NATIONAL COORDINATION MEETING

NATIONAL SCIENCE FOUNDATION
4121 WILSON BLVD
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ARLINGTON, VA 22230

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P R O C E E D I N G S

(9:04 a.m.)

MR. BARKER: Let's get started. Welcome everyone. I'm glad that we could have such a great

turnout here today.

Just introducing myself, my name is Byron Barker, I'm the chair of the Wireless Spectrum Research and Development Senior Steering Group, out of the Networking Information Technology R&D Program.

I actually -- that's another hat that I wear with the wizard group, what we term as the wizard group. My day job is working in NTIA. I'm in charge of the strategic planning division there, working under Mr. Carl Nitia.

So we're excited to have this program and to get into this topic of understanding the spectrum environment. We have, like I said, we have a full day ahead of us today. As it says, it's a workshop. We're here to work. So I know we're all excited about that, or you wouldn't be here.

I just wanted to make sure that we're all kind of, looking forward to what we have here today.

For the lineup today, let's start off by warming you up. Kind of like in baseball terms, get you loosened up and get you ready at bat and it's opening day today, starting of major league baseball. So we'll do this by starting off with the keynote speakers, PM session there that will be moderated by Dr. Rangam Subramanian. So we're excited about that.

We will kind of hear about what their thinking is in regards to some of the current

economic policy thinking that's going on. To kind of help set the stage of what we see as the importance of understanding the spectrum environment and what monitoring may mean to that.

Following that, we'll have the next panel that will talk about some of the current projects, activities that are going on out there, particularly in industry and in the federal government that's involving monitoring. So we'll kind of get some insight of what currently is going on today.

Then we'll also follow-up with some actual demos that will be happening along some of the rooms.

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I think it's 515, 565 --

PARTICIPANT: And 595.

MR. BARKER: 595, so the idea is to frame our thinking of what would be meaningful and achievable goals for spectrum monitoring. And what we might want to identify and prioritize is actionable recommendations, especially those for research and standards that need to be pursued. So we'll kind of get going with that, get our thoughts ready for the breakout sessions that will follow.

We'll have a lunch break, obviously. As part of that lunch break, we'll move around, around the demos -- the demonstrations, the exhibits that we have in the three rooms. So you can kind of get a chance to get a better feel and more one-on-one with some of the great things happening out there relating

to spectrum measurement environment.

We will then assemble back, but what I would like for you to do is to, on your badge I think we have designated -- if we don't --

PARTICIPANT: We have lists outside and lists on the door.

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MR. BARKER: Okay. And that reminds me, for folks that have come in, we do have a sign-up out in the front. If you can, please initial that you've come in. I know some of you have just come directly in, probably didn't see with the crowd out there, that we have a table with the sign-in list. So if you can, if you haven't done so, please initial off that you're here.

And while I'm at that, for logistics sake, if you need the restrooms, you just go directly out the door where the elevator corridor is and right to the right there are signs right there, it's posted, that tells you where the restrooms are in that area there.

So we'll assemble back at our respective session locations and I'll talk -- I'll give you room numbers later on as we move along. That'll be it. We've divided these into true focus areas informing policy, decision making and spectrum and management; making interference resolution and enforcement more effective; and usage, being able to make the data usable, interchangeable and available, especially for

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coordination. So we broke into three breakout sessions.

So I would like to start off by refreshing how we got here today. As most of you know, back in June 2010, the President released a memorandum on unleashing the wireless property revolution. One of the key objectives that was identified in that, was to direct the federal agencies to work together, with the non-federal community, including academia, industry and the public safety sectors to create and implement a plan that facilitates research, development, experimentation, and testing by researchers to explore innovative spectrum sharing technologies.

This essentially became what is called wireless research and development senior steering group, or what we call as the wizard group. Today we have held a series of workshops, or up to now, this one being the fifth, that address the challenges defined in the Presidential Memorandum.

During the wizards' first workshop at Boulder, back in July 2011, we looked at the current

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portfolio of R&D projects that we had on the federal side, and at the same time, we were using the workshop to gain insight to what's going out in the

private sector side and looked at what was underway and planned so we could see where there could be possible gaps of what's not being researched and developed at the time.

The participants indicated two reoccurring themes on recommendations. One, the national level testing environment is critical for validating spectrum-sharing technology under realistic conditions and the need for a spectrum inventory. One, it allows us to better understand the spectrum environment.

At the second workshop, held in Berkeley, back in January of 2012, key concepts and criteria were discussed and established for a national level testing demonstration environment. One, it could provide a comprehensive spectrum sharing test and evaluation capability. During the discussion it was noted again, the need for empirical information occurring in common spectrum use. If not, it would

present a barrier for us to move forward with some type of testing capability that we envisioned.

The third workshop, held in Boulder in July of 2012 identified realistic projects whose implementation would significantly support the plan to meet the Presidential memo's goals. In that discussion, we discussed what would be mechanisms for spectrum sharing. Again, in that discussion, it was noted how important having spectrum use information

would be.

One, it could be shared among some or all users to help mitigate potentially incompatible spectrum use.

The fourth workshop, held at MIT, last year -- last April, almost a year ago, resulted in the recommendations for economic and policy research that would be needed to promote an efficient and shared spectrum environment. Again, a key component of the economic policy research agenda included the need for data, models and empirical methods to there identify spectrum needs, usage, and interference implications.

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So one can see, the need to better understand the spectrum environment has been a common thread throughout our past workshop discussions. This workshop will focus on new opportunities for understanding the spectrum environment through improvements in monitoring the data analysis. How spectrum monitoring might improve spectrum utilization.

I think we can conclude that pretty much what has been done in the past on spectrum measurements or monitoring, has been generally short term, ad hoc efforts that provide only brief snapshots of information on particular bands on an incumbent's usage.

We need to find ways that we can make it

more meaningful, effective, and sustainable. More importantly, what can make it more affordable.

So I guess that's the key here is, what can we do to help us better understand the spectrum environment.

So I see the third base coach waving me on. I'm supposed to leave the base here. But before

I do, I want to give a special thanks on a great job on our planning committee. Particularly our chair for the planning committee, Mr. Dennis Roberson, did a fabulous job in keeping us on point, keeping the -- getting this orchestrated, getting that organized in the format that we have today, including the committee itself, that included Mike Cotton, Rangam Subramanian, Min Sohn, Bill Horn, and Dale Hatfield, and our infamous Joe Eeps. Is Joe here today?

MR. EEPS: I guess I've been through this (off microphone.)

(Laughter.)

PARTICIPANT: Hiding in the back.

MR. BARKER: I'm totally surprised Joe is here today.

(Laughter.)

MR. BARKER: Good to see you, Joe.

I especially want to thank Wendy and Mark for a great job you guys do, supporting us. We wouldn't be here today if it wasn't for NCO and your support particularly, Wendy, so appreciate it. Thank

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1 I also wanted to say a special thanks to
2 NSF. Particularly, Larry Goldberg, in making the
3 funding available through their grant program and
4 supporting the logistics. Our folks that had to
5 travel, helping them with their travel costs there.
6 So I really appreciate that. So let's get started,
7 let's play ball here.
8 I'd like to introduce Dr. Rangam
9 Subramanian. Rangam just recently arrived at NTIA
10 working in the office of spectrum management,
11 particularly with me in the strategic planning
12 division. He's my chief spectrum technology policy
13 strategist to support us on our long-term planning
14 efforts there.
15 Prior to NTIA, Rangam was at Idaho
16 national laboratory, spearheading the establishment
17 of INL's national wireless user facility, to include
18 leading their program to research and develop a
19 nationally recognized spectrum agile radio
20 capability.
21 He's been a serving member, from day one,
22 on our wizard group when we first stood up, I think,

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1 back in November 2010. And while I'm at that, my

former co-chair is here today, Andy Clegg, Dr. Andy Clegg. Glad to see you here, he left me hanging a little bit there. But we're having a hard time finding a replacement for you right now. But we're glad to see you here today.

So I guess, with that said, with no further ado, I'd like to introduce Rangam to introduce our keynote panel here.

MR. SUBRAMANIAN: Good morning everyone. Thank you, Byron.

This is the fifth workshop that I've been involved in. I've been involved in since the first one. Seems the number of participants has been growing on, we started with 30-35 back in Boulder, a couple of years back and now we have 130 plus, here. That really tells the importance of what we have been doing in physics and how the collaboration, initial collaboration went and mostly I believe this is the biggest national think-tank, I would think, for everyone from government, industry, and academia participating in this and this has been growing.

This is an indication of the importance of value with the whole concept of spectrum sharing or spectrum agile technologies.

We know new boards paradigm coming out, I believe of things addressed security and confidence in the new paradigm is what is -- still needs to be built up. There are a lot of questions, a lot of

people still doubting across the stakeholders. I don't want to pick on anybody. But we are in a situation that this needs to happen, as many national leaders have already acknowledged. That means new technologies, proof of concepts, spectrum measurements, spectrum usage, which are very fundamental to new policy rule making, enforcement, and coordination. Coordinating the spectrum usage.

Now as you human beings, you know, we are typically new to this but if you really look to the history of life of the human beings, we have gone from being introverts to being (off mic) And I think we can, and we will, and I think we should.

To get this context rolling, I have to understand how do participants can help and support

the government, industry and academia with targeted specifications and recommendations.

Today, one of the very specific things we are looking for is specific recommendations. We have been talking about this for several years, several decades, I should say. Can we have something very actionable? You can say, hey, these are a couple of things we have to do at lesson one. To have this, to get that energy going here, we have a fantastic panel here. I don't think we could have chosen any other better team than what we have today.

Mr. Tom Power, I would like you to come and take a seat, Dr. and Mr. Mark Gorenberg.

Please, give them a hand.

(Applause.)

MR. SUBRAMANIAN: I will give detailed introductions as they start speaking. But I want to make this very fun, enjoyable and actionable keynote panel. Nothing is pre set-up. The questions I am going to be asking, and you will be asking, nothing is pre set-up. Before I do this, I want to take off my MBA hat, you know what I mean by that. So to make

it all easy. Let's have some fun, let's have some real discussions and energy going on here.

The way this will work is, every panelist is going to get about eight minutes, roughly eight minutes. It's not realistic, but eight minutes will be good. They will speak on their talking points and then I will pick it up from there, have some set of questions, then we will leave it to the audience. We have enough time today to go over most of your questions that you will be having. Please start writing them, if you have not written them yet. But as we go, you can write it down. Let's have things going on today.

Now, first to speak will be Mr. Tom Power. And I don't think he really needs -- any of the panelists here really needs any introduction.

Tom Power is serving as the United States Deputy Chief Technology Officer for Telecommunications at the White House Office of

Science and Technology Policy since August 2011. As Deputy CTO, Tom helps develop and coordinate administration policy on telecom and technology

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issues. Before joining the OSTP, Tom has served for more than two years as the Chief of Staff of National Telecommunications and Information Administration, NTIA, at the Department of Commerce.

At NTIA, Tom provided policy and managerial direction for a wide range of agency activities, including spectrum, Internet policymaking and Recovery Act broadband grant programs.

Between 2000 and 2009, Tom served as General Counsel of Fiberlink Communications in Blue Bell, Pennsylvania. From 1994 to 2000, he served in supervisory roles at the FCC and he was also the Senior Legal Adviser to the FCC Chairman William Kennard, advising the chairman on broadband, common carrier, and mass media matters.

Before joining the FCC, Tom was a telecommunications and litigation partner at the law firm of Winston & Strawn. And many of you know Tom is a lawyer, but a very technically sound lawyer.

Please welcome Tom.

(Applause.)

