense of self-regulatory like the standards bodies, you know, and then I think there's more of a promise there because you've got true democratic institutions that get together in a transparent way, and I'm talking standards-wise, and come up with, you know, standards and say, You know what? This is resulting in, you know, too many problems. We're going to have to tighten it up here. You know, I think you're more likely to get consensus that way because folks are harmed not through the regulator because somebody's got a stake in it. And we may have a situation like that coming up where something's kind of really unregulated—you know, I'm not going to mention the case—but people are going to regulate that. The receiver standard we've been talking about, you know, it's going to be really—receivers are unregulated right now. And I don't know how many years ago—I mean, I know the policy task force recommended receiver regulation and—

MR. ROBERSON: Dale didn't fix it 50 years ago. That was the problem.

MR. TENHULA: Dale recommended it. You know, so, you know, I, that's my only issue from a regulatory standpoint.

MR. ROBERSON: There are other cases where there are the increases. Energy Star is one of them. The miles per gallon is another one where there are improvements that are built in over time. Currently though I don't know all the details—Julie Knapp raised this to our receiver task force but in Japan for receivers they actually have implemented, they have standards and they have implemented a requirement that the standards improve their character—much as was suggested by our friend from Cisco that that is being implemented in Japan. I wish I knew all the details behind that, but it is rumored that that is, that is the case. And that may be in one form or another the sort of thing that we, that we need to do with the incrementing that's been suggested.

MR. CHAPIN: Dan's been waiting for a long time so we'll take him first.

MR. LUBAR: Dan Lubar, White Space Alliance. I'm going to come at this from the other direction. And it dovetails nicely with John's question. In the CSMAC meeting the other day there was a discussion about enforcement and Dale, this sort of goes to your points in your presentation about enforcement. The term that I saw that sort of caught my eye was technology enforcement. So if you can sort of do it in a cause and effect kind of way—you talked about economics, Peter—if there is somebody who is going to suffer a harm, is some, are some of the tools that we're talking about using here and sharing, technologically speaking, can there be an enforcement and transparency in using the technology we're talking about to change that Coasian bargaining dynamic? I'm just sort of curious to hear your feedback. Instead of trying to preemptively, you know, regulate it, use the technology to mitigate it.

MR. CHAPIN: I don't know that anybody is excited to field that one. Actually, maybe I can—go ahead.

MR. HATFIELD: Let me try. I'm not sure I completely understood. But I think going back to what Larry Lessag, you know, how do we, how do we agree on these types of things? And one is through norms, social norms. You hear that, I do it because the people I'm working with and so forth. The other way is to impose architecture that says, you know, If I'm in this location I can't, I can't transmit. That's, that's where the architecture, that's an architectural solution. And then there's marketplace solution and the sort of Coasian bargaining thing we talked about. And of course there's law, there's sort of the law and regulation. I sort of lean toward staying away as much as we can from the traditional type law and regulation here and try to rely more, as I said before, on sort of the multi stakeholder groups. I'm not sure that addresses the question completely.

**MR**. TENHULA: What it raises for me, Dan, is—and be ready for some Latin—ex post versus ex ante regulation, right? Ex post, enforcement, and ex ante regulation. So ex ante regulation is like a power limit, right? And but you can also do some contents in between. I think that's what the CSMAC recommended is have kind of capabilities in place that when and if there is a problem you can solve it, you know, by calling home or changing firmware, something like that. It's like an airbag, right? In a car. You hope you never have to use it but it's there just in case, right? Or seat belts. And those are regulatorily imposed. Because, you know, even though we have laws, an ex ante law that says, You shall stop at a red light, guess what? All people don't stop at all red lights. People run red lights; therefore, you need airbags to save your life in case somebody runs a red light. So there's an engineering speak for that. Then there's probably econobabble for that. But legally, ex ante and ex post and combinations of those where you have those capabilities just in case, you know, you know, the black swan, you know, starts flying around. Do they fly? You've got a remedy just in case.

MR. CHAPIN: Dr. Sahad?

DR. SAHAD: Well, I wanted to comment that this discussion of receiver standards, databases and some looney tune ideas that John and I were talking about yesterday actually can fit together, right? You can imagine a cheap way of doing, or a very simple way of doing receiver standards could be—this is probably a nutty idea—that the receiver has to be able to accept sort of simulated interference or the behavior of simulated interference. So you can imagine that in the databases you can have simultaneously not just this is the actual environment you have, but this is the storm that's coming through, simulated storm of other activity in neighboring bands. It just shows up and the device has to deal with it. It has to react to it in that way. And if the device is reacting in such a way that it's behaving badly—the problem with cheap, bad receivers is that you can make them and the users don't know that they're bad. The user thinks it's fine because there's nobody in the neighboring band. This gets back to the idea of making them act flaky when they should be flaky and the user should expect it to be flaky. So I think there is some way of combining the ideas. They may be all nuts, but I wouldn't comment.

MR. ROBERSON: I'll jump on this one. It absolutely is the case that these can be combined. I'll reference back to the panel yesterday, the discussion about the very large amount of data in the database, much of which is static. If we characterized each of the devices and characterized the potential environment including the storm, you can use that data to grant or not grant access to a specific piece of spectrum. Over time we will have the ability to use this kind of information to make spectrum really efficient, and to give the huge abundance that is in the PCAST report, abundance of spectrum that is possible; that there is the opportunity for us to have with use of all of the tools.

MR. CHAPIN: I'm going to make a pithy comment before I hand the microphone over to William and that is, this session is really all about trust. I mean, I think what Anaj is proposing is that we should provide mechanisms in the system so that users do not place trust in the devices that they shouldn't be trusting, which is perhaps a useful tool to think about.

MR. WEBB: On the general issue of receivers, it's like when I was at Ofcom it cropped up so many times and we studied it so many times and we never did anything much about it because the problem is always intractably hard. But I think you need to be a bit careful about imposing standards. There may well be a whole class of receivers that cost a dollar that you don't want to harden against every eventuality because they are throwaway. It's a bit like saying umbrella manufacturers must make umbrellas to withstand 100 mile an hour wind that might happen. But actually if you buy a five dollar umbrella you don't expect it to do that; you expect it to break in that situation. And that's just fine if that's what you want. If we're not careful we'll end up with standards that mean a whole class of devices can't be implemented because it gets expensive, so we have to watch for that kind of thing.

MR. ROBERSON: But I think that's the beauty of the database, exactly the point of the question. Because when you know it's a throwaway device you then put the maximum guideline that you presume that you are only going to grant the utilization in sort of the worst case scenario, or you presume that it doesn't matter; you can give it anything because if it breaks, as you said, who cares?

MR. HATFIELD: I would just add that one of the things, you can label the umbrella so at least as the guy at the metro station is selling them, Is this a hundred mile an hour umbrella or is this a two mile an hour umbrella? And I can make then the right choice of then whether to buy it or not. So I think the information to the consumer would help. In all seriousness, back in the canard years we were toying with the idea of having the receivers sort of in, you know, platinum, silver, and gold, that sort of thing, where we could at least give the consumer some idea if you're in Wyoming this will probably work fine. If you're in downtown New York urban aware it probably won't work very well. You try to complain to us we'll say, You're using it in an appropriate place or in an inappropriate place.

MR. CHAPIN: Steve?

MR. BERGER: I think your comment, one of the problems I'm seeing is that so often the person selecting the radio is not the consumer, but the person who's buying the module to put in some other piece of equipment that then has a wireless link. And they have absolutely no wireless inside radio experience. To them it's a drop-in module and they have a wireless link. And it's really concerning some of the selections that you see get made along that line. Another comment I'd make is that I think sometimes we have a three way issue here and perhaps it's worth thinking about. And that is, you know, perhaps you're the victim and over here there's a possible interferer. And the solution might be that if all our cellphones perhaps would share certain information we could manage this. But now after you got, how do you require a third party to give up information at some cost of battery life that would help us manage the interference information?

MR. CHAPIN: We're scheduled to go to 12:15. I'm just sort of monitoring the flow of things here. I think we should cut it off at 12:00. So we'll take one more question. And then if there's any final comment from the panel we'll take those.

MR. HANKINS: Dan Hankins, AFTRCC. My question goes to what happens if these systems cause interference to business applications, you know, like differential GPS or you're using a radio link to gather data, and the loss of that would prevent a company from conducting the normal operations. Would that open up the potential for a liability on the part of someone where you could seek monetary damages?

MR. ROBERSON: Sounds like a lawyer question.

MR. TENHULA: I'm sorry, what do you mean by interference? (Applause.)

MR. TENHULA: Did you mean harmful interference?