MR. POWER: That was lawyer, right? It

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sounded like you said something different.

(Laughter.)

MR. SUBRAMANIAN: I am sorry for the mistake!

MR. POWER: Of course, many people equate the two.

Thank you, Rangam and good morning everybody. It's great to be here, and thanks for everyone who has had a hand in putting this together from NSF and Dennis and Wendy, of course, and the infamous Joe Eeps. Sitting infamously in the back.

So a lot going on, you know, the work of groups like this and workshops like this that really help move the needle. And, you know, as important as this work is, as it goes on over here, it's also a big day over at the FCC today, where they're expected to adopt an order, both in the AWS3, spectrum proceeding and the five gigahertz.

I just want to start by just mentioning one thing, which is the work of my colleagues in the federal agency, the defense, the justice and the other agencies, who do such an amazing job. We have

really showered them with work over the last five years. Two Presidential Memoranda, a monumental piece of legislation, the PCAST report, all the rulemakings and (off mic) of the FCC and then we, you know, impose a sequester and cut their budgets.

(Laughter.)

MR. POWER: It's tough. I've been working really closely, now, for about three years with them and it's a really impressive group over there. So I commend them, just as I commend all of you for all the work you're doing. Because, you know, Rangam was talking about how sharing is becoming, not just in this area, but throughout the economy, a bigger -- a bigger aspect of what we do and it's government agencies, it's industry, it's non-profit, it's public safety, it's everybody coming together on those issues.

As I am talking about agencies, you know, one thing that always comes up when you talk about the agencies, is the idea of incentives or awards basically giving -- giving the agencies a greater incentive to share or (noise) spectrum.

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So just a side note on that, you are probably aware that in February the Office of Science and Technology Policy released a request for information, seeking public comment on various ways of promoting or giving agencies greater incentives. We accompanied that with a report that we have commissioned to sort of summarize a lot of the literature out there. So we've gotten those comments in, and they are going to be on the OSTP website, I think tomorrow. So some folks had been asking when they could take a look at them, I think they are going to be up tomorrow. So just keep a look on the

OSTP website.

So of course, part of what we have been asking the agencies to do, has to do with the subject of today's workshop, which is how data and monitoring spectrum use can help us be more efficient. I think for me, one big aspect that got this momentum going, I have to give credit to Mark Gorenberg, and the PCAS, because of their, you know, the big vision they had. Which was essentially, if we're looking to make more spectrum available for innovative commercial

uses, you can focus on, what I will call the traditional way of doing it, which is define the band or bands that the commercial sector finds most appealing because of the propagation characteristics of the spectrum and just lift out all of those federal systems and move them up the band somewhere, plop them down over here and then, you know, you've cleared that out for commercial use. That's great if you can pull it off, but it's very costly to uproot a whole bunch of systems and it takes a lot of time and that's not in anyone's interest. So the alternative is to find opportunities within existing assignments, starting with the federal side. Is there excess capacity there that could be made use of.

And, you know, we hear and in evidence of this, you know an agency that stopped using a system but retained its assignment, agencies understandably say there's not a lot of that. But that's the

question. We need to get to the bottom of what is really available. So in last year's Presidential Memorandum, the President directed NTIA to create a framework for the agencies to conduct and report on a

quantitative assessment of their actual usage of the spectrum.

Byron mentioned the word "inventory," folks often are looking for the government to produce an inventory. I think this effort is, in some ways, what the President has asked NTIA agents to do, in some ways, narrower, but deeper than what a generic inventory could tell you. So -- and this is what I mean by that. If you just look at the 1755 and 1780 spectrum, that's the subject of today's rulemaking, it's 25 megahertz of spectrum, I think there are like 800 federal systems operating in there.

So if you wanted to say, you know, how much spectrum is being used there, when you multiply 800 systems by 25 megahertz, they are using 20,000 megahertz of spectrum in a 25 megahertz plot.

Well that doesn't quite work right. I didn't take physics, but I think there's something wrong with that when you say it in that light. But of course the fact is, there's sharing going on. There's temporal sharing, there's geographic sharing and so what we need though, to get to the bottom of

is, what does that usage actually look like. How encumbered is the band.

Now, in that particular case, of course, we're going to be relocating a lot of systems out of there. But my point is that you can't just look at an inventory that's sort of like a, you know, like a street map of where people live. You know, like a real estate plat. Because it's much more complex than that, given geographic temporal sharing and, of course, as we move ahead technologically, looking at more advanced forms of sharing (off mic) radio.

So turning back to the President's Memorandum, there were a couple aspects to it. The memorandum directed NTIA to come up with metrics so that agencies would report on their actual usage of spectrum and the particular bands that the memorandum directed NTIA to start with, were the bands that NTIA had previously identified through some interagency work as the ones most prone -- or most appealing for use by the commercial sector. So start with those and let's really do a deep-dive on what it looks like. And the memorandum directed NTIA to come up

with metrics and parameters to inform the decision.

If, for whatever reason, we know the spectrum is either not going to be useful for the commercial sector, or is just really not capable of

relocation or sharing, for whatever reason, there's really no reason to spend a lot of time. And, you know, you're get into some interesting issues here. Sometimes federal systems are designed to mainly listen. You know, pointed up to the skies and over the oceans to detect activity that would be presumably unwanted. But it's just listening, so you don't see transmissions going on, hopefully, in a lot of these bands. So you've got to solve for those kinds of issues too, because if you define usage as transmission, you are not really capturing the full picture.

Of course, the memorandum also directed NTIA to focus particularly on bands that might be available for sharing or for clearing in metropolitan areas, where the commercial demand is going to be the most. And it's a two-way street, the memorandum said of course, the agencies have to continue to execute

their missions and in some cases that could include, actually increasing spectrum. But we want to do it efficiently.

One of the ideas that has come up recently is what some folks call reciprocal sharing, which is where you have commercial licensees who have not built out. And there could be opportunities particularly in the rural areas where they haven't built out, but where the federal agencies could make use of them, particularly the defense department.

So, you know, if unused federally assigned spectrum creates opportunities for the commercial side, then it can work the other way too. And I know there was discussion of this leading up to today's order of the FCC, the agencies were talking to the FCC about potential opportunities in that band, and I don't think we're at a point now to come out with any rules on that, but it is something that's going to remain on the dashboard.

So then the agencies will do these quantitative assessments of their usage of spectrum and then report them to NTIA, which then just further

informs the process of next steps for freeing up spectrum for commercial use.

Then, this same approach, to what I've described so far, is going to be in specific bands, that same approach will eventually be sort of filtered in so that we get that information across all bands. And we're going to do that by taking advantage of the process already in place where every -- usually every five years an agency has to come in to NTIA and basically redo, or re-up its assignment. As part of that, every five years, they'll just be required to add this data -- this data about actual usage as they come back in to renew the assignment.

That's a staggered process so it just depends on whenever the assignment was made, so that'll take a while to kind of filter through the

system. But that, you know, eventually if we can get all these pieces together, should give us the best picture we've had of federal spectrum usage.

One other related piece I should note was the President directed NTIA also to consider or establish a pilot program of actual spectrum

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monitoring. And I give credit to Dennis because he's done as much as anyone in this field, by actually going out into the field and trying to figure out what is the best way to measure and monitor spectrum usage to make it really useful for the purposes we've been talking about here. The President's fiscal year '15 budget set aside, I think, about $7 million for NTIA to get this up and running. We've got to work with Congress to get that through. But that's a third and important piece of this effort.

I'll just finish by noting that, you know, from the federal perspective, trying to solve these issues is a lot harder than it might look. And I know you folks know how hard it is. But the more I work with these -- the folks at the agencies, the more impressed I am at the level of effort they're putting into this. But, you know, I was talking to someone the other day who sort of made the point that, you know, if you're a commercial carrier or a licensed carrier, you can -- you've got a license to bill out some area, you can figure out, strategize about where to put the towers, how many towers to put

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in, how much is going to be offloaded to Wi-Fi, what is the basic quality of service you are trying to provide. All of those factors -- it's hard, but you control the levers.

You could say the federal government is in the same position, but the big difference is in the federal government you really have different agencies, you know, DHS and DOJ and the Defense Department, these are all different agencies running different systems -- completely different systems. They're not -- you know, it's not like a cell system or, you know, a wireless carrier setting up its own network. These are all completely different systems that we try to coordinate together. You know, NTIA can help with that, but it makes it really hard to try to make these decisions in an interdependent way. But that's really the focus, and as we have seen over the last few years, with the great demand -- increase in demand of spectrum, it's more and more important for the agencies to continue to work together with each other, and as well as with the industry and the other stakeholders. Which is another direction, as

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the Presidential Memorandum pushed on, that we be given the work of a Congress spectrum management advisory committee, that again, has helped get us to

today, over at the Commission with the aid of his band.

So I will cut off there and hand it over to Dale or Mark.

MR. SUBRAMANIAN: Thank you, Tom.

Next we have Mr. Mark Gorenberg. Mr. Mark Gorenberg is a venture capitalist and owner of Zetta Venture Partners, which is focused on investing in early stage companies in data analytics. He currently serves as a board member of Domo, Follow Analytics, InsideSales and Optimine. Previously he was a Managing Director of Hummer Winblad Venture Partners, which he joined in 1990 when the firm began investing in its first fund.

Over the time, he has served as a board member for numerous successful start-ups, including Omniture, AdForce, NetDynamics, and Scopus Technologies. Earlier, Mr. Gorenberg was with Sun Microsystems, where he managed emerging new media

areas and was a member of the original SparcStation team.

He currently serves on the President's Council of Advisors on Science and Technology (PCAST), the Board of Trustees for Massachusetts Institute of Technology (MIT), the Board of the National Venture Capital Association, and the FCC's Technological Advisory Council. He doesn't sleep, by the way. As a member of PCAST, in 2012, Mr.

Gorenberg chaired the report the President called "Realizing the Full Potential of Government--Held Spectrum to Spur Economic Growth." He graduated from MIT and received master's degrees from the University of Minnesota and Stanford University.

We are extremely lucky to have him and the right person to really get these things rolling here.

MR. GORENBERG: Thank you, very much for that very generous introduction. It's quite an honor to be here today. Special thank yous to Byron, to Dennis, to Wendy, to Joe for the great program they've put together.

It's quite an honor to be on this panel

with people like Tom Power, who actually is, I think, will be the voice of the White House today for the movement that's going forward. And truly the architect of the Presidential Memorandum that came out about a year after the PCAST report. And also here with Dale, who has put a lifetime into this field, who was a huge voice behind the PCAST report, and heads up the policy advocate; for a long time about receiver management which I'm sure you'll probably talk about.

(Laughter.)

MR. GORENBERG: We'll ask him some questions and get him out there. The PCAST report was truly a labor of love, we spent about nine months on that. A lot of people in this room were very

actively involved in the reports and you'll see the list of names. And I would like ask the people who were involved, if at least they would raise their hands to get recognition from this group. Please. They truly deserve it.

(Applause.)

MR. GORENBERG: Thank you.

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As you know, the report came out in July of 2012 on the notion that -- about creating really the first spectrum superhighways. The notion, if you want to use it by example, The Roosevelt Administration that came out with the idea of creating the interstate highway system, about sharing the roads, it was implemented in the Eisenhower Administration, here we look to more of the concept of spectrum, 100 years after the sinking of the Titanic, to say, is there a better road, is there a way to do spectrum sharing. And we thought that spectrum sharing was the only way -- and particularly dynamic spectrum sharing -- was the only way to provide the resources to meet the problem that we were dealing with that dense usage will drive the idea of new technologies, and a large thing that drove us was the idea of innovating and I'm certainly looking forward to seeing a lot of the ideas at the break or during lunchtime that people are working on.