MR. HANKINS: Yeah. The bit error rate kind of goes up to where you can't do your job anymore.

MR. TENHULA: So is it radio navigation service or safety service?

MR. HANKINS: Well, in this case actually sometimes it's used for safety as well as radio navigation.

MR. TENHULA: So that service is seriously degraded then, right?

MR. HANKINS: Yes.

MR. TENHULA: Or if it's not one of those types of services, is it seriously degraded or obstructed or repeatedly interrupted?

MR. HANKINS: In our case it would all be the same.

MR. TENHULA: What do the facts show?

MR. HANKINS: I take your point.

MR. TENHULA: There's no jurisprudence over the resolution of interference disputes; absolutely none. It is done in an ex ante approach of presenting a worst case scenario based on modeling, right? So if interference occurs, harmful interference I mean, how do you resolve that? Do you go to court and say, you know, This guy ran into me. He ran a red light. He wasn't wearing a seatbelt. He had a crappy receiver, right? Who's liable in that situation? How do you, what court do you go to to resolve that dispute? The answer is there isn't. It doesn't exist. And that's a fundamental issue. Like one of my core questions is, what's missing from any of these frameworks is basically there's certain fundamentals of spectrum management, spectrum regulation that are missing. One is, you know, a workable definition of interference, one is a place to adjudicate these kinds of disputes. Another one is, you know, the enforcement we've all talked about. You know, there's probably a list a mile long, basic fundamentals that should've been put in place 50, 60 years ago. They don't exist.

MR. ROBERSON: Today practically you go to the FCC and hope it works out.

MR. HATFIELD: The FCC will say, You don't want the answer. Go back and negotiate.

MR. HANKINS: It was something that was filed in civil court, you know. I'm not an attorney. But we employ an attorney who advises us in ways that raises the hair on the back of our neck quite often.

MR. TENHULA: Well, a defense lawyer will file a motion with the judge that says, This is an issue of primary jurisdiction with the FCC. And in order to delay things and draw things out as long as possible, they'll say, Okay. The judge agrees. They'll file this declaratory ruling request with the FCC to decide if this is in your exclusive or primary jurisdiction, the FCC will rule on this. Maybe a couple of years later, after a lot of rounds of comments and meetings and things like that, if the parties are still around and haven't filed for bankruptcy, you know, then, you know, then it gets back to the Court and the Court will say, Sorry, I have no jurisdiction here or maybe, I have jurisdiction over this little part. This is exactly what's been going on in the cellular booster cases. I don't know if anybody's following that, but it's an interesting case study. It eventually ended up at the FCC and a rulemaking process. But it's a very interesting case study. Cellular boosters basically are sharing the spectrum, you know. And the incumbent cellular industry is saying, They're causing interference. What happened was, the funny thing is the cellular street, they went to court and they accused these booster companies. They didn't say, They're causing harmful interference but they raised a bunch of other legal issues but then it ended up back at the FCC. That's the issue we have to deal with. There's really one entity in the world—I mean, NTIA too when there's a federal party involved—when there's nonfederal parties that deal with interference issues. In the country, not the world.

MR. ROBERSON: Actually we spent a fair amount of time on this with Mark talking about this within the PCAST group. And what we concluded is that the issue that you're raising is a today issue. As we move into a dynamic spectrum sharing regime, the probability of having disputes is raised very very rapidly. So the absence of these kinds of fundamentals is really going to be very very visible. So we viewed this as an opportunity to establish alternate dispute resolution mechanism so that there would be a means by which—alternate dispute resolution mechanisms are very very commonly used in all sorts of areas, but not in this area. So establishing that as the norm so you have someplace to go, a justice of the peace that'll say, Hey, work it out or at least resolve most of the issues. Even knowing that there is such a place will resolve a lot of issues because there's a knowledge that there is someplace to go that there will be a resolution, and that will be a deterrent for people doing some of the things that they do today.

MR. HANKINS: I'm happy with that answer. I just wanted to make sure somebody thought about it.

MR. ROBERSON: As you can tell there's a lot of thinking and conversation, but not resolution.

MR. CHAPIN: I'm going to self-disclose that I have not read all 200 pages of the report. But did that discussion make it into the report?

MR. ROBERSON: I'm going to let—it's in there but it's not definitive.

MR. GORENBERG: We didn't talk about it as a recommendation; it's as a byproduct.

MR. CHAPIN: I'm going to repeat that for the record. Mark says that it did not make it to the level of a formal recommendation, but it is in the discussion.

MR. ROBERSON: Yeah. Maybe I'll have a meeting with Mike later or he can jump up and do it. In the end we decided that this, as with many other things, was a bridge too far for our efforts, and was not the center focus. But we did list it as something that had to be put in place. We didn't propose how to put it in place, but we suggested that it was something that—

MR. TENHULA: What is it?

MR. ROBERSON: The alternate dispute resolution mechanism so there is an established alternate dispute resolution mechanism. I won't even get into this. This is a sufficiently complex subject—remember, I'm a professor—that I got the dean of our law school involved in this. And he started sending me the journals that were relevant to this. Very very quickly I decided the approach that was taken in the PCAST Report was exactly the right one to raise it as an issue, and not even attempt to come to a resolution; that that was beyond the scope of our task or capabilities or focus.

MR. HANKINS: Thank you.

**MR**. CHAPIN: All right. So I'm going to open just for the committee if there is anyone who would like to make a final comment before we close the session.

MR. TENHULA: I just want to, I'll follow up on that. I just find in page 54 of the report creating a robust framework for dispute resolution, the heading. And it references—I haven't read everything yet either. I searched for a key word like "dispute"—the middle class tax relief and job creation act creates a framework for disputes associated with clearing and reallocation of federal spectrum use. That's actually something I'm working on at NTIA. And there's a notice for proposed rulemaking. I'll put a plug in. It's still there. Comment are due August 1. Go to the NTIA website and look for that federal register publication, notice of proposed rulemaking on the dispute resolution panels. This is one small area, you know. It only involves, you know, disputes over the implementation of transition plans that are submitted by federal entities. You know, so if a federal agency is taking too long or something to relocate a system, then, you know, the nonfederal licensee that had won the license at auction can come in and submit a dispute to NTIA, NTIA then creates the three member depute resolution panels. And they then have 30 days to decide the dispute. And then there's actually then a provision for even going to court on that so it's penetrated the regulatory ecosystem as we say, so we'll see how it turns out. We had actually when I was at the FCC there was an alternative dispute resolution mechanism implemented, and a lot of effort went into doing that for the relocation of microwave incumbents and the PCS bands. And my recollection is, you know, all that effort went into that, coming up with that, there was only one dispute that ever made it to the FCC between a microwave licensee and a PCS licensee. I see Pepper shaking his head so it must be right.

MR. CHAPIN: William?

MR. WEBB: I'd like to conclude by saying don't forget to look at the bigger picture. It's very easy to say, Gosh, this might lead to more interference in a TV band but I don't see that happening because some other useful service is being provided to the affected consumer. Would the average consumer expect very occasionally interference with his TV if that means there is a machine to machine out there that monitors their heart rate and calls the emergency service before they have the heart attack? I'm sure they'd accept that tradeoff. So, you know, I think when there's interference it's because someone is providing a service that is of value to people who get the service. If you do everything in the round while we're focusing on the downsides there's upside as well.

MR. ROBERSON: I'll just give a fun opportunity. The spectrum observatory that I suggested, we have the great opportunity to view that from anywhere at any time. So those of you that want to see what the spectral weather looks like in Chicago I'll put that up after we conclude for your viewing pleasure.

MR. CHAPIN: Anyone else?

MR. BERGER: Yes. I'll just make the comment that following the theme of the conference, it's going to be increasingly important to follow the consequential chain on these interferences and I think successfully cross battle from radios into computer science so that we capture the opportunities to at times mitigate in the software, if you will, and not just try to do everything on the radio side.

MR. CHAPIN: Great. And my final comment is just to say, point out—I'm going to use the legal that Peter put together, the Latin, excuse me, ex post versus ex ante. Most of what we've heard on this panel is about mechanisms that ex post will reduce and mitigate and solve problems. I think that that's a major theme, transition, and validation in the regulatory environment going away from the almost exclusive ex ante approach that we have today so one that's a bit more balanced in order to accommodate the needs of the new sharing approaches and the new technologies. So thank you very much for your attention. I believe lunch should be served. (Applause.)