And also the idea of building out from

coverage to building in for capacity. With that, I

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would frame some core ideas that went beyond the idea of geographical databases, the idea of what we call the spectrum access system, the three-tier system where you have the incumbents -- you have the ability to have licensed spectrum with a priority and then, of course, general access spectrum use. Which, in a sense, took its roots from unlicensed spectrum, but had the idea of having a license associated with it.

We also put in the ideas of being in our receiver management framework, the idea of creating a spectrum policy team in the White House that brought together various factions and also could work with the agencies, the NTIA with the FCC, et cetera, to move that forward.

We looked at the idea of incentives, as Tom talked about, trying to come up with a spectrum currency system that would motivate the agencies to move forward and also one where you would advance in the spectrum to location fund more efficiency so that the people could be rewarded for making their systems more spectrum efficient oriented.

Those are just some of the sort of basic

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ideas that we put together. I think that some of the

-- the evolution has been very fast. As you know, as we talked about, the PM came out in June of last year. Rulemaking has gone on at the FCC now, 3.5 band, which was started by a speech by George Chenokowski, at Stanford in September of 2012, and then the Commissioners voted unanimously in December of 2012 to move forward with that rulemaking. That's undergone a lot of work, John particularly deserves a lot of credit at the FCC for moving that forward.

And it's had a lot of comments, but those comments seem to be converging, and that's converged around a speech that Chairman Tom Mueller gave on Monday at Brookings where he capped it off by saying that he would circulate to his Commission -- to his fellow Commissioners to up the rulemaking to make the PCAST vision a reality. If they designated the 3.5 gigahertz band as the innovations band, and the four tenants of that he talked about was the first proposal for the three-tiered system.

He talked about second, how a flexible band plan going into the spectrum, the sub-bands.

Third proposal, to have flexible usage, clearly small cell, in motivating a lot of this. But it will be a number of uses of applications.

And finally, to look at the economic incentives. And a couple of things that I find that are very exciting, is one, that there's a lot of work going on by Jason Furman and his organization at the

-- who's the Chairman of Economic Advisors -- on the idea of creating what you would say is a short-term, smaller geography licenses, the economics around that, how do you -- how do you look at that from a budgeting standpoint going forward. How do you make that a reality?

And the other is the notion of moving forward as we talked about in the report with the model city. And that's something I know that Tom is working very closely with. The idea that you will have a place where you can essentially go beyond testing, but actually implement all of these different technologies together, to see them in action, to see them working against the various government systems.

And then the third thing I find very exciting, is some of the research -- some of the work going on to look behind the 3.5 band. The 3.5 band, which is very exciting to me, is one that the NTIA to their credit brought forward very early on. It did not because it was really looked at initially from the idea of more traditional, you know, tower and not small cell techniques. But as that moved forward under the PCAST concept, that became very exciting to people and that becomes out of the Petri dish -- sharing the radar systems.

We looked at the idea of the 2.7 to the 3.7 band and there's a lot of work going on there now

to try to look for the next set of bands. And also, interested in areas above that, like the 3.7 to the 4.2 in the C band. But there's no reason why these frequencies can't be extremely valuable, particularly in the sharing arrangement. We've gotten great usage out of the 2.4, we've got great usage out of the five gigahertz. This seems very fruitful.

And also, if you look out ten years from now in some of the little work I'm doing in my day

job, I think ten years from now, cellular the way -- the use of wireless spectrum, cellular the way we know it today, will not be the dominant use of the wireless -- the Internet of things, which is one sort of marketing moniker, we call it techno physical systems, 50 billion devices, frankly, all using wireless technology, creating huge amounts of data, turbines by General Electric create seven times more data than Twitter.

So that the use of all this data in wireless applications is going to be huge. As you go out, this will become a very big force, and these frequencies are just from a lot of the new applications that we're talking about, and particularly with sharing techniques.

So with that, I'll pass the baton over to Dale. But again, thank all of you for your work, for your innovative work going forward. The very first endorser of the PCAST report was a group called Wind

Forum (noise) 150 innovative companies, we couldn't be more grateful for the support that we got from the community.

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MR. SUBRAMANIAN: Thank you, Mark.

Next on to Dr. Dale Hatfield. Dale Hatfield is currently a Senior Fellow at the Silicon Flatirons Center for Law, Technology, and Entrepreneurship and an Adjunct Professor in the Interdisciplinary Telecommunications Program, both at the University of Colorado at Boulder.

Prior to joining the University, Hatfield was the Chief of Office of Engineering and Technology at the FCC and immediately before that he was Chief Technologist at the Agency. He retired from the FCC and the government service in December 2000.

Before joining FCC in December 1997, he also was a CEO of Hatfield Associates Incorporation. Before founding the consulting firm in 1982, he was the Acting Assistant Secretary of Commerce for Communications and Information and Acting Administrator of the National Telecommunications Information Administration. Before moving to NTIA, Hatfield was the Chief of the Office of Plans and Policy at the FCC.

He has over 50 years of experience in

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telecommunications policy and regulation, spectrum management and related areas. He has been almost there, everywhere, and he knows it all.

(Laughter.)

MR. SUBRAMANIAN: He holds a BS in electrical engineering from Case Institute of Technology, an MS from Industrial Management from Purdue, and he also has an honorary doctorate. Please welcome Dr. Dale Hatfield.

(Applause.)

MR. HATFIELD: Thank you, Rangam for the very, very kind introduction. I'm just getting over a cold, so my voice is a little raspy, that explains it. But I really do want to thank everyone who made my -- gave me the chance to be here and talk a little about interference resolution and enforcement. Within the bigger context, if you will, of the subject matter of the workshop using data and monitoring to improve spectrum utilization.

Before I jump in to my remarks, I think it may be important to distinguish, because it confused me for a while, between a, more passive, ideally

longer-term spectrum monitoring aimed at measuring spectrum occupancy for the primary purpose of identifying under-utilized or inefficiently used spectrum; and b, more active, real-time spectrum and direction-finding measurements that are aimed primarily at detecting, identifying, and locating

interference sources for mitigation and enforcement purposes.

I'm going to be focusing on the latter of the two. But one of my messages, of course, when we think about monitoring for the prior purposes, we also think about the monitoring or enforcement as well.

When I sat down and scribbled some notes as to what I might say this morning, I thought I would lay out a few hypotheses that I think are true and kind of build on those. I won't have time, but I will go through a couple of the things I think that may be -- that may be obvious to you, but I think I'll go through them anyway.

My sort of first hypothesis or premise is that the United States is experiencing explosive

growth in wireless devices and systems that successfully must operate, not only in increasingly close proximity to one another and the frequency space and time domains, but also to other electrical and electronic devices that unintentionally or incidentally emit or are susceptible to electromagnetic radiation. You may have read recently some of the problems they are having with the electronic ballasts in light fixtures causing interference to nearby small cells. Well that's sort of a new -- to me anyway, a new sort of interference thing that we would not have been thinking about not

very long ago.

And of course, as we all know, that densification stream produced by a whole bunch of different things, and need to increase capacity, the need to reduce guard bands, the need to take advantage of temporal -- take advantage of gaps in time to get temporal efficiencies. And, of course, as I'm saying, I think this increased densification really increases the risk of disrupting and harmful interference.

So my first hypothesis or premise is that there is continuing growth and demand for spectrum, nothing new there, that is producing increasing densification which, in turn, increases the risk of disrupting the harmful interference or at least harmful and disruptive interference of a different type than we are normally associated with dealing with.

My second hypothesis or premise is, that the increased value of the radio spectrum resource will put pressure on both the FCC and the NTIA and other government agencies, like to my right here, to appropriately protect this radio resource and in particular, to be able to more quickly and effectively resolve cases of interference when they do arise. And of course the latter is especially true for services that are critical not only to our economic and social well-being, but the public

safety, homeland security and (off mic).

More specifically, in terms of the PCAST recommendations, going back to Mark a bit, the immediate prospect of increased sharing of spectrum

between and among federal government and non-federal government-controlled devices and systems, creates new challenges -- creates new challenges in terms of the institutional relationships and processes that are used to detect, identify, locate, mitigate, and report on interference incidents. These challenges have been exacerbated by the wider availability of illegal devices capable of jamming or otherwise disrupting wireless systems that are part of the nation's critical infrastructure. It's one of the things that caused me to lose a lot of sleep at night is this issue of intentional, intentional, intentional, intentional jamming. So it speaks to the importance of enforcement and to measurements in support of enforcement.

Clearly, clearly, the value of dynamically shared spectrum to commercial entities depends upon the processes and resources spectrum managers have available to reduce the number of incidents of harmful interference; and B, to resolve them quickly when they do occur.

Similarly, the willingness of the federal

government agencies to share larger amounts of spectrum in more dynamic ways, depends upon their confidence that applicable rules, regulation, contracts and memoranda of understanding regarding such sharing will be effectively enforced in a timely manner.

In other words, I really buy in to the PCAST vision, but ultimately, it's the willingness or incentives, to use your term "incentives," depend upon -- depend upon trust. Because I, as an investor, will be hesitant to invest in spectrum if I have doubts about whether I will be protected adequately from interference, and certainly if I'm in a national agency that has defense -- homeland defense sort of responsibility, my willingness to share is going to depend upon my trust that the enforcement part -- my enforcement part will work.

So we've got to make sure that we have the appropriate tools and the appropriate processes to work quickly and effectively with cases of interference when they arise. As I say here in my notes and I've underlined it to do, otherwise will

undercut the very basis upon which increased sharing called for in the PCAST report rests.

I'm going to run out of time, so let me just touch on a couple of other points in a more

summary fashion. Once this is -- a classic two-edged sword, I see on the one hand, this marvelous new technology that's doing all these things to make things much more dynamic to the digital with changing waveforms, all these things that are such magic things going on. But all of those tend to complicate -- tend to complicate the enforcement.

In the old days, when -- I have some friends here from the Enforcement Bureau at the FCC, and are pretty straightforward, you found that really high antenna that was sticking up out there, it was running at high power, you could DF on it from a great distance and they were really nice to you, they even, you know, every so often gave their call letters so you knew who they were, you know. And moreover, they used what, the AM and FM, so you know, there wasn't too many modulation waveforms you had to choose from.

But put yourself, just for a moment in the seat of the FCC's band today with these changes that are -- changes that are going on. You're dealing with these myriad of waveforms and people are jumping around, the interference may be much more -- much more transient. In many services we don't have anything like call letters anymore. Those were kind of handy, you know.

(Laughter.)

MR. HATFIELD: That leads to another point

that I'll make in a moment. So on the one hand we have, you know, these challenges, but on the other hand we have these same tools can be applied in ways to help us on the enforcement side.

I know John Chapin, in the back here somewhere, yeah, John. I believe, John, you were the person who had this brilliant idea -- I think it's brilliant -- that we have handsets going around, have a lot of processing and storage capability, why don't they store the last, what, minute or two of the INQ information in the receiver and you would put it on a loop and if you had interference incident, what you

would do, you would stop, save that, and then you would go through a post-processing thing where you could take a look and say, okay, my call dropped repeatedly at a certain intersection, other people's calls dropped, let's do a -- let's take a look and find out what's going on there. These are the sort of things that weren't possible before.

I'd like to talk a little bit more about big data and some of those things, but I don't think I have time. But the point -- my point is, very simply, that the technology -- wonderful technology that we're seeing is a two-edged sword, of the one hand it's enabling us to do really, really sophisticated things which presents problems. On the other hand, that same development in technology, for giving us some tools that we didn't have before, that

we can apply to enforcement problem.