## 2.3 Session V: Closing Panel

### 2.3.1 Panelists Remarks

MR. DEVRIES: Okay. So let's get started again. Thank you for staying. This session you'll see that we've moved the microphones. We're going to do the Q and A a little differently this time. Since we really want to have more of common sharing, sharing of ideas about the highlights about the surprises and silences what I'm going to do is to invite you to come up and pose your comment or your questions not only to the panelists but also to the audience. I'd also ask people to stay within two minutes if you can; that way we can get more thoughts and opinions. And we'll make sure that we stop—I hope I will be able to do this—before 4 o'clock. If past experience is any guide, the conversation will be really good. Please start coming up. I'll just get things going with a couple of questions. The thing that actually came up for me while we were talking in the hallway, two related questions. We've talked a lot about how far we've come in the last thirteen ISARTs or last three years. And Jerry McGuire has come up as a movie. My favorite quote is, Show me the money. So two related questions. The first question is, where's the money to pay for this going to come from? It's going to take a lot of money. I'm not sure that the money the PCAST identified is going to be enough. So show me the money flow. And the related question is, if the money and that willingness isn't there, what's the price of doing nothing? If we just punt and just go along for a few years, another four years and nothing happens, is that okay? Or do we lose something fundamental? Jump ball anybody.

MR. MARSHALL: One, I think the price of doing nothing is, if we look at the Wi-Fi economy we won't have another. If you look at employment in wireless infrastructure it's gone down because it's static. If you look at employment, there's some wonderful statistics in the Wi-Fi industry and it's massively increasing. So I think we have seen where we create disruptive opportunities people rush in. So we shouldn't think about it as a couple hundred million dollars of spectrum administration; we should think about this as there's going to be a new industry in this. We see Europe moving out. We see Singapore moving out. William had a lot of good comments on that. The price is the billions of dollars. I mean, I think PCAST's argument was not whether what we put out was the best spectrum policy. It argued that this was a policy that enabled innovation. So I think we should be focused on not saying about right and wrong and interference and dBms and all that stuff. But think about this as what types of rules will promote the creation of these billions of dollar industries in America.

MR. DEVRIES: So to create the billion dollar industries you've got to put in seed money. Do we have enough seed money?

MR. MARSHALL: We have enough seed money if we can get her constituents to give it to us. In the end, let's face it. The government has this horrible thing, you know, known as spectrum. And it profits from scarcity. So measuring spectrum policy by revenue creation, by eking out tens of megahertz at auction easily the government is actually throttling the opportunity for innovation. So we have to get the mindset of thinking about spectrum and spectrum policy as an investment to enable innovation rather than as a revenue source to pay off the deficit. If we do that, we'll always try to make it scarce; we'll always try to make it expensive, and we'll essentially kill off all the opportunities for people to grow. I think we have to ask this question differently.

MR. DEVRIES: Moving to John. And by the way, the microphones are open. Feel free to start lining up.

MR. CHAPIN: I'd just like to make Preston's comment a little bit more concrete with my favorite new billion dollar plus industry that would grow up if we had enough spectrum for it. You know, the smart city, the smart county, you know, all of the automation of our meters, of our infrastructure, of our traffic lights, of our things in our lives that cause friction and get in our way and prevent us from using the resources around us efficiently. Automating all of that with small cheap devices requires spectrum. And if you do that, the efficiency savings and the benefits for our economy are so great it would more than pay for the kinds of costs that are associated with freeing up that spectrum for those uses.

MR. DEVRIES: Not to be skeptical, which is easy for me, but that sounds like trading off guns tomorrow for, you know, guns after the axe falls in January. I mean, how do you actually make that argument?

MR. CHAPIN: Can you make your metaphor a little more clear?

**MR**. DEVRIES: I'm sorry. I got carried away with metaphors. We're in a situation where there's a great deal of pressure on the budget. There's not enough money. The little I understand about the process when ideas get put forward by, you know, advisory committees, the best that the government servants can say is, We don't have the money for that. They can't say it's a good idea, this is a bad idea. It's simply, We don't have the money to do that. It's up to Congress to do that. In an environment where we have a deficit, we have a debt, everybody realizes or believes that they need to cut funding rather than increase it, it sounds like we face a prospect where there isn't going to be the money to pay for all this stuff. And you know, if I think about, How do I sell this, and you're saying, Well, then maybe innovation which you're going to lose, it's always easy to say, Yeah, we'll lose it. You know, America's still great. We'll be fine. So are there, what other arguments can we marshal, to coin a phrase? It’s innovation. Do we pay a price if we don’t did this? Do people die if we don’t do this? Does the, are there services that can’t meet their missions if we don’t do this?

MR. CHAPIN: Just as a rejoinder, to respond to that, I think the key thing is this is not a big bang change. You can do it incrementally in small fractions of the spectrum, which the cost to implement it there will be less because the risks are less or the incumbents are easier to move. And so you start small. And what’s the total amount of spectrum assigned to the Wi-Fi ecosystem? It’s 100 megahertz.

MR. DEVRIES: It’s 84.

MR. CHAPIN: It’s not that much. Think about the size of that ecosystem. But let’s look for those kinds of opportunities before we assume that we have to clear a thousand megahertz to make it happen.

MR. DEVRIES: Michael?

MR. CALABRESE: I’d just add to both ends, both sides of that equation. On the economic side it’s to remember that, you know, this kind of activities isn’t like other outputs. It’s widgets; it’s infrastructure. I mean, it’s really broadband kind of activities input into everything else in the economy. So it’s not just innovation. It’s productivity which is at stake. On the other hand, as John said, it can be very incremental. And it can also be self-sustaining. So, you know, as Mark mentioned this morning, one of the PCAST recommendations was there is already a spectrum relocation fund, which notionally has billions of dollars in it, but it can only be used for those frequencies that were auctioned. And if we make that an, if we broaden that concept into a revolving spectrum efficiency fund or spectrum innovation fund so that all the agencies, you know, can draw on that because they’re not going to use the, you know, the budget for their mission to promote the sort of general social goal of, you know, of spectrum efficiency. But if you have a fund like that so that, and it’s replenished not just with auctions but perhaps with other types of user fees, then releasing fees for the secondary, this idea of the three part primary, secondary, tertiary generated access were even at that level. And a lot of equipment makers hate when I say this, but you could even for unlicensed devices you can conceivably have a one time, a very small one-time certification fee measuring with, you know, the hundreds of millions of Wi-Fi devices how that would add up and be year after year revenue. So even a portion of the types of revenue you can have that replenish a fund like that that was used to pay the cost of doing this incrementally means that it doesn’t have to hit the, you know, the general operating budget of the government at all.

### 2.3.2 Session V Q&A

MR. DEVRIES: Okay, good. Let’s move to questions from the audience. In order to try and change the mix, rather than have one question and then have everybody on the panel react, I’ll ask two or three, depending on how many people we have questions or comments from the audience in a row. And then I’ll ask from time to time if panelists have any comments, so panelists, keep track of the things you want to respond to.

MR. WEBB: In the UK this was done quite easily. We charged the military well over $100 billion a year to access spectrum. But if they allow sharing, they get a reduction on that. Actually they could implement this and save money rather than spend more money. That's not the situation here. But actually what you want to do is build an infrastructure and the government can't afford it, like how you pay for a new major toll road or something like that, why not get the private sector to build the database like you would the military to get that to work, and then they can take 10 percent of the revenue that flows through for those into that spectrum? There's plenty of ways to do it. I mean, it's the right thing to do and minus any kind of impediment to making it happen

MR. DEVRIES: Go ahead.

MS. MOORE: Are we supposed to ask questions or make comments?

MR. DEVRIES: As you wish, comments or questions. And you don't have to address the panel; you can address the audience as well.

**MR**. NELSON: Can we get people's names for the record?

MR. DEVRIES: Yes.

MS. MOORE: I was about to give my name. And I get an extra 30 seconds I get to rebut. My name is Linda Moore. Oh, I'm sorry. It's not turned on. My name is Linda Moore. I do work for Congressional Research Service. To clarify, Congress is the client of Congressional Research Services. However, the comments I'm making are my own words. They are raw ideas which at some point will be properly refined into a report for Congress. But as of right now, these are my ideas and not those of CRS. To deal with the funding I think there's been too much emphasis in asking Congress for assistance in funding. Frankly, evolving the spectrum relocation fund into a more flexible fund is a very good idea, and I think that's something that should be promoted, and would be a source of funding. But I think it's more important to look at the regulatory environment. And Eric said something, we need to test not just technology but also regulation. Tom is, as always, a little dubious of regulation. Preston said something. I don't think it was on a panel but I'm not sure because he's always on. But basically we need a differently type of regulatory regime. I think we need to think of dynamic spectrum access as the next Internet. We need to think of—not in terms of regulating spectrum. We need to think of it in terms of regulating a flow of information legislatively, regulatorily. We've got to get it into a right regime. We have to get it into a differently business model for venture capital. PCAST gives us a couple of points where we can completely rewrite market economics for the way spectrum is used to a totally new model that fits the dynamic spectrum access technology. The old model for current allocations is broken, I believe. It has a limited life expectancy even in Congress, I think. And by the way, the law specifies already that the FCC is not to consider the value of the spectrum when it places it up for auction. I know Congress doesn't treat it that way, but it's already in the law. That's all I have to say. That is my proposal for discussion, which is to pull away from how do we regulate this but, how do we not regulate it, okay?

MR. DEVRIES: Thank you. We'll take two more interventions.

MR. TENHULA: Okay. Peter Tenhula, NTIA. One of the questions I asked during my time was what is the missing ingredient, what are the missing ingredients for effective coexistence models. I want to pose, answer that question kind of with a question related to a couple of observations about industry structure involving the supply chain or radio equipment or infrastructure equipment on the commercial side versus the federal side. There might be, but then the question is, because you've got, and for example there are no U.S. suppliers of infrastructure equipment on the commercial side, they're all foreign owned, you know, maybe smaller—major suppliers. On the federal side, you know, there's definitely a lot of different, but they're really on two sides of the fence. We have representatives from all of these, some of these, most of these suppliers here. And my question is, does this present an opportunity especially when we're talking about federal and non-federal, for these federals, these suppliers, these traditional suppliers to the federal government and these traditional suppliers to the commercial sector to maybe have some collaboration, joint ventures so that both sides can take advantage of the technology, you know, and maybe the services aspect of it? That's kind of my question. How do you maybe matchmake?

MR. DEVRIES: Okay.

MR. MUHAMMAD: Hello. My name is Muhammad from Industry Canada. My question to the panel is across the border coordination, specifically what regulatory challenges do you anticipate? For example, both the U.S. and Canada want to deploy dynamic spectrum sharing technologies in the U.S. and Canada which is separated.

MR. DEVRIES: Good. So let's turn to the panel. I'll start with Michael just to see if he has any comments he'd like to make since he actually has a plane to catch. Michael, do you want to say, give us any parting thoughts before you have to leave?

MR. CALABRESE: Just a quick one. I took much of that as the ones I understood it as comment. But I think I do agree with this, that we really have to consider this, you know, more broadly than—it's a much broader issue I think for the future than just what you might call spectrum reform, which seems to treat it too narrowly. So I think as Linda was saying, if there's ways that we can tackle this that get at it as, you know, is really, you know fundamental communications policy and infrastructure, you know, that may help widen their lens. Because on Capitol Hill I think one of our disadvantages for example is that there is only a very small handful of members—actually maybe hardly any members, but even among their staff it's just probably the most senior people on the Commerce Committees that understand this at all and it's not considered an issue of general concern but it should be.

MR. DEVRIES: Thank you. Anybody want to respond to some of the comments and questions? Tom?

MR. KIDD: Sure. Actually, a couple of things. Back on the question of where the money would come from, I think Michael hit on the point. The money will come from those things that the people with the money consider less important than spectrum. So the goal is, spectrum has to be more important than everything else, than the other stuff, and then you get the money. You know, that's not the case in all offices. That may not be the case in various places. We get in this room and by the end of 48 hours together we get pretty liquored up on how important all of this is. We go back to the real world and we sit in a staff meeting and man, we just want to gush about ISART, two minutes into it people are going, I don't care. You know, talk to me about something else. So the money will come from those, from the lesser of whatever that happens to be. It may not be lesser important; it's perception. It's what the people with the money perceive to be important. Linda hit on a point that is true. I don't like additional regulation and stuff like that. So how will we get a lot of these things done? I think we need to get some regulation out of the way. Rather than trying to figure out how to regulate something into existence, not to use a word that may not sit well with other people, but we sort of need to deregulate it into existence. We need to get things out of the way so that we can move forward. It doesn't mean regulation that's loose. That means possibly pulling things—you know, we talk about sharing of data. Part of the reason we can't share data is because there are rules that prevent us from sharing data. We don't want to argue whether or not sharing data is a good thing intrinsically. We all agree it's a good thing. We need to go after those rules that prevent us from sharing data. And then on to the thing about across the border, because I've had to deal with this through my military career, the caution in cross border is as we get all liquored up in here, we need to make sure we don't get too far outside the box with our neighbors to the north and the south. If we get too far, then we run into challenges, major challenges. As long as we're close—we may not be thinking identically but as long as we're close to what Canada is doing, they're close to what we're doing, we're close to what Mexico's doing, they're close to what we're doing, cross border not a big issue. We start thinking on our own, they start thinking on their own, it becomes a really problem. Depending on the systems and the power, those border zones can be pretty large. And there's a wealth of population that lives especially along the northern border. So it becomes a challenge there.

MR. DEVRIES: Preston, then John.

MR. MARSHALL: I think there's a lot of good comments, most of which I would agree with. I think the idea is to have private people build a toll way, but the fundamental problem though is the government is the only one that has the data right now. So I think the private sector will take off just like it has in TV white space and build a toll way and return revenue from some of those rents to the government. But the critical enabler is we have to get data out of the government. In fact, the government does it for free now. There's a filing on 1755 I think from TMobile, and the government is going to look at that for free. Mission funded. So it's really a definition of defining part of the spectrum management mission as supporting general sharing rather than case by case sharing. If we just do that, just said that, He is responsible as a part of his mission for supporting a general framework to determine sharing versus running lots and lots of fire drills for individual sharing cases, we'll create the transparency. So we're not really asking for something brand-new. What we are asking is doing it for all U.S. citizens and make it visible rather than just on a case by case basis. I think if we do that, you know, it doesn't look like such an awesome game changing hundreds of millions of dollars.

MR. KIDD: Can I real quick follow up? I want to say something that I've said at every ISART that I've been to, and I haven't had a chance to say it here. The federal government agencies are appropriated funds to satisfy requirements, okay? If doing something wonderful is not a requirement of that agency, of that acquisition program, they can't just pull some money out of the program and decide to do something that the program manager thinks is wonderful, okay? The money was appropriated to satisfy requirements. If he disuses that money to do something wonderful that's misappropriation of funds and they can't do it. This is important. When we are defining these requirements for these programs that are out there, if we want them to be able to hop from band to band to band, that had better be in the requirement. If it's just a good idea, unless there's money left over—and I don't know any program out there anywhere in the federal government right now that has a bunch of money left over—it isn't going to get done. They're going to satisfy the requirements, whatever that is. So it's vital, all the things that Preston just said, if you make it my job to do this—the reason that the TMobile is being done is because we have a requirement to coordinate those STAs and to work with it; it's part of the system so there are requirements to do that.

MR. MARSHALL: We on the House staff actually have some language what would be changed to make sure you have the scope to go do this in addition to everything else you do.

MR. DEVRIES: So let's go to John.

MR. CHAPIN: I was going to respond to the question, or the comment from Industry Canada, which I think is very well taken. And my answer—I'm going to channel Peter Stanforth, who I don't think is in the room anymore—that new emerging database based regime is ideally suited to treating border areas differently from other areas in the country. So if coordination that's with Canada requires that some channels not be used, we don't have to worry about whether we can or can't use them in Manhattan; we just assure they're not used within 20 miles of the border or whatever the required distance is. We're going into a world where I think cross border coordination will be easier than it was in the past rather than harder.

MR. DEVRIES: Good. So we have a very patient questioner.

MR. HUNTER: I just wanted to add too I think a generalized framework to sharing as opposed to that one office. I think as John alluded to the big bang theory, you know, we need to evolve. I think this is new particularly from a federal non-federal perspective. So we have to take those incremental steps, and I think as we go forward we will learn some things that can actually be incorporated into a more generalized framework. So it is an evolution, and it's going to take these incremental steps to really bring all these great ideas into the bigger structure we've been talking about.

MR. DEVRIES: We have a question. Would you mind using this one?

THE FLOOR: Following on the funding, I wanted to throw out an idea that is somewhat in the spirit of experimentalism as was asked for in the national broadband plan. And I don't see any of it happening. One thought is I'm a custom link corporation. And we had radio designs ready that would fit into the white spaces very very nicely right now. We have all kinds of customers saying, If we had some certainty to do that we'd be ready to go here shortly. So could we possibly—and white space is somewhat separate from the sharing up above here. But would it be possible to just take a small piece of white space, maybe here and a little bit there and a little bit there, and offer that out to someone that went to the database and then bid in a location to run a link for a customer who would pay lease to the government for maybe a five year period or something and then up for renewal; in other words, start to generate money and also show real usage right now that—and I'm not talking about machine to machine or the smart grids, but rather high value activities like hauling a business that's off fiber into a hosting center that is on fiber for example.