Let me -- sometimes I feel like I'm on a soapbox a little bit, but let me say, well one time it was incentives, you know, we're not going to have sharing unless we have the incentives right. And that's good, I see we're right there, and, of course,

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I've been on the receivers, having to do something about receivers since almost the start of my career. I guess right now, my comment is that we need to take in enforcement at the time we create rules and systems. Enforcement can't be an afterthought.

What you need, right, is you need hooks, and to be able to do the sort of interpretation of finding out what sort of things have gone wrong.

Too often what happens is, we make rules for a new service and then hand them to the enforcement bureau saying, okay, we've done our work, go enforce it. Well, like I say, that may be difficult today because unless there's some ability to identify who the bad guy is and so forth, you're going to have a tough time doing your enforcement function. So when we talk about 3.5 gigahertz and so forth, we need to think early and strongly about what we're going to do to make sure that enforcement is done properly. Because if it doesn't, it undermines this trust that I'm talking about if we can't, we can't make it work.

Okay. I think that -- oh, let me make one

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final observation, and I'll stop, I promise. I've been doing some work for the last few months and then in preparation for this conference, and what I'm learning is that there is an enormous amount of monitoring data already being collected by people.

For example, all the carriers do extensive drive tests for very good reason, because they want to know where their coverage is, and they even might want to know where the coverage of their competitors are, so they can do a better job. The tower companies, what do they do? They do extensive drive tests because they want to know where would be a good place to put a new tower. And of course, there's specialty, I think here in the room, what is it, DESS, the satellite sensing, they do extensive measurements too.

So when I look around, there's all this information and it looks to me it's all being collected in what, silos. I think there are opportunities, I believe there are opportunities using this sort of data -- the big data thing gets a little flaky. But I do believe there's a real

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element of truth there, we have an awful lot of information that we're not fully taking advantage of.

And then secondly, as we think about what

we want to do in the future in terms of occupancy type measurements, we ought to think about what we can sort of tagalong do in terms of enforcement as well. So let me stop there.

MR. SUBRAMANIAN: Thank you, Dale.

Now let's start with the question answer session. I'll start with a few questions to the panel, and then I'll leave the floor open and you can ask questions.

Let's start with the PCAST. We had both -- I think all of them mentioned the PCAST.

Mark, you were the leader of the PCAST report, let me ask you a straight question. Are you happy with how the global indices stakeholders reacted to the PCAST report? Are you happy with the set of actions that govern the things you did so far? If you think, why, what are the things that you're happy about. If not, what are the actions that?

MR. GORENBERG: I'm actually not just

happy, I'm actually thrilled. I mean, you have to think about this. We're less than two years since the report came out, we've already gotten a Presidential Memorandum, a huge uptake at the FCC, a lot of stakeholders that are involved to try to move this forward. We have a band designated with a new terminology innovation band. We've got leadership on so many different quarters. And again , a huge credit to Tom for what he's been doing at the White

House. Huge credit to people like Dennis over at the FCC and the NTIA.

You know, I feel that this will be implemented in this administration, and that is one of the greatest things that you can think about, which is, to have a report come out and actually have it move forward.

I really appreciate Dale's comments on moving into being done. And it's really great also to realize that when we started this report Dale was talking a lot about carrots.

(Laughter.)

MR. GORENBERG: His incentive word was

carrots, carrots, carrots. Now I guess you're bringing the sticks.

(Laughter.)

MR. GORENBERG: So this will be implemented with both.

And I think the other part about this which maybe we've seen, as we see change at some of the agencies like the DOD and Tom can probably speak about this better, but just in the small amount of time that I've spent and huge receptive ear to move this forward. I mean, people are realizing the alternatives to clearing spectrum the costs involved, the time involved, the fact that it takes years -- well, it will take years to get any usage by the commercial sector. It's just untenable.

The idea that you can start off in a system and actually gain use very quickly and then get more and more use as you progress

(Sound interference; loud buzzing)

MR. GORENBERG: -- that's a win for everyone. And I think the agencies, and particularly give credit to DOD because they have so much federal

spending it's been a huge partner in that regard. And private industry has been and obviously many -- we've already seen prototypes of spectrum access systems. I think we'll see far more work on (noise).

I do think that this public/private partnership is going to be really something for us to watch.

MR. SUBRAMANIAN: Are you happy with how we are reacting to this?

MR. GORENBERG: Yes, I am.

MR. SUBRAMANIAN: I have one more question for you on this. If you do this PCAST report again, do you think you will change any of the foundations or recomendations.

(Simultaneous conversation.)

MR. SUBRAMANIAN: If you do this again, now that it's about a year, is there together that you might change the recommendations or --

MR. GORENBERG: No, I think that we -- we have a lot of stakeholders involved in crafting the recommendations that we get. I think we're very

happy to get to the planning tests.

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MR. SUBRAMANIAN: If we could give --

(Applause.)

MR. SUBRAMANIAN: Dale, what is your take? You have been in this business for close to 50 years, what is the think-tank perspectives on the PCAST and where do you think the government work -- how do you think about it?

MR. HATFIELD: Well, I'm trying to think of the right word. Probably ecstatic. I mean, I think it really is true the progress that's been made in two years is incredible. There's some things that still bother me. The principle right now is not losing control of this resource where people go out and buy cameras, for example, and think that they can use them with immunity. And those are the things so that continues to -- that continues to worry me, at least my current (off mic).

And then, of course, Mark set me up. I mean, how can I not say, you know, as the receiver, I mean, you know, we just cannot afford to let people, you know, I'm not picking on anybody, you know, you get a 10 megahertz assignment and then claim they

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have to have protection 100 megahertz on either

side because they got crappy receivers. I mean, that is just -- you know, we can't afford that any longer. We just really cannot afford that. And the same sort of transitions that we talk about, I'm, as you may know, a big fan of something called the Harm Claim Threshold, as a way of trying to give a little bit more precise. The challenge we've always had is how you define harmful in appearance. I mean, nobody has been able to do it successfully because I think it's an impossible problem. And that what you have to do is go to something like Harms Claim Threshold so it's the subject and you know when you use some sort of maybe a multi-stakeholder group or something to come up with the right comments and then transition over time to the receivers and (off mic) over some period of time. So I am still concerned about the receiver.

But I, generally speaking, feel very, very good about it.

MR. SUBRAMANIAN: Now to Tom. Obviously you must be very proud of the action that has happened after the PCAST. And there have been two

national memorandums and that being one, what is next? What is the perspective? We keep talking about this African woman now in various economic sectors also we are talking about recreating the innovation and can you bring that light of innovation again ? What is the next setup that you think from your White House perspective?

MR. POWER: You know, I just have to start by remarking as Dale was talking about interference with when we started getting that buzzing sound.

(Laughter.)

MR. POWER: I think he's got a little bit of ice that he --

(Laughter.)

MR. SUBRAMANIAN:

MR. POWER: Well, I mean, you know, I made mention earlier and I appreciate Mark's comments about the agencies and the work they're doing. But, as I said earlier, we have dumped a whole lot on them. There is plenty they have going on now. But based on, again, (off mic) and Miranda and legislation and all the regular FCC, so much of it

born out of the PCAST report, and I will tell you, sitting in the Office of Science Technology Policy, you know, a lot of what we do is help develop and implement and then coordinate the agencies and really getting agencys together whether it's on spectrum or any other issue, and it's a really hard job to -- you know, each agency has their own mission, they have their own leadership, they have their own staff, usually they have their own budget, they have their own appropriators and authorizers on the Hill, you know, they are (off mic) in a sense. And so trying to align everyone and get everyone going in the same direction, you know, under the best of circumstances

where everybody is totally motivated, even then, it's very hard. And sometimes it's even harder.

So I think, you know, we've pretty much got our plate full. I wouldn't expect to be able to impose any more work on the agencies.

I will say the amount of effort that's going on throughout all stakeholders, not just the government, really is remarkable and I -- you know, when you're in the weeds as all of you are and all of

we are, you sometimes can lose focus of that. But I had a privilege of meeting a month or two ago with a woman who was a former, sort of equivalent of FCC Commissioner in France. And she's been commissioned by a French cabinet secretary to write a report on spectrum in particular. And she reached out because she wanted to talk about PCAST and all the spectrum sharing issues going on here. And I had a wonderful meeting with her, spent an hour or so over at the French Embassy. When we got to the end of the conversation and she said, I've got one more question for you. Why is your President the only leader in the world that talks about spectrum? She said, you know, in the rest of the world this is just some dry technical issue, and would never get anyone's attention. I'm -- she said, I'm commissioned to write for (noise) I mean, that's like as important as we've got here. But, you know, you've got a president who has pushed legislation through, he's

got two memoranda, he commissioned the PCAST report, what's going on? Why is that different?

And I sat and just reveled in the moment

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for a moment. And then -- and then I just said, well, it's the economy, pure and simple. And she chuckled and she goes, well, we have an economy.

(Laughter.)

MR. POWER: And I said, well, your leaders should be talking more about spectrum. But I really do -- I think the plate is full. So I think the next steps are, you know, implementing 3.5 and implementing the 5 gigahertz issues. We're looking at all -- a whole number of fronts. One of the -- you know, you asked Mark about his success and I -- you know, if you go through the PCAST report you can see action on almost everything.

One of the things he talked about was this idea of a model city and this would be an idea of like having a real world environment to do, you know, actual deployments and the sort of pre -- well, for Mark he would probably have his own vision of it, sort of pre-widespread commercial deployment, but you're actually out there operating in a real environment. So we've been talking about ways to maybe make that work, talking to the FCC. I mean,

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they -- I think all the tools are there, it's just a question of getting the players together, whether it's industry, government, public safety, and a city or two who would want to collaborate. So we might be looking for some more motion in that area too.

MR. SUBRAMANIAN: Thank you. Okay. Now, let's talk about investments on a broad perspective. Typically the moment in particular has invested in a huge rate in multiple economic sectors especially on the basic research, while the industry has jumped in on the up high taking it forward.

And that has given global technology leadership in the United States in almost every sector.

Now, the question for Mark is, are you happy -- I know -- if you could look at the last 10, 15 years, a lot has happened to the application space, the moment of application space, you can look at the return -- soon the other company that is -- that is created in this value as stock markets go up but it tells the basic fundamental research, many companies have floundered, the the OEMs, and the

(off mic) have floundered. Now, are you happy, Mark, with the investment right now and how is the Silicon Valley right now working? Is it really hot right now, not -- Silicon Valley, Boston, Dallas, so many others and Washington, D.C. You can think yes and what are some of the examples -- if not, why not, and

what can be done?

MR. GORENBERG: You know, it's interesting right now because I come here and we talk about, are we doing enough to invest in -- we sit in Silicon Valley and people ask every day, they ask these panels, are we headed to a bubble? Are we doing too much investing? But I would argue in areas like mobile and in data, and analytics particularly, it's been a great area to invest in which is why I decided also to create a focus fund and purely consider it.

I've seen a lot of great poster children out there for the use of this data. I would call it the next wave of analytics. Professor Tom Dowling at Wharton Business School calls it analytics 3.0. The idea of analytics for business impact. So going beyond traditional analytics, going beyond big data

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infrastructure to the going into the idea of how do you sit through this data, how do you apply machine learning, how do you do predictive analytics and prescriptive analytics to really make sense out of it all.