MR. NEBBIA: Just a couple of comments on the funding side. Ms. Moore will be able to tell us a little bit more clearly. But certainly the rules do not allow for the government to collect money from groups or even as was suggested by the gentleman from the UK, we're not in a position where we can say, We're going to collect some money from you, and we're going to go off and benefit from it, and run some program that we think is a good idea. The programs that the government has in fact are generated by direction that we're given, appropriations are set aside for much of those things. So we don't quite have the—

MS. MOORE: It doesn't work that way. Not what he's talking about.

MR. DEVRIES: Let Karl finish, and then you can come back and comment on that

MR. NEBBIA: As has been said before, the ability to say we're just going to redirect what we're going to do based on income we've had, I don't think it's quite that flexible. I did think for instance on the work, as Tom was saying, we do apply ourselves in the analysis that we're doing. We're working on 1755 to 1850. Certainly one of the things that incentivizes that and helps that is the recent law changes that enable the agencies to look at that as planning activities which can be recouped through the spectrum relocation fund. At the same time the specific decision was made during the process of approving the law to pull the same allowance for any work that was done in terms of planning for use with unlicensed. So in fact in that case, while we're looking at five gigahertz right now, and there may be a lot of work that needs to go on there, the specific decision was made not to link the relocation fund to sharing with unlicensed, which is a considerable part, or at least potentially a considerable part of what the PCAST group has said is happening at five gigahertz.

MR. DEVRIES: Thank you.

MR. GORENBERG: I feel like a kid in the candy store to be able to ask this question of six very smart technologists. But since they're here, we talked a lot about the top down, about databases, receiver protection, et cetera. You probably talked about this yesterday, and I apologize if you did, but I'd love to get sort of a handicapping from the group of the bottom up, which is, you know, of the technologies that people have talked about in the past, the bottom up technologies to make radios better, let's say for example, which of these are sort of your top three that you think are the most near term, the most commercial near term from the bottom up? And what do you think would accelerate that to be able to be accepted at this point, whether we're talking about commercial devices or federal devices that would accelerate the whole process? However you want to go through that question.

MR. DEVRIES: Good. We'll take one more question, and then we'll turn it over. Go ahead. Comment? Question?

THE FLOOR: To Tom's point about our neighbors, country neighbors beginning to think independent, I know of two examples already that are out there. Canada has allocated 1830 for utility use, not a band available in the U.S.; possibly won't be assigned that way. And Mexico appears to have selected ATT band plan for 700 megahertz, which is completely incompatible with the U.S. 00 band plan. And I expect several activities in the Caribbean to also plan that way, you know. How are we going to get around that if these countries continue to express independent thinking?

MR. DEVRIES: Good. Let’s turn it over to the panelists. You have a lot to work with.

MR. MARSHALL: First question, that first question that we didn’t get the gentleman’s name, was in fact really the poster case for three tier licensing. You can go to one of these databases, find what frequency is open. If you want exclusive, go bid on it, create revenue for the Treasury and get a secondary license to that frequency or at least use the frequency. I think that’s exactly the use case. Our only problem is finding the seed corn to get enough frequencies into the database to start the process to become self-fulfilling. I think we recognize we need congressional language to allow these receipts to come in because it wouldn’t be a conventional auction, but that process, get some spectrum in, maybe at 3.6, get it acquired, get some cash, and make the whole thing self-sustaining.

MR. DEVRIES: Thank you. Any other comments? John?

MR. HUNTER: With respect to the near term technology I think that’s part of the STA that was filed. There are some cognitive attributes associated with LTE. I think some of the services features are going to be tested. And it’s a matter of some could call it sensitive void, but it would essentially put a throttle on throughput whereas at the same time not causing harmful interference potentially to federal users. So I think near term I think LTE holds promise to prove that out. And also dependent on the incumbent systems and the amount of bandwidth that you’re trying to spread the interference over a larger spectral density. So we’ll see. I think we’ll have more to follow as soon as we learn more on the monitoring effort that’s under way.

MR. CHAPIN: So in answer to Mark Gorenberg’s question about technologies that are available in the near term to make things better, I’m going to describe a meta technology which would help us make things better rather than directly making things better itself. We build black boxes into cars. We build black boxes into our airplanes. We should build black boxes into our radios as well. It’s just a matter of storing some information. It can be a circular buffer that you overwrite periodically, maybe it has 24 hours of information in it. The reason that that would be valuable is that one of the things we’re primarily concerned about is collisions, interference. And the black box helps you figure out very cheaply and quickly why that collision occurred so we can start getting data back from the field about what’s happening that led to interference, and rapidly get into an innovation cycle with our spectrum access data to make them more efficient. Generally if you’re concerned about whether the spectrum is being used effectively you can just sample the black boxes statistically over some large area, and you can get some information about whether a given channel is actually being available enough of the time to justify a higher cost or investment. Basically that would support a more rapid innovation cycle. It’s a very straightforward thing. Any individual manufacturer could billed it into their device without waiting for the whole world to go forward.

MR. DEVRIES: I'm going to use facilitator's prerogative and just do two follow-ups, John. My follow-up to you would be, why would a manufacturer add even pennies to a bit of material on the device where the margins are already so thin to do that?

MR. CHAPIN: I would start with something like an iPad rather than a ten dollar phone. So the margins are high enough if you can provide a better communication experience to your user that's worth a whole lot.

MR. DEVRIES: Preston, you raised something which I—maybe it's just me—hadn't realized. You know, I was thinking about money is the obstacle. You may need congressional language to make some of these bootstrap pieces work. Are there other statutory obstacles where in fact none of this is going to happen until congress moves?

MR. MARSHALL: I think that's a Peter Tenhula question. Peter said we are all lawyers, so maybe we can all answer the question now. But I think the assumption was to take revenue in to run these micro auctions that probably required specific language, and I think probably set it up as sort of unlicensed but the goal is to create a revenue stream with thousands of customers for spectrum rather than just four.

MR. DEVRIES: Is that the only place where as far as—you're not a lawyer—where you think there's a statutory obstacle to implementation?

MR. MARSHALL: I think our assumption is federal government shares spectrum today.

MR. DEVRIES: Okay.

MR. MARSHALL: We're only setting up a very flexible and open framework. We're not fundamentally changing anything.

MR. DEVRIES: Peter, is this a common problem?

MR. TENHULA: Yes. I mean, I don't want to provide legal advice and this isn't a legal opinion, yada yada yada. But there was provision in the President's jobs bill from last year right along these lines which authorized agencies to share or lease—they used the word "lease"—spectrum and keep the money. You know, because that's, that's what they need to have. They basically need to be authorized to keep the money and use it for their own purposes to avoid anti deficiency or anti implementation or something like that. There's language out there, and it was pretty good language. It was part of the legislative proposal in the 00 megahertz in the ten-year plan, and the President's bill on jobs. And then it was tied to the spectrum relocation fund incentives for agencies. But that was dropped.

MR. MARSHALL: I thought you were going to say it was done. It was such a nice buildup.

MR. DEVRIES: Yes, but you know, with the Hill things have to be dropped four times before they pass. Two questions.

THE FLOOR: I want to comment about the earlier comments regarding American companies and whatnot. Just a reminder that currently there's an LTE deployment in the U.S., Verizon and AT&T—

MR. DEVRIES: Could you get closer to the microphone?

THE FLOOR: Probably one of the largest silicon deployments in the history of the U.S., and this employs tens of thousands of people regardless of where the companies are headquartered. And besides, you can think of Qualcomm, Northcom and many other phone companies on the phone side, and IOS and Google and so on.

MR. DEVRIES: So let me—

THE FLOOR: So we have to be careful about this stuff.

MR. DEVRIES: Let me ask you the follow-up. I know you're in the R&D side but you're an executive. So you think about this. Can you see Ericsson getting into the business that Raytheon is in, essentially getting into the business of selling systems to the federal government if it doesn't already?

THE FLOOR: I don't know if Ericsson sells system to the government. We have a joint venture with Motorola, which does this kind of thing in the past. We have—

MR. HUNTER: If I could add to that, I think to that point Ericsson tried that, right? Ericsson, we had Ericsson Federal, and it was spun off to a new company. I think it's Oceus Networks and they are doing just that, providing LTE high technology to the federal government on various aspects. But it does, I think when we start talking about U.S. based companies versus foreign national companies, I mean, these are worldwide companies so it's multinational type firms that provide all this infrastructure equipment that all of us depend on. I know Alcatel Lucent based still rely on a lot of things coming out of the U.S., and that's for all companies.

MR. DEVRIES: Thank you.

MR. RUDEN: Again, Mike Ruden, AT&T. Dr. Chapin's point about the black boxes and wireless devices, you any recall a recent article in the news over the CMRS carriers using a piece of software called carrier IQ, and how that brings up the expectation that consumers have of privacy and privacy rights. So even though it was to their advantage to have this optimized network in the process, there is this dialogue going on in the back of their head that there's some privacy breach at some point on their personal privacy.

MR. CHAPIN: I couldn't agree more. And there's a number of aspects to the black box proposal that we didn't go into which are specifically focused on privacy. I'll be glad to talk to you about those off line.

**MR**. DEVRIES: Other comments or other questions that anybody would like to make?

MR. ELLIS: I just wanted to add a slight point of clarification to a point that Karl made about the government collecting money. There is the Technology Transfer Act of 1986 that does allow federal research labs to actually enter into cooperative and development agreement. ITS does that. We have executed a number of cooperative research and development agreements over the years where we were testing various radio terms and development validation.

MR. DEVRIES: Let me ask while Linda comes up, let me ask a question. It came out of the WSRD meeting a couple of days ago. We've been talking a lot about sharing, and I think mostly what people talk about is sharing spectrum. But there's another way you could say, Well, let's just take the sharing. Somebody is the owner of the spectrum, but we will share network infrastructure. You can go up another level and you'll say, Well, we'll share not just the network infrastructure; we'll share the access connectivity and people will compete based on the applications they run. So really it's a question of where somebody sees their competitive differentiation, or I suspect people should direct me. When I think about an agency, what's mission critical for them. Is it the spectrum? Is it the network infrastructure? Is it the connectivity? So the question would be should we just be focused on spectrum sharing, or are there other opportunities in these other kinds of sharing? Preston?

MR. MARSHALL: I think there have been a number of people who have tried and been frustrated in arguing that they would like to build cell networks that were capable of wholesaling to all of the suppliers. And there just hasn't been the growth of that. It seems like all the suppliers are willing to dump the Wi-Fi. But we haven't gotten the same models that say, I'm going to deploy general LTE FPTO cells in my hotel, and I'll handle all your LTE traffic for you, hopefully buying the spectrum through the SAS and making our work look good. But I'm going to buy the spectrum and deploy a FPTO cell network in my hotel, and I'll handle—you don't have to blast from half a kilometer away LTE. And enough people talk to me about wanting to do that and thinking this fits. But somehow the business opportunity share—maybe you don't share the tower like in D block, but there's a tower sharing and then there's also these underlay networks that it would really be a shame to go in the back of this room and see four different FPTO cells each locked to a different provider. PCAST Report I think contemplates the opportunity for someone to come in and set up these kinds of offload networks. Our premises offload will become the new CMRS. But there really hasn't been the work to develop general authorization for 3GPP standards for going across systems and all. There's a wonderful opportunity offload side to start to do that.

MR. DEVRIES: Point of comment? Did you want to comment?

THE FLOOR: There are GSM networks that use various forms of sharing. There's a main upgrade in the other ones essentially from—even when you have to, for example Virgin Mobile leases from Verizon or what have you.

MR. MARSHALL: This is actually the other way around. I want to put a FPTO cell up there and I'm going to let all four guys on it. I'm going to make a private deal versus an MDNO.

MR. DEVRIES: Thank you. So, Linda a question? We're beginning to wrap up. I invite the panelists to start thinking about the last question that I'll ask you, which is what unfinished business do we have that we need another ISART for.

MS. MOORE: Thank you. I beg your indulgence. I do this every day. And I would not sleep well tonight if I did not explain actual process—

MR. DEVRIES: Could you please speak into the microphone.

MS. MOORE: I'm sorry. I need to explain please the actual process by which money would possibly be available to develop dynamic spectrum access ideas. PCAST did make it sound too simple, I agree. This is the law. Congress passed a law in 1993 that authorized the FCC to set up competitive bidding process to allocate spectrum in a more efficient manner. There's a whole history to that. In the bill there was language that the FCC should not consider the value of the spectrum. And Congress set a sunset date for that law. I forget what the date was; 2002, I think. The law was then extended and congress realized here is a Pay-Go rule which says you can spend new revenue. Spectrum auctions are new revenue. They are outside the traditional rules for appropriation. So if you're doing, under the Pay-Go rule, if you spend money you have to find new money or cut something. Spectrum allows you to spend new money, because every time you reauthorize the auction process you restart the revenue stream. So we've had two occasions now—three occasions—no. Yes—three occasions where Congress—and also the original law said the money had to go to the Treasury. So on three occasions, Congress has modified the law and created a special fund to receive new revenue into a specially created fund and then paid money out of that fund. That's the process that we're talking about. That's how it rides on the law. And that's the legislative action that would have to be taken. You would have to go in with a new law either modifying the spectrum relocation fund language or creating a totally new fund, and set up an auction process that would put money into that fund, but you cannot do it until 2022 because that is when the current auction fund, the auction authority expires. So but it might be—

MR. MARSHALL: You can change the date?

MS. MOORE: You can't—okay. This is where it gets tricky. This is CPO. That's why PCAST made it sound too easy. I need to explain the legislative process.

MR. DEVRIES: We don't want to get too deep in the woods.

MS. MOORE: Yes, exactly, precisely. Beyond this we don't want to go. But it really, I want to make it clear it's not, it's not set. There is a solid legislative basis for it. Okay? Thank you.

MR. DEVRIES: Thank you. We have two more questions in the queue. Those will be the last two questions, and then I'll ask the panel to wrap up.

MR. LUBAR: Dan Lubar, White Space Alliance. For those of you that are aware, our new Republican commissioner was at the CMU venue last week. And I didn't actually have a chance to see or hear the speech, but I was reading it today. And I notice that there was, speaking of money, there was a comment that he made about starting a new office at the FCC, to get back to the point of money here. Reality is we're sort of having a perfect storm as far as the FCC is concerned. At the same time that budgets are being trimmed inside the beltway world these new requirements are coming along for creating sharing. And let's face it. I don't how many of you are familiar with the process that Columbia labs go through to do certifications and bodies that they need and how OET is situated. But there's a reality there that says at the same time more requirements are coming along, the funding is being cut. What's interesting about our commissioner, our new commissioner, he asked for an office of entrepreneurship innovation. I know that commissioner positions are political, but it's interesting idea that in a time where budgets are being trimmed that innovation and entrepreneurship is usually a source of the kind of invisible money if you will when you're hard at work or creating innovation to bypass the way things are being done. I'm curious to ask the panel, given that background and what the Commission is asking for, is there a way forward? Or are we talking about systems here that are—I'm sure Eric would agree—that are very long-term, there's no way to really be agile, use entrepreneurship, hear what your thoughts are about the new commissioner's comments and if that's something that realistic or, if you will, not a real source of funds but a source of new way of dealing with things.

MR. DEVRIES: Thank you. Anan, you have the last two minutes of the mic. Then we'll start working our way down the panel.

THE FLOOR: A minor comment to Preston regarding the multiple operate the frequency. Increasingly there's a trend to a single physical box actually supports. You can ascertain that will see the notion of a third party deploy a box but offer a virtual base station and so on.

MR. MARSHALL: Is that one of your products?

THE FLOOR: So that world is not too far away. I think that it can happen in the marketplace as long as the providers are comfortable with doing that. So the technology's out there. It should become practical.

MR. MARSHALL: Make sure we put in shared spectrum.

MR. DEVRIES: Good. With that, let's wrap up. And we'll start with Eric. Last thoughts, please?

MR. NELSON: Actually, could I defer until I can collect my thoughts?

MR. DEVRIES: By all means.

MR. CHAPIN: If you search on Hershel Rand you'll find a paper that Don and I did in 2006. So unfinished business. Just following up on a dialogue that Preston and I had earlier today, which I think would be highly valuable for next year's ISART, let's talk about defining harmful interference at higher layers, not just the physical layer, and going along with that, enforcement mechanisms for redressing harmful interference if it occurs in the field. There's regulatory issues, federal policy approaches, crowd source enforcement, multi stakeholder entities. We talk about the adjudication approaches that Peter brought up. Maybe this is a chance for the lawyers to really weigh in with some creative thoughts. And let's talk about approaches, costs, and trade-offs for enforcement because it's such a critical part of the way we're going forward.

MR. DEVRIES: All right. Thank you.

MR. MARSHALL: John stole two of mine. I have one left.