I think you're seeing that as one temple I think you're seeing huge investment now and we talked about this industrial sector for analytics data and mobile which will be widespread through the whole country. I've seen startups all the time outside the Silicon Valley. I mean, Utah -- investing in companies in Utah and Minneapolis, seen companies,

you know, in the heartland. Talked to a company recently in Milwaukee, talking to companies in places like Pittsburgh and Detroit. And there's a renaissance in this area now for young startups. So I think this will be a great area for investment. And I think you will see investments by some of the larger Internet companies. I know we have people here from Google who obviously invested strongly in this area and larger companies are investing in this area as well.

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I do think that one of the areas that we have had a lot of investment clearly has been in the private sector and the areas around spectrum. But that's because that's been a scare commodity controlled by, you know, in a different way. And our whole vision was that if we could make that abundant, if we could take that and make it like Wi-Fi is, like the 2.4 is, we'll get huge investment of startups that sit on top of that as well. And I believe that that will be the next renaissance after we can start some of these innovations

MR. SUBRAMANIAN: What is the

MR. GORENBERG: Pardon?

MR. SUBRAMANIAN: What are the thoughts on this, the investment plan?

MR. HATFIELD: Well, that's outside my wheelhouse, I'd say, as they say. One of the things that I see some -- just because people who call me,

is there seems to be a lot more interest in people trying to find as spectrum issues under look things and in other words which is really kind of intriguing because as the spectrum gets more valuable and we get

more flexible and so forth, you would hope that's exactly what people are doing. They're saying, gee, look we got this, and we put it with this beside it. We got that. We could then create something that has even higher value.

I don't spend an awful lot of my time on the investment side, but the things that -- that is a sort of thing that's encouraging to us. I do some investing, but it's mostly -- mostly pretty narrow -- narrow technologies and that stuff, in this area though, as much as I can.

MR. BARKER: I know we're getting close --

MR. SUBRAMANIAN: Yes, next give me the audience --

MR. BARKER: -- so since I have Paige kicking me in the leg.

(Simultaneous conversation.)

MR. SUBRAMANIAN: Yes, thank you.

PARTICIPANT: Fundamentally two key enablers are (noise) not just spectrum usage information, but technology process as people. And it is a two-way street and ultimately sharing is

sharing. It's not just sharing in the federal spectrum with commercial users. And, Tom, you mentioned starting discussions of reciprocity. How far along are we in that notion, and what progress are we making there?

MR. POWER: I think we're at the beginning. I mean, I guess you could imagine a few different variations of this, but, you know, one would be that going forward is Commission issues as far as the licenses, this would just be condition in there. You know, I don't know, the details of it. So frankly I think we're at the beginning and part of the reason for that is, you know, it was raised, I believe, in the FCC and I know there were some discussions going on and I think for the (off mic) it was just -- although they are the biggest winner out of it, you know, they're really focused right now on petition plans, on the planning for moving systems out and how they're going to share with systems that are there. And I think it was just, you know, you want to get there, but I think it was just the burden of trying to solve enough that was on their plate.

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So we're at the beginning stages, but, you know, I do think it is inevitable. And the trust issue is really one way to think about it. But it is the flip side of enforcement because folks have to be certain.

And so, you know, when you're a federal agency and you've got some really vital mission that you have to execute. I mean, that is your job. And so, you know, you sort of know how you're going to design your system and then you build protections around that. And, you know, DOD does that, DOJ does that, DHS does that, FAA does that, you know, and this goes back to you know what the PCAST looks like Okay, that's great and makes sense, but does that mean that in fact there are some opportunities. We do get smarter and develop trust and enforcement and new technology, you know, is there some availability there we can shrink, essentially, the footprint of the feds and make more available on the commercial side, and vice-versa. It's a little simpler doing it the other way because you just sort of look to see where it's built or because of, you know, (noise) as a license, you can tell a lot more easily what's

available for sharing.

So it's easier to do just more at the beginning stages, I'd say.

MR. SUBRAMANIAN: Thank you. Anyone else? Please raise your hands.

(Pause.)

PARTICIPANT: Since I made some of these group sharing measurements 20 years ago, there are two classes of people whom I've found and there is a little bit different. One is public safety with whom

I work very closely. They have a very simple principle, my spectrum is mine, and your spectrum is mine when I need it.

(Laughter.)

PARTICIPANT: Which makes it a lot easier. But they have reason for that because they are concerned about life safety. They want to go home safely to their families that evening. And anything that might impinge on that and they're all from Missouri -- they're very concerned about it. So it's not always that private sector wants to jump in, but sometimes (off mic) throughout the spectrum and trust

issue because what.

The second area though is a little bit more interesting. For example, if you take microwave, they sometimes have 35db modules. So, and the reason they have the the modules is not because they need it at all times to carry their megabits per second, but it's because their regular constraints that say that it has you will still continue to operate and that you must have enough time of at least so many minutes of up time, that's the downtime of only so many minutes per year.

So now those are folks where if you are willing to incentivize them, if you are ready to -- that's why I looked, that's a single harm --(noise) a dynamic threshold as well. Then there might be actually ways of doing it. They wouldn't mind some

money for all that that they got and somebody else uses it and taking its money out. So I think it's a different clientele. I think it's taking each approach sensitively with respect for why they want the way they do. Then I think you do have an opportunity.

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MR. SUBRAMANIAN: Thank you. Any other questions?

MR. BARKER: There wasn't a question in there, was it?

MR. SUBRAMANIAN: It was a comment.

PARTICIPANT: University of Pittsburgh. This is a question for Mark in particular. I'm interested in his question of investment in systems. So if you had a proposal for a company that relied on (noise) document how comfortable would you be about an investment like that? I guess I just -- and I'm looking at a sort of a rubber-on-the-road type of a reaction.

MR. GORENBERG: It's a broad question to talk about it in generals (noise) spectrum. But I'm happy to if you have a start up --

(Laughter.)

MR. GORENBERG: Happy to go and to talk with them and to see what they're doing. But I do think the whole area, you know, the whole intersection of (noise) mobile data, we talked about that. It's just the huge uptake area that's going to

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be going forward. And so I have to -- the answer to your question is more, what is the infrastructure that's done by the big players? What are the middle levels and the applications that are done by the startups? And that's really the idea to ferret out. And so what I would look at is, you know, what's their positioning in the market? And also, what kind of leverage they can have, what kind of partners can they have to move that forward? Are they going to help them forward or are these going to move forward -- said we'll help them and they can get a huge wave underneath, then there's probably a greater (off mic).

MR. BARKER: Two more with the Drug Enforcement Administration. We've been talking to industry and as technology has branched out now and there's more, looks like in the future a lot more machine-to-machine type wireless devices that are going to proliferate. Is anybody doing any basic research to understand how that's going to change the noise in general (noise) areas especially in the urban density?

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(Laughter.)

PARTICIPANT: Because that's going to change design dynamics and everything after that.

MR. HATFIELD: Here again, I've had hot flashes over the years.

(Laughter.)

MR. HATFIELD: That's one (noise)

(Simultaneous conversation.)

MR. HATFIELD: We don't know near as much as we should know about the background increase in noise. Now, some we know actually is going down, like emission noise, automobile emission noise, I think has actually trended down. But one of the things we've had in the tack for how many years, Dennis?

MR. ROBERSON: Fifteen.

MR. HATFIELD: Something. Since the tack has been in use, we simply got to understand more about what's happening to the noise floor. When I talk to the old timers, old timers like me, everybody says, gee, that the background noise is ten degrees higher than when I started my career or something

like that. That's what they'll tell you. But getting real factual information in the area is really tough. I was talking to somebody here about the idea with these airborne measurements that perhaps you could go out and make measurements over the ocean or someplace where there's absolutely no noise. Anyway, making some measurements there and then doing some measurements in supposedly unoccupied spectrum in urban areas and get some sort of feel of

what the delta is between the very isolated area and urban area.

We need to get a handle -- really get a handle on this because the switching powers apply. The -- as I mentioned before, the electronic ballasts, there's just all kinds of things out there that's contributing now to noise and we don't have a good handle on it.

PARTICIPANT: Good morning. Ted Rappaport from NYU. Spectrum sharing is very promising. There's a lot of good work happening, but I wanted to ask the panelists what their thoughts are about the new spectrum band that's been shown to be viable and

that is the millimeter wave spectrum, especially for small cells where there's tremendous international interest. And work over the last few years has shown you can get gigahertz bandwidths, channel chunks that are so much bigger than the 50 megahertz chunks we're talking about today where you can really unleash not only spectrum, but capacity to keep up with the heavy demand.

The U.S. has always led the way with the ISM band and permitting spread spectrum. Where is policy and where is the U.S. going to be looking for the millimeter wave bands where we see China and Korea starting to make big investments?

MR. SUBRAMANIAN: Tom, do you want to take this?

MR. POWER: You know, I told Dale I was going to meet him at the reception later because this is one of the three things that I need to ask him about. I am not the guy to ask on the technical, you know, capabilities. I hear lots of excitement just as you're describing. You know, I will tell you, I don't think, because the rulemaking (noise) out of

the FCC are any great policy shift within the administration any time soon, but it's something we need to keep our eye on. But I will confess, I'm not much detail of what the options are.

(Simultaneous conversation.)

MR. POWER: My professor might be able to.

MR. HATFIELD: I'm not sure I can say very much. Yes, we need to do it. I mean, the pressure here is so great that if we can find ways of going higher and using spectrum. As an old man, I can't help but tell you, I can remember when we were laying mobile radios at 150 megahertz and the proposal was to go to 450 and everybody said it wouldn't work, it was too high, you know.

(Laughter.)

MR. HATFIELD: So it's sort of sometimes -- I'm not kidding, you know. Yeah, and so, you know, we tend to dismiss some of the higher frequencies too quickly and all the things that are going on and so forth. It's something we sure should be taking a serious look at.

MR. POWER: One piece of this, you know,

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Rangam spoke earlier about the difference between basic research and applied research and how we historically or consistently historically look to the government to help fund the basic research through NSF and then industry sort of takes it from there. And it's easy to see why. You know, the question about what is your investment strategy when it comes to shared spectrum? You know, once the investor or company can actually see a return on investment and a business model, you know, the money starts flowing. Before that when the investment is likely to create social good, but it's unclear how or who is going to get it, we kind of look to the government that's what the government does is look out for everybody.

In the present environment, it's really tough and, you know, we're basically in a scenario where if anybody wants to propose funding for anything, you got to show how you're going to pay for it by cutting somewhere else.

Now, you know, one exception to that is if we fund spectrum auctions because the auctions generate the revenue themselves. So you don't have

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to find some other way to pay for that, that's what

pays the agencies to relocate out of their bands or to prepare to share the bands is the auction proceeds.

When we talk about unlicensed, we throw that out the window because unlicensed isn't creating revenues. Unlicensed might generate the same amount of social benefit including Treasury revenues because companies get profitable and pay taxes and all that. But from a legislative budget perspective, it doesn't count the same. And the (noise) policy and the budget environment is such that we've got to make tough choices like that, but we really should do it with our eyes open. And, you know, from my perspective, you know, when we talk about let's say wave technology, you know, that would be a wonderful place to go pursue it. But in the budget, you know, environment, it's like, all right, how do we pay for the next, you know, 10 million, 50 million of research. It's got to come from somewhere else. That's kind of the environment we're in, which is big stuff.

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MR. GORENBERG: This is definitely throw in a friend time. So, (off mic) may have a good answer for us.

PARTICIPANT: (Off microphone.) All on the website so you can see what's going on. And I think it's actually fairly substantial investment and military recognizes the importance of this as well.

MR. SUBRAMANIAN: Thank you.

So I think it's also, let's have some wrap-up comments from the panelists.

What do you think is the key take away of recommendations of interest to you from the workshop today from the (off mic)? This time for Mark.

MR. GORENBERG: Well, I plan to learn a lot. The reason why I came here today was to learn a lot about what's going on. And we have, you know, there's a great panel coming up on key projects. They're going on. And then also the demo that will be going on and then, of course, the conversation. So I think it's just a great time for the evolution of innovation.

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MR. SUBRAMANIAN: Thank you. Dale?

MR. HATFIELD: I can't add anything to that.

MR. POWER: I would agree, because the work groups and events like this is just essential and you know, it's not going to be on the front page of (off mic) but essential to what we're doing.

You never know.

(Laughter.)

MR. SUBRAMANIAN: Thank you so much. Please.

(Applause.)

MR. BARKER: (Off mic) Special thanks to

our keynote panelists. And it's really great for you guys to take time away. FCC was supposed to be on (outside noise) she couldn't make it because of the

That and trying to make up time. What we're going to do is we were supposed to have a 15-minute break, so we're going to cut it to ten to try to get some time back. So if we could get everybody back here at 10:40, that would be great and we'll start off with our second group.

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Thanks

(Whereupon, at 10:30 a.m., a brief recess was taken.)

P R O C E E D I N G S

(10:50 a.m.)

MR. BARKER: If we could take our seats so we can start our second panel here, the projects panel.

I would like to introduce Peter Tenhula, from NTIA. He's our principle spectrum advisor to our Assistant Secretary Strickland and he also serves as a principle advisors to the ITS.

Peter prior to coming to NTIA was with Shared Spectrum Company where he served as the vice president and chief counsel for the company. And during that time he also served at the Wireless

Innovation Forum -- where he served on the Board of Forum and also was the chairperson for their regulatory committee.

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Prior to that he served for about 15 years in FCC in various positions from chief counsel to chairman Mr. Powell -- Michael Powell and he also, I guess, one of the biggest positions or opportunities is when he served as the director of the Spectrum Policy Task Force. So I'd like to welcome Peter.

MR. TENHULA: All right. Thank you, Byron.

Byron did mention that like Tom, I am a liar.

(Laughter.)

MR. TENHULA: And a lawyer.

(Laughter.)

MR. TENHULA: So I'm going to fake it with all these great technical experts up here for this panel on key projects involving the spectrum data and spectrum onframe that are currently going on.

So we've got a great panel and without further ado I'm going to introduce them. But before I do is quick about the format. We're going to try to do a -- we don't have much time. We have about six minutes -- six to eight minutes each for each of

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the panelists.

Can you hear me out there?

(Chorus of no.)

MR. TENHULA: How about now?

(Chorus of yes.)

MR. TENHULA: Like I said, I'm a liar.

(Laughter.)

MR. TENHULA: I don't want a microphone on.

(Laughter.)

MR. TENHULA: So this is our batting order for our panelists today. About six to eight minutes each for kind of presentations, opening remarks. There are plenty of slides. They're all on that website too along with their bios. And I'm going to go ahead and instead of intros, just a few lines of their bios.

If they're able to get their (and) presentation and find that will allow us for some Q&A focused on the particular presentations. If not, we're going to just move to the next panelist and have plenty of time, hopefully for Q&A before you

break for lunch.

Most, I think, all except for one are having demos or exhibits during lunch, so part of this is to not only talk about their project, to talk about what -- provide a preview of what you're going to see in the exhibit space.

So a quick introduction for each. The first presenter we're going to go along the lines here is Jesse Caulfield from Key Bridge, which he founded in 2001. Prior to Key Bridge Jesse led the research development and service delivery efforts for Sysco System, IntelSat, Comcast Cable, and American Tower Corp.

Next is my colleague from NTIA, Mike Cotton. He's actually out in Boulder at the Institute for Telecommunication Sciences where he is in the telecommunications vision and has been there for about 22 years; right out of college, right, Mike?

MR. COTTON: Uh-huh.

MR. TENHULA: In the meantime he also got his MS in electrical engineering at University of

Colorado, Boulder in 1999.

So he's been there since 1992.

Next after Mike is Anoop Gupta from Microsoft. He's worked at Microsoft for over 13 years. Currently managing the development team for Microsoft's Technology Policy Group.

Previously he was an architect for OEM Consulting Services and a senior consultant for Microsoft Consulting and a developer of Microsoft Office and Windows. So if you have any questions about that, you can probably ask (off mic)

(Laughter.)

MR. TENHULA: Dennis Roberson is next. He's the Vice Provost and research professor in computer science at Illinois Institute of Technology in Chicago. He is the cofounder of IIT's Wireless Network and Communications Research Center and also the President and CEO of Roberson and Associates. And he serves as the Chair of the FCC's Technological Advisory Council and serves on NTIA's Commerce Spectrum Management Advisory Committee and has no spare time.

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(Laughter.)

MR. TENHULA: Prior to Illinois Institute of Technology, he was executive vice president and CEO of Motorola startup in Chicago.

(Laughter.)

MR. TENHULA: Dr. Marja Matinmikko -- sorry about that. I'm ashamed I can't pronounce or finish her name because my grandfather would be embarrassed by that. I hope it's close.

But Dr. Marja, I'm going to say, hails from the VTT Technical Research Center in Finland. And is a senior scientist there. She received her master's degree and a Doctor of Science degree in telecommunications and engineering from the University of Oulu.

My grandfather would kill me.

(Laughter.)

MR. TENHULA: So, next is Georg Schone,

coming from Germany where he's been a radiocommunications expert with more than 25 years' experience in all kinds of telecom, radio telecom stuff. He has been a member of -- he's a member of

the Board and CTO for LS Telcom AG in Germany and since 2012, Board member of the U.S. entity LS Telcom, which is in Bowie, Maryland, right up the street.

Okay. So I've asked each of the panelists to give us five or so minutes of opening comments and slides and presentation about the themes of the workshop today. We are focusing on this panel on the specific monitoring and database projects that the panelists are leading or involved in or studying very closely.

So, without further ado, I'll turn it over to Jesse and we'll go down the line. Do you have the clicker?

MR. CAULFIELD: Yes.

Good morning. My name is Jesse Caulfield and I'm the President of Key Bridge Global. Most of you probably know us as one of the certified vice base database administrators here in the United States. We offer and operate two versions of a whitespace portal. The whitespace portal -- the community whitespace portal is a free portal which we

offer as a part of the undertaking for our -- as a whitespace database administrator. We also have an enterprise version which is essentially a supped up version of the former which is particularly popular with users who have very complex radio environments and need to register those for protection.

The reason why I bring that up is one of the things that we did when we built our portal was we started with a set of APIs. We started with a database, then we wrapped a set of APIs on the engine essentially to run a whitespace database on top of that and then we used those APIs to build our portal. And that's the approach that we've taken from the very beginning. Start with the data, build an API, and then build a really nice user-interface on top of that.

This API we offer -- or rather is used for a number of carrier resources. For example, we've built some whitespace client software that accesses our APIs, the spectrum data or rather the data itself, and then in addition to the whitespace one of the things essentially a separate development that we

had undertaken in parallel with the whitespace database was spectrum monitoring partially to characterize the whitespace spectrum for the benefit of the new unlicensed users who could get essentially

two versions of reality. One version was what the database saw, which is essentially a binary -- there's something in the band, or there is not. And then there's the empirical evidence that there is something in the band and it may not be suitable for use even though it may be legal for an unlicensed operation.

So, very early on we recognized that while whitespace may be available for use, it may not be suitable for use. And we decided to develop -- start developing a spectrum monitor solution to characterize that spectrum for the benefit of our users, both licensed and unlicensed.

The licensed users want to know if an unlicensed user is perhaps encroaching or -- and the unlicensed users want to know, for example, if the licensed spectrum stops at the border or doesn't.

We offer this as a series of data, raw

data and database. We have a fairly substantial database matched in the whitespaces by our peers, the other database administrators, and we also pull in unlicensed transmitters wherever we can find them. We try to characterize those as well, not only in the whitespaces, but in essentially every band that we can address.

We also have databases of profiles for the benefit of our users for their own network modeling, tower sites which are, for the most part, available

from vendors as well as government sources.

A little bit of cloud for marketing purposes.

(Laughter.)

MR. CAULFIELD: Everything is in the cloud.

Part of the API that we found is especially interesting is providing visualization. And that's essentially taking this data which is primarily -- for the most part geo-located or geo-tagged and allowing our users to map it. Right. You can take in a lot of information very quickly

when you map that information.

So at its core, mapping is -- mapping in geo-location or geo-tagging is integrated at a very low level into the data, into the databases themselves into the APIs, into the query mechanisms into the APIs as well. So you can start with the frequency, you can start with the location, you can start with a general area to query the database to look for that information. And then you can visualize depending on the user interface, you can either collect that information in a (inaudible) format according to your great parameter, so you can visualize it using our mapping.

And then modeling. So I mentioned earlier the database and the empirical versions of reality. So we have developed and incorporated into our API

set a series of (noise) models. You've probably seen these pretty maps where these pretty keyed maps. We have a series of algorithms where we take empirical data and we match it against predictive models and we use that to essentially autocorrelate and correct the path -- the area of Pavlos models to increase the

precision, I guess you could say -- well, not precision, increase the accuracy as much as we can. And here are a couple of examples. Urban environments, some rural environments, these are some pretty heat loss maps. Most of you have seen these so I don't want to take too much time to explain them. But the concept here is, you can take some statistical point, some empirical measurements, and that will essentially allow you to adjust the topology of your Palov's to improve the (off mic).

Some mapping. These are some pretty screen shots taken from our whitespace database. What you see here are point sources, so these are transmitters. The lower right-hand corner is a public safety network in Los Angeles. You can see there are quite a few notes there.

What we're showing here are the protected service areas. What we are not showing here are the overlays of the predicted as well as the empirical ratio propagation. But the two -- taken together the two are very important.

And here's a pretty print of a waterfall

chart. You've seen this before. This is sort of the meat of why -- or the substance of why I'm here. What we've done is we've taken this spectrum monitoring solution and we've integrated it into our databases. So, for example, we've taken the peak detection algorithm since we know where the sensors are, we correlate those with known transmitters. And when we don't know where the transmitter is, or rather when we don't know what the transmitter is, we've identified something, an unknown point source, and we can typically correlate it to some geographic area and identify the general geographic area of what those are depending on essentially the constellation of sensors.

Another interesting point here is in the lower right-hand corner you see the waterfall chart. This is a graphical output of the raw data. Now, we store the raw data. And for our interests and our customers, they're primarily interested in just is the channel -- is there energy in the band or not? But we actually store all of the data.

Now, our focus is on the sensor, we're at

very low cost sensors and data collection and data storage. And not necessarily on sophisticated analysis of the data. And for that reason, that's

the exact reason why we surface all of that data to our users through an API so that they can either download the data in bulk and crunch it on their own workstations or work with us to integrate some algorithms on the server side and we can crunch it for them. And that's what I would like to talk to you about at the demo.

There are a couple of other slides here, but they're really more relevant to whitespaces. So I'll go ahead and end it here and answer any questions you may have.

MR. TENHULA: We don't have time for any questions unless one of the fellow panelists would like to quiz Jesse on anything or we can hold questions until the the end.

PARTICIPANT: We have one interruption. We lost the video for the webcasting. We just need to reboot it. It will just take a minute, but we need to stop for a minute for them to do it so that

it doesn't interfere with the slides.

MR. TENHULA: Okay.

PARTICIPANT: So I asked them to do it between speakers. So, Mike, if you don't mind.

MR. COTTON: Uh-huh.

(Pause to reboot the system.)

MR. TENHULA: In the meantime, for a bonus, for all of you who have taken the time and effort to be here, any questions for Jesse real

quick?