MR. DEVRIES: Preston, for you to be at a loss for words—

MR. MARSHALL: I wouldn't go that far. But I think the premise behind all these spectrum sharing, particularly white space sharing, is that we can do general system-on-system coexistence modeling of MBAN and adjacent. All we've ever done today is system-to-system TV white space, a TV white space, TV system against a very specific kind of application. 1755 going to, the STA is, again, a very specific federal system against a very specific incumbent system. The viability of the whole regime to allow new innovation and be technology independent is if we can do general and general, somewhat down the framework that John Stine talked about today. I think it would be a real contribution if we can look at what are the processes for that. To some extent we spent a lot of time talking about money. We've got to go through I don't know how many federal systems there were in the 1755 report and all those. But we have absolutely no idea what it really takes. So are we asking for a hundred million dollars over ten years? Are we asking for a billion over ten years? Is this something some of my grad students could do back there? You know, we have absolutely no idea what it takes to go through the inventory and start to characterize them into any possible use of the band. So I think taking from case studies through and developing sort of a rules of estimate so that if we do get someone who wants to fund this on the Hill we go in with some credibility other than saying, Well, how much will you give us, which is about the only answer that we can do today to quantify this.

MR. DEVRIES: John?

MR. HUNTER: Yes, just real quick. I think as far as unfinished business I think there's actually quite a bit of unfinished business. So as these projects continue to evolve I think we probably need to reconvene and leverage lessons learned as we move forward.

MR. KIDD: So I think we all agree that the processes that was my panel kind of talking about those need to move faster. I'm torn between the idea that we need to figure out how to make the processes faster, or does a group like ISART need to determine what is the product that these processes are providing, and is there an alternative method to providing that product. Is it possible that the way that we're building the widget just can't be made fast enough so we need to figure out a new way to build the widget? We need to figure out what are the values, what is it that we are doing in the federal process of providing a frequency assignment or whatever, and is there a completely different way that we can produce that same product but do it fast enough. Cheaper, faster, better, exactly. Cheaper, faster, better. But and maybe we can't. Someone made the comment if I was heading on this journey I wouldn't start from here. Maybe that's true. Maybe we can't get there from here. Maybe we have to go somewhere else and start from there. Then there's something I wrote down here because I mentioned it and had seen it. I just want to throw it out as a little prediction and see how right I am. I think in ISART 15, 16, 17 we're going to be talking about spectrum hackers. We're going to be talking about how to combat them, how to find them, how to whatever. At both DEFCON and SchmooCon there have been people who have been showing how to own cellphones, how to hack. It's amazing what this community is doing and it will explode exponentially. And you're going to have 17 year olds in the basement that are going to be doing things that we haven't been able to figure out how to do in a billion dollars lab.

MR. MARSHALL: HAM radio returns?

MR. DEVRIES: Eric, any thoughts about the panel?

MR. NELSON: Yes. One of the things I think is necessary as well is a roadmap. What are the next steps? PCAST support kind of lays out some of the, you know, what are the regulatory processes that are going to have to be changed. Because if those are going to change how do people even get started to start putting together, you know, product, developing business plans if they don't know what it's going to take to navigate their way through the regulatory process. There's going to be issues there. Our spectrum sharing innovation test bed program that we're doing here at ITS in cooperation with the Office of Spectrum Management had a situation where one of the participants was struggling between the trade-offs between participating in TV white space or participating in our test bed. And the TV white space was a temporary draw for them because there was a clear roadmap for them that led to an eventual revenue stream potentially down the road. So it's important for people to see what the regulatory process, while it may not be settled is at least clear.

MR. DEVRIES: Thank you. Eric will come up and close the conference in a moment, but before he does that, please join me in thanking the panel. (Applause.)

MR. NELSON: So again, Pierre, you expressed your thanks. And I've got a number of people. It's going to be the same names and faces. But I just really want to thank the support staff that we have that helped us put together the conference, in particular Ruth Chillemi and Amy Weich, two of our secretaries at ITS that have just put in countless hours helping getting everything coordinated and helping keep those of us, Chriss and I somewhat sane in the process with all the details that they have been managing. As well just like to thank again all the session chairs and speakers for all the time that you put in in preparation. And Mike Cotton as well. Mike gave a presentation at the conference but used a teleprompter. He did a nice soft handoff to us this year. Not only did he kind of set the theme, but also helped us get, you know, the structure of the conference set up and some of the initial themes that we would cover. I want to also remind people about the surveys. This is important feedback. If any of you read any of the news this was back in April about the GSA conference if you remember all the news about that within the federal government there's a lot of scrutiny being paid to the value of conferences. So if we're going to have an ISART 2013 it's important for us to be able to pull out those surveys and show, you know, any potential auditor why we do this and what the value of it is. So that's why we're asking for that. On the subject of ISART 2013 we also are putting out requests for any potential sponsors. The Office of Spectrum Management has sponsored the conference for a number of years. But they haven't always been the sponsor. National Security Agency has sponsored it in the past. And we do need another sponsor for next year, so if anyone's interested in doing that please contact me. My contact information is in the program. Just a little bit of a detail. I know a number of you probably tried to get on to the portal. I received a little bit of feedback and I hear people kind of chattering about it. If you've gotten on to the portal and you're trying to download all the presentations, it's a little bit of a hassle; I've heard all that. So we will actually take all of that and bundle it all up into a single file with the exception of Joe Heap's presentation. He's asked us to hold off until he has final clearance on that. We'll bundle those up and get them zipped so you can pull all of them down at once without having to navigate into different folders.

MS. HAMMERSCHMIDT: So I want you guys to really thank Eric because he took a lot of his vacation time. And he would answer phone calls and I'm sure his wife wasn't too happy. I didn't do a lot of this; this was his vision. And so I really want you to thank him for such a terrific conference. (Applause.)

MR. NELSON: Just closing thoughts. I just wanted to thank you for just a stupendous attendance. I was getting a little nervous there. I think about three or four weeks ago we only had about 60 people registered. And but we had quite a bit of a last minute turnout. Quite a few walk-ons too. And I think we might thank PCAST Report indeed because right after that came out there were a number of people calling all of a sudden, you know, asking if we were taking walks-ins. So just thank you for all the interaction. Like I said at the beginning, we record this so we can go back and just try to sift through this multiple times, try to absorb all this. It does help us to find new research programs or areas of emphasis. So I want to thank all of you as well.
(Applause.)

# Why DSA is better deployed and modified rather than modelled in detail

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*Abstract* — **The approach adopted so far to enabling dynamic spectrum access (DSA) is to undertake detailed modeling of the worst case interference and set in place conservative rules. However, even this approach cannot guarantee that all factors are taken into account, is hard to specify in any license and very difficult to monitor in practice. A more pragmatic approach is to implement systems and modify their allowed operating parameters should interference occurs. This paper discusses why this may be both the only practical approach and one that is also likely to reach the optimal position much more quickly.**

***Keywords-component; dynamic specturm access, DSA, white space, interference, spectrum management, regulation, spectrum usage rights, SURs.***

## I. Sharing is on the basis of an acceptable or agreed amount of interference

Dynamic spectrum access (DSA) involves sharing of spectrum and any arrangement other than the very simplest form of sharing is made on the basis of interference. For TV white space, DSA devices are allowed to access the spectrum as long as the interference they generate does not materially impact on the services delivered by the incumbents. In unlicensed spectrum, coexistence between different systems is on the basis of the impact of their interference on each other. Even when systems are in neighboring frequency bands, the impact of interference across the band edge is a key metric for defining spectrum licenses.

So simplistically, when enabling DSA, we might expect that we could define what an allowable level of interference between different systems is, enshrine this in appropriate regulation and police actual behavior to ensure it stays within defined limits.

As this note discusses, while simple in theory, this is extraordinarily difficult in practice.

## II. We can define interference using tools such as SURs

Defining interference levels has been much studied. A good example is the Spectrum Usage Right (SUR) approach developed by Ofcom in the UK [1]. This allows a license to be defined in terms of the interference caused to others rather than the allowed transmit power. A license typically has limits setting out the statistical behavior of both the in-band and out-of-band power levels experienced throughout a geography. For example, a license might specify that signal levels of -80dBm/MHz must not be exceeded in more than 5% of locations throughout a country when measured 1.5m above ground level.

Ofcom looked in detail at how such license conditions might be verified and concluded that the best approach was via modeling rather than actual measurement. All interested parties would agree a propagation model to adopt and each would make available details of their transmitters such as location, antenna patterns and power levels. A propagation tool could then predict the signal level at any location and then determine the statistical distribution of the interference.

There has only been limited experience with SURs but sufficient work has been undertaken to give a strong indication that they can be practically adopted, at least for licensed use of spectrum. Whether they can apply to unlicensed use is less clear, although there have been papers addressing this [2].