PARTICIPANT: Just curious, what are the general frequencies that you've been covering with your monitoring so far?

MR. CAULFIELD: That's a good question. So we've been monitoring to date, 50 to -- 50 megahertz -- I'm sorry, 50 kilohertz to 2.5 gig. And that's -- I can go into it later in the session, but what we've really focused on is low-cost sensors and essentially the economic threshold that we found was below 3 gigahertz the sensors are fairly affordable and we found a really great partner to manufacture those for us. We do support -- so we do support

bring your own device. You know, our client and our database is essentially spectrum agnostic. It can store the data in however much data you want to put into it.

But from our collection perspective that's the sensor that we've felt so far or that we've been using.

MR. SUBRAMANIAN: What's the coverage of sensors? How much coverage does it have how many sensors?

MR. CAULFIELD: It's propagation. It depends on --

So the question was, what's the coverage area? What's the use of a coverage area of a sensor? And it's really propagation.

MR. SUBRAMANIAN: How many sensors is it?

MR. CAULFIELD: Sorry?

MR. SUBRAMANIAN: How many sensors --

MR. CAULFIELD: The sensors right now are at customer locations. We operate a three node network here in the Washington, D.C. network as a demo network.

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MR. TENHULA: Okay. We're going to move on to Mike Cotton. For those online, we appreciate your patience. We had to reboot the system, but we are back up. Unfortunately the camera is not working right now. But I think you can see the slides. I hope you can see the slides. So there's about 15 or so online. So welcome you to our continuation of our panel. And next will be Mike Cotton.

MR. COTTON: Hi, I'm here to talk about NTIA's spectrum monitoring project that we're just about to give up here. You know, we're really excited about the project. We're hoping that will contribute in all the focus areas that we're going to work on over the course of today.

So, just a quick outline. I want to talk about sort of our current mode of operation in terms of how we make spectrum measurements. And then I want to -- you know, that's kind of a situation or a system that works for us right now. For everything that we look to do and then I want to talk about sort of catalyst for change and why we're moving in the

direction we are with this new project that came in

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the form of a budget initiative that didn't get passed in the last budget, but NTIA leadership has decided to put some money towards this project this fiscal year.

So ITS' current mode of operation, you know, we've been doing these spectrum measurements for a long time, really since the 1970s. We started out focusing on federal agencies that were acquiring LMAR bands quickly and people asked us to kind of keep them honest on whether or not they were using them or not.

So, since the 1970s we've had this program that's called the radio spectrum measurement system program and we've developed a whole suite of capabilities and hardware setups to basically go out and do broadband spectrum surveys from 100 megahertz up to 20 gigahertz. So we'll load up this van with the measurement equipment that's shown in the upper right-hand corner and we'll set out and do a band by band sweep where detections, schemes, antennas, preselected designs are all set up optimally for the services that we're measuring each band.

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Okay. So this is obviously overdone for

today's thing. But I just wanted to mention that this is something that we roll out and it suits all of our needs. It's big, it's expensive, but, you know, we're kind of recognizing that it's a little bit overdone. So recently we've been putting more focus on sort of more streamlined systems where we go out and focus on particular bands. Like last year we worked on characterizing that 1.8 gigahertz band. The year before that we made an effort to go out and characterize the 3.6 gigahertz band. And, you know, this work, we do, do a lot of the -- we do have the mathematicians and the physicists to kind of come together and do a lot of the theoretical framework development that's needed to be done in these areas. And, so we do take a little bit of time.

I guess my point is, there is a latency -- significant latency in our mode of operation now where we make the measurements. An engineer gets the data, processes it, writes it up, and at a minimum it's like a six-month delay for data. So that's one of the big things that we're trying to change with

this new project that we're basically trying to automate all that and pump out the data to users on a more shorter timeline.

So the catalyst for change, as I mentioned, Tom mentioned this earlier today too, there was a Congressional budget initiative from NTIA that made it all the way to the last budget vote and

didn't make it in there. It was for two years, 7.5 million. But we turned it around. We do have funding this year for a million and a half. It started two weeks ago. So we had six months to work that project and make as much progress as we can.

Again, we're really excited about that.

So one of the things that came out on the budget initiative plan is that we put out an NOI in August and, you know, we've had a lot of feedback from panelists here on the table so it establishes some context.

I'm going to just leave this as items on the slide for people to look at. But basically there are objectives to monitor spectrum real time and make that data available. And then basically after two

years assess whether or not we want to have that as a long-term plan. So there's going to be kind of a strategic decisionmaking process about what this project can provide for us.

Now, this venue here, I mean, this is a great turnout. I'm really excited to just see what kind of feedback we get from the people in this room. We also had a whole number of collaboration tasks on here. The plan is, is to allow for other sensors to put data into the database just like Jesse mentioned, and also have an API in the output so people can take that data and get to it.

But we're going to take some care and make

sure that a lot of the sensitive spectrum issues are taken care of so only authorized people can take a look at that.

So the basic development tasks that were put out in the NOI were develop a centralized database, develop prototype sensors to measure particular spectrum bands, particular bands, and to establish a network of ten sensors in ten metropolitan areas to collect data. So that's to be

done in about ten years.

In that NOI really there weren't a lot of specifics, so once we decided to actually pull off this project, we had to kind of make some decisions about how we were going to narrow the scope in order to implement to get real practical deliverables at the end of this year.

So this is the project plan that we came up with. This is how we kind of narrowed the scope. I mean, the first thing, and that's the biggest thing, is that we need to focus on is the quicker output of the data. So we're going to design this database. I should actually take a second to mention that we have a new collaboration with NISS, the information technology laboratory which has been great. I mean, we're very much on the RF side of things, so we're developing the database, we're really going to lean on these guys to help us out and develop that part of this project with best practice.

So it's been a very nice collaboration so far even though it's only been for a short time.

The other thing -- significant thing that

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we need to do is we need to basically replace that $80,000 center piece of our measuring system, that's the one single box, with one of these CoT Sensors that we're going to move next door to take a look at during the break.

So, for us, you know, we understand that at we -- you know, we've been working with the spectrum analyzer for 35 years and we really know that system. We know the dynamic ranges, we know how to move that up and down to measure certain levels whether it's low levels or high levels. And so we really need to understand and evaluate those boxes. And just for the procurement process, the government procurements process, we need a matrix of capabilities versus costs to say, okay, we need this type of sensor for this application. We need to buy ten of them, so these three are best, here's the lowest cost, procure. So that's what we're going to do for our second item.

Then we're going to design prototypes this year for radar spectrum and also for LTE. Just we think that those are going to involve COTS sensors

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from two different price points, and so we're going to develop those two price point COTS sensors into our system.

And finally, we're just going to go for end-to-end functionality where the sensor is pushing data to the database and is making available to authorized users.

This is basically what it's going to look like. The sensors are out in the field, and come in over the IP network, they're ingested into the database and made available to authorized users.

MR. TENHULA: You're going to have to wrap up.

MR. COTTON: Okay. So we have just initial thoughts. That was for fiscal year '14. I think those were ambitious points. The thoughts for fiscal year '15 are the ten sensors that we would like to deploy are sensors to monitor 3.6 gigahertz spanned along the East and West Coast and the Gulf Coast.

And that's my contact info and references.

MR. TENHULA: All right. Thank you.

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We're going to move on to Anoop.

MR. GUPTA: Hi. My name is Anoop Gupta. I lead the technology policy group for Microsoft.

One of the projects coming out of my group is the Microsoft Spectrum Observatory. That goal to have this project is to collect data and disseminate

it for spectrum data and disseminate it to various parties that include researchers, academics, government, and industry as well.

The goal is that -- the reason we have this goal is that we feel that the more data people have to base their decisions on the more likely -- the better those decisions will be. And by making sure that all the data is publicly available it also allows some discourse on most all those parts.

This here is a snapshot of just what we have in place today. The site is wide, it's been wide for about a year and a half, two years. And we have -- in the past we were running stations ourselves and we had about four -- four wide. We currently have a few more and our -- actually have this, the robots spectrum R efficient, so it's not

just U.S. based, but international as well.

In the past year we have been working on lowering the cost of our solution so that way we could get more and more of these stations up around the world. We recently got the support for stations that we can basically roll out for $105,000 apiece. This includes using lower-cost system RF sensors like RFI and USRP Radios. And you will see both of those in the demonstration over here.

And we've got a mobile solution using USRP stations as well.

The architecture of the system is similar

to one that has been talked about by these two gentlemen on my right here. The idea is that we have basically a PC attached to an RF sensor that has network -- Internet access as well. We constantly monitor the spectrum hardware from 50 megahertz all the way up to 60 megahertz today. The type of hardware that we have in there, we're open to pretty much any kind of hardware, but we currently support USRP Radios and RFI.

There's also -- by having a PC attached to

these RF sensors, there's also the ability to do a lot of a preprocessing on the data before we upload it. One of the key issues that we have with the solutions that we've come up with in the past is that there's a limit to how much data we can upload to a central repository. Right now we upload about one minute level data so you can estimate an average without a (off mic) granularity. In the future we would like to go to about 5 degree second data, but that will start to push the amount of throughput that we have to the PCs.

You also have to remember some of the PCs we're talking about are located in places like Africa where the Internet connectivity is not as good as it is in other countries.

One of our co-events has been around the openness and collaboration. As part of this, as of today, we went totally open source. All the source

code, including our portal and our RF sensor scanning code, is available under Apache. So it's open for anyone to see at this point. And we're welcoming collaborators.

What can this be used for? Some of the comments to what this can be used for, Jesse kind of pointed to some uses that he's been going down the path with. But we're open to other types of uses. We've been working with academics at MIT, University of Washington, UCSB and Rice and we're starting abroad and actually look for more partners in that space. We're also looking for partners in regulatory -- regulatory interface as well as industry. So it's not as though we want to go this alone and that we're looking for one specific use case out of this. The goal was to make this something that can be reused for the various different potential solutions.

This is an example, DSA would be one. Jesse actually pointed to this. This solution is going down this path a little bit more in terms of having kind of a database that actually gives you more feedback than just a propagation model would and be able to do more than we would have to --

MR. TENHULA: All right. We actually have some time if the fellow panelists would like to ask Anoop about his presentation or any questions first

I'll open that up. And then anybody in the audience questions for Anoop while we have his slides coupled. Anybody?

(No response.)

MR. TENHULA: Okay. That will give us more time at the end. We're going to move on to Dennis Roberson.

MR. ROBERSON: Good morning. I decided to add a little energy into this (off mic) as well as by standing up. I'll be sharing with you really a few family pictures. This is at least sort of how I view this. We've been at this for a good long time.

How many of you are already familiar with IIT's spectrum observatory.

(Showing of hands.)

MR. ROBERSON: Okay. Then we don't need the presentation.

(Laughter.)

MR. ROBERSON: We'll just enjoy the family pictures. Can you hear me in the back?

(Chorus of no.)

MR. ROBERSON: No. So this --

Okay. Good, so onward.

This is the backdrop of our spectrum observatory. Some years ago we actually coined this term, "Spectrum Observatory". I always favored

"listening post" but somehow --

(Laughter.)

MR. ROBERSON: -- we ended up with spectrum observatory. The initial spectrum observatory is on the top of a 22-story building on the campus of Illinois Institute of Technology. And this is what you see, the skyline of Chicago and that was our focus for the spectrum observatory. It gave us a great opportunity, unobstructed view of that environment.