## III. Unanticipated factors such as TV AGC can dominate

Recent experience, though, shows that measurement of signal levels may not necessarily provide an accurate guide to the impact of any interference. For example, it has become clear that digital TV receivers are much more susceptible to burst-like interference than to continuous transmissions. This appears to be because the automatic gain control (AGC) in the TV receiver is confused by the sudden appearance of a burst and quickly reduces the gain such that the TV signal level falls. Some measurements suggest that some TVs may be 10–20dB more susceptible to burst-like signals. In this case, specifying interference purely in terms of the average power levels seen across a geography would enable higher interfering powers than could actually be tolerated.

It could be argued that this is due to poor design on the part of the receiver and that the spectrum sharer should not be penalized as a result. While theoretically sound, the politics of allowing significant interference to occur into domestic TV receivers would be controversial!

This leads to the conclusion that the impact of interference can only be characterized with certainty when considering one particular transmitter, with a certain waveform, and one given victim, with particular susceptibility. Even then, the transmitter waveform may be variable (e.g., depending on cell loading) and there may be myriad models of receiver with differing susceptibility. This has all the appearance of a near-intractable problem. Testing every new technology into a band against every existing receiver that is using the band would be a hugely costly exercise and a major impediment to the innovation that DSA is aiming to introduce.

## IV. Measurement of interference will generally be near-impossible

Even if it is decided to regulate on the basis of measured signal levels, measuring them is near-impossible. The difficulty in making measurements over large geographies of time-varying signals in any practical and meaningful manner was what persuaded Ofcom to select modeling rather than measurement as the verification process for SURs. However, modeling can only work effectively where there are fixed and time-invariant transmitters. For DSA, the allowed interference levels might vary according to location and the use of spectrum by license holders. There may not be base stations. If there are multiple DSA users the means by which the allowed signal generation is divided among them may need definition. So modeling is unlikely to provide a particularly useful approach.

To understand the problem with measurement, consider a type of Wi-Fi used in TV white space. Measuring the signal level caused by millions of nodes scattered throughout a country would require huge number of measurements across a wide area taken for long periods to capture the fact that traffic levels may vary dramatically. Measurements would need to be at 10m from ground level to understand their impact on TV receivers using external antenna. These measurements might need to be frequently repeated as penetration levels of DSA devices grew. It seems unlikely that anyone would have the inclination or budget to undertake this.

## V. Noticing and reporting on interference may be difficult

A different approach would be to note that interference is only a problem if it can be noticed. It may not be particularly relevant to worry about whether a DSA device is exceeding its allowed or intended interference levels if it is having no actual impact on any licensed user. This might be because there was no licensed user in the vicinity, because their equipment was superior or because the assumptions made on interference were conservative and there were adequate margins to accommodate the increased interference. Users could indicate when the experienced interference and action taken accordingly.

Unfortunately, this is also far from being as simple as it sounds. If we again take the example of a TV viewer, they may experience interference but might (1) ignore it, (2) assume it is due to their receiving equipment and purchase a new receiver or (3) not know to whom they should report the interference. If the interference is sporadic, as is normally the case, it may be difficult for anyone investigating the issue to replicate the problem or to have sufficient time to track it down. Further, it cannot be assumed that the interference is due to a DSA device – it could be due to anomalous propagation, weather conditions, failures at the TV transmitter or many other causes.

In some cases, determining interference may be simpler. Professional users such as emergency services can be told where to report interference issues, can typically be relied upon to have well-installed equipment and can potentially have monitoring devices attached to the equipment to perform diagnosis over time. The same may be true for some types of military usage.

If the problem is widespread then it is likely that whatever the difficulties it will be noticed and resolved over time. The more difficult cases are where the interference impacts only a small number of users in a manner that is annoying but does not completely prevent reception. Perhaps, in a world of blogs and on-line discussion groups, even these issues will bubble up to become visible to the regulator eventually. Indeed, through a website that can be readily found by users and allows them to enter simple details of the interference experienced, aggregating this information across a large number of users might allow patterns to be spotted and diagnosis to be performed without measurements. Development of such websites and tools might be an important part of implementing DSA.

## VI. With these uncertainties better to take some risks and address issues post roll-out as needed

The analysis above suggests we can broadly adopt one of two approaches:

1. Exhaustively test any new technology against all existing receivers in the target band, construct detailed sharing scenarios and build conservative models to lead to allowed usage.

2. Use generic approaches such as SURs and set in place mechanisms to monitor interference should it occur as far as possible.

In the TV bands the first of these approaches has been adopted. This was for two reasons. Firstly, the difficulties with this approach were not understood and it was assumed it could be made to work effectively. Secondly, a political "bargain" with the broadcasters where they were guaranteed no interference was necessary in order to progress the required regulation. This political bargain may have significant repercussions in limiting the efficiency of use of this vital band, but was likely the only way ahead at the time.

Selecting between these two approaches is a choice between risk and reward. The first – exhaustive testing – is low risk. It results in the least likelihood of interference or that the rules of DSA will need subsequent modification. But it is conservative, leading to a lower benefit of the use of the spectrum. This lowers the GDP contribution of spectrum, innovation and growth. The converse is true of the second. It seems likely that the risk in this case falls mostly on the DSA user. If there is severe interference to the licensed user then, subject to the points noted earlier, it will inevitable eventually be noticed and the rules of access modified. If this results in, for example, a change in the allowed transmitter powers for the DSA system this could be highly problematic for a system designed with overlapping cellular coverage. The shrinking of cells as power levels are reduced could leave a coverage gap around each cell that might require massive network re-planning to resolve. The balance of risk toward the DSA user is generally simpler to manage since the license holder typically has a deployed and stable system and is in low-risk mode whereas the DSA user is implementing a new system, technology and service and the risk of changed spectrum access is just one of many that they face.

Selecting between them will also depend on the risk-aversion of the licensed service, the political difficulties in introducing DSA and the level of experience gained with DSA operation. If DSA access in TV bands is successful it might be expected that the perceived risk of DSA access in other bands will reduce while the evidence of the reward of this approach will increase. Hence, it is likely regulators and users will move from the first to the second approach over time.

History and instinct also suggests that the second approach is better. History tells us that excessively cautious regulation can prevent innovative new services being deployed by raising the costs unsustainably. This has been true in many frequency bands, especially in the US, and with technologies such as ultra-wideband (UWB). History also tells us that interference in licensed spectrum bands is very rare due to a worst-case analysis of a situation that is extremely unlikely to occur. As a result, large margins are built into operation. In practice, systems can work adequately with high levels of interference as Wi-Fi and Bluetooth have shown. This high intensity of usage has led to a very large economic value and utility for users. If the 2.4GHz band had been planned by regulators, they would have concluded the systems could not share and indeed that Wi-Fi needed careful planning. So we can observe that in systems planned by regulators interference almost never occurs and that in unplanned systems interference can be tolerated unexpectedly well. The risk-averse approach is currently much too risk-averse. A move towards an approach that embraces greater risk is overdue.

Finally, consider the practicalities of relaxing rules under the first approach versus tightening them under the second. Relaxing rules would require modeling, measurement, consultation, lobbying and more. There is little benefit for anyone except the DSA user. It seems likely that regulators would be unwilling to do this and it would be very slow, costly and burdensome. Tightening rules in the face of evidence of interference could be done immediately. If we assume that getting to the optimal set of rules will require experience and iteration, we will get there faster and more simply by starting with more relaxed rules and tightening them.

This is why a new approach to spectrum regulation is needed that embraces greater risk of interference, balanced with stronger powers to address it should it occur.

### References


[1] See, for example, http://stakeholders.ofcom.org.uk/spectrum/spectrum-management/spectrum-usage-rights/

[2] M Cave, W Webb, “The unfinished history of usage rights for spectrum”, Telecommunications Policy 36 (2012) 293–300.

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The 13th Annual International Symposium on Advanced Radio Technologies, held in Boulder, Colorado, July 24–26, 2012, presented the second conference focused on *Developing Forward Thinking Rules and Processes to Fully Exploit Spectrum Resources.* Following on from the previous two ISARTs, ISART 2012 looked at *Case Study 2—Exploring Approaches for Real-Time Federal Spectrum Sharing*. Topics covered included The Federal Spectrum Ecosystem, Current Federal Efforts that Can Increase Spectrum Sharing, Institute for Telecommunication Sciences Spectrum Survey Activities, TV White Space Tutorial, Fresh Approaches to Spectrum Sharing, and Validating and Regulating New Sharing Schemes. The keynote speaker was Larry Strickling, Assistant Secretary of Commerce for Communications and Information, National Telecommunications and Information Administration. This volume of proceedings is taken directly from the court reporter's transcription of the conference. A best effort has been made to correct spellings of names and terms of art, but it is in no way an "edited" transcript.

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