What we'll talk about today is a little bit of the history, to observations, our current work and why it's important. The project history, again, so many of you are familiar with what we've done. I won't spend very much time on this, but we did start out in 2007, this is National Science Foundation funded program from the get-go and right through. So it's been a terrific thank you and a great

opportunity to talk about it in this building. Our partner who is Shared Spectrum Corporation. They had done a lot of snapshot studies and really gave us an enormous helping hand in getting started. We jumped in at the 30 megahertz to six gigahertz, you, we felt that was the relevant and important spectrum, so that was the area that we focused on. And you can see some of the -- again, family pictures of folks doing the work, setting things up in our location. But this has been a significant effort for that period of

time. And actually we've collected data throughout.
The important part, we quickly found, though, was that one nice solution was not appropriate. One size does not fit all. So we started expanding into different realms and collecting different sensors, the Rockwell Collins sensor, let's see, RFI, CRFS, have become a partner with this. USRPs are also a key component of the system as already has been mentioned is these parts. All of the providers are here, I think. So you'll have an opportunity to see some of the things that are done. At multiple sites, as we've moved, not just

multiple sensors with multiple ranges, folks have got specific things like LR systems, but also multiple sites and this is continuing to evolve.
These are the basic sensors and the kinds of things, the waterfall charts, and getting down to details. This is one of our showoff pictures -- well, this one was a 3 kilohertz, but we carried on down to even finer resolution bandwidths, you see the size resistance there.
Some of the locations, the top of the tower, running for seven years. The harbor point on the east side of Chicago running for a couple of years now. And then a shout out to Motorola who have lent us their lab on wheels that we've taken many snapshot studies around Chicago so that we can take a look in our last run, north, east, south, west of

Chicago.

The observations -- this is where the family pictures really come in and this is also where the caveats come in. Somehow this is -- we've got some funny things here, but this is particularly for Preston.

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When we are doing spectrum occupancy, this is energy detection. We establish a noise threshold, whatever is above that threshold. There's something there, if it's below the threshold it's not there. The caveats which -- some of which disappeared below the screen. Low power signals, you often don't see distant signals, shadowing, all sorts of things that come in that can limit what you're actually seeing. So sometimes when we talk about the 10 percent or 20 percent occupancy people go crazy, and they should, because there are things that we don't necessarily see, and that's why we use so many sensors.

Family pictures, the transition for visual television, the opportunity to see things like the movement of this. We can see it highlighted, the 700 megahertz. The video that some number of you have probably seen our U-Tube video. It shows the transition over a period of three years or 700 megahertz, the opportunity to see things both with consistent usage over time and the special usages in holiday seasons.

One of our favorite pictures, the Chicago

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snow storm in 2011 where you can see the change in usage for LMR versus the commercial users and the highlight of the opportunity to share spectrum in specific areas.

Current work, a number of studies that are going on, observation studies, that is a radar, one that we're doing together with my colleague who will be speaking next and across the world.

And then the key importance of all of this, we've already spoken to this from the other groups --spectrum sharing. But the whole second item is this opportunity to see human activity, use in policymaking operations, and an interference in enforcement that we'll be talking about.

That's it.

MR. TENHULA: Thank you, Dennis.

All right. We're going to move on to some international flavor. And Marja.

MS. MATINMIKKO: Good morning, everybody. I'm Marja Matinmikko and I come from Finland research center in Finland.

I am really happy to be here and I'm

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thankful for the invitation.

I already this morning learned a lot about U.S. situation.

A situation (off mic) number of countries, we have a lot of neighboring countries, so the situation is more complicated than here. But I'm very happy to see that there's a lot of (off mic) . I think in Europe we can learn a lot from what is happening here.

So we can expect to (off mic) measurement. U.S. collaboration program. We also have spectrum measurement ongoing in Finland.

And in Europe, the European workshop in January we can expect (off mic) measurements. And there they expressed quite cautious view about how spectrum occupies the measurements could help regulators. And we have to know that these measurements could be used for multiple purposes. And I think the idea of the workshop and the regulators was to focus on how measurements can help regulators. (Accent and off microphone).

There are also other applications

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So now you will find the presentations of the workshop in the web, so you can go and check the Europeans' work.

Message from European regulators there is no problem in making(off mic)

(Coughing)....

MS. MATINMIKKO: So this is a kind of summary of what is happening in Europe. I think there will be some kind of follow up for this

workshop, but I don't know about the details yet, what would happen after this.

Then other things about spectrum sharing. So there are a lot of activities unrolling on spectrum sharing models and methodologies all over the world. The U.S. approaches (off mic) but also in Europe there are many (off mic) categories for spectrum sharing. Collective use of spectrum (off mic) and then the other one is LSA and the license which is now promoted by the European Commission. They (off mic) before that came out last year. And the idea in this LSA approach is to allow additional authorized licensed users of bands (off mic) or where

there's some kind of incoming spectrum. So it would be a kind of controlled spectrum sharing with licensing agreements. And most proper be this kind of (off mic) use of databases.

So LSA is a kind of hot topic right now in Europe, in research, in regulations . They have already started to study this. They have (off mic) about this LSA. It is now coming out of the system about how to use LSA concept specifically in the two to three -- two to four band. (off mic) communication networks to share with other incumbent.

But Europe is a quite complicated place. We all have national regulators that decide what systems are to be used, the different bands. For example, the two to three, two to four band incumbent

uses quite different than other country. In Finland we have PMSE servers, cameras, but in other European countries other places there are different users. So it's a kind of some kind of harmonized tool because the market size 100 Euros is still quite more, so we need some kind of harmonization at some level.

So here is a picture of LSA. For example,

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of LSA, case of LSA where a whole lot of operators who share spectrum with incumbents and PMSE systems.

And in Finland we have (off mic) we made the world's first (off mic)

And later this week we will show the (off mic).

So the basic idea here is that there is a need for some additional mechanisms, some kind of database where you have information about the (off mic) that could be used on a shared basis.

And then there needs to be some kind of controller unit for the mobile operators to entrust their -- reconfigure their network to operate according to this

But we will show them it's doable. But, office, it depends a lot upon what the incumbents and then how to protect their system that's an open question. It's not easy.

So some final remarks. Regulators, they have (off mic) about what spectrum (off mic) spectrum access.

Then question for me to specifically is

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looking to in our research when I do this LSA, they share it now. It's the hope (off mic) in Europe. And then the question is how the spectrum measurements could help when this kind of flies into the sharing. Did you have the same question here when you were -- how spectrum measurement could help in this sharing.

And I think that's an open question and in Europe so far it has not been discussed. There are a lot of opportunities for that. For example, the interference considerations, how to divide the (off mic) for sharing, how to protect the act. The LSA reported it starts with the principle that you have protect the incumbents that are there and then you allow additional users who are also protected to some degree. So it's the Spectrum measurements that will help there. Be more than happy to get that on board.

MR. TENHULA: All right, thank you. That's great. We don't have any time for particular questions on this, but I'm sure we definitely will come back to it. And I'll turn now to Georg.

MR. SCHONE: I think I will be also

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standing up. It's easier.

MR. TENHULA: Grab this. We call it the Phil Donahue mike.

(Laughter.)

MR. SCHONE: So I hope everyone can hear me. But this model looked better to me to speed it up a little bit.

Chairman, ladies and gentlemen, thank you very much. My name is George Schone and I'm coming from LS telecom Europe dealing with spectrum management since quite some years. And I was asked to give a little bit of an idea about the results of business model behind databases and that is really a questionable thing. And I will now --

Just to give you the first idea about it, I made some snapshots from the whitespace database and you can see here with low population density, low communication density, you will find many available channels for infrastructure for low power sites, much easier there and you can use the whitespace. The question is, allowed to use whitespace there?

If you go more in a place with more

population density and quite some communications, not too much, but still you see only a few channels available. And if we frame our --

(Simultaneous conversation.)

MR. SCHONE: -- visit downtown, you see I have more or less nothing available and I still have to share with all the other plan users. And I am

always behind the ones who are in a higher level like you just tell me, a three-layer approach. And the whitespace devices on the lowest level, they are more or less (inaudible). So it's really questionable where this will at the end work out for (inaudible). There are some quite proper trials, but we have to understand we are currently in a scenario where we only have a few stations running. Here try, there try, they're a little bit of a network. But, that is not what we have, for example, in WiFi where we really have massive communication and it's very questionable. And therefore --

To give you a little bit of an idea about what are the differences now between what we have in U.S. versus the U.K. where the U.K. regulator are

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just now also starting a whitespace project, you see, you have on one hand the external communication we are talking about and you see here in different steps of what such a whitespace database has to perform and while in U.S. where is this approach of the database has been moved everything on its own and has to collect the data from the FCC, from the neighbor countries from the LDOPS operators. This is not the same for the U.K. In U.K. all this is delivered from the OPCOM. It sounds easy and it sounds as if it's good for a much more direct scenario. If we have a look here to a device communication there we see we have more or less everywhere the same here gray, all

this shows we have differences from any happening. And the difference happens in the propagation calculation in the analysis of scenarios. And there the U.K. model is far more complex than the U.S. model at least in the few of the (inaudible) environment where it is more precise. It is really approach taking into account the range building effects and so on. On the other hand, triangulation, it's massive vector of ten, it might be even more.

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On the other hand, they are not doing calculation so often. The U.S. is having an update frequency of 15 minutes for EMSD for LDOPs devices while the U.K. gets free hours. So the U.K. put a U.S. model will be much faster in reaction on the (inaudible) in very densely populated areas. We still have the hope, but for the U.K. model it might be identified more real whitespaces. But this will only show up once this model is rated

We have now to see how the future turns out. There are different models on the way. And the models will prove to be successful. But we have questions about a business model.

Thank you.

MR. TENHULA: Great. And I'd like to kind of start the questioning off. We've got about 20 minutes for questions before we get to lunch and the demos.

The one that springs to mind presentation

they're often cost driven. What are the costs? And you mentioned trying to get the costs down to below $5,000 per unit. And Mike mentioned we're starting

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at a baseline of about 80,000 per unit right now. And don't think Jesse mentioned the cost issue (off mic) and I've talked about it depends on the range of costs.

Let me ask kind of the first four presenters kind of how you see the tradeoffs between the costs of a sensing device, you know, and then it's networking components and feed it into the network, you know whether backend database or for the front end display, but also the -- how this, you know, the end unit, the cost of that end unit drives these things and how that potentially might present a dilemma for the traditional spectrum analyzer technology, some of which are demonstrating, I think, at lunch as well, that, you know, typically sell very expensive boxes. And they're very complex boxes. Can you get us just quickly to summarize where there's tradeoffs and kind of what we see as the kind of key cost target points?

MR. CAULFIELD: We did a bit of research on this early on, so I'll take a stab at it.

What we found is that there's --

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essentially there's debt function at about three gigahertz. Now, this is a little -- maybe the data is about a year old, so it may be a little bit out of date. But, we found that sensors and detectors below three gigahertz tend to range between two and five times less than sensors and detectors that can range above three gigahertz about. There's also a difference in antenna kits. Two antenna kits are not compatible. So you can get a wideband antenna kit with relatively flat gain that can go up to two and a half to three gigahertz. But you can't get one -- but you need an entirely separate antenna kit to detect above that. So your antenna kit gets more expensive if you're doing significant wideband detection. So, from our product development perspective, we essentially cut it off at three gigahertz and developed out own internal product because we needed a sensor that went up to three gigahertz. Now, there's another economic threshold which is what are you trying to measure, how much are you trying to measure. And from what we found was if you're actually trying to peak into the signal, you

pay for that capability.

If you're simply trying to make an accurate measurement of energy, you can save a lot of money if that's what you're looking for. So if you draw back and you sort of, I guess, place some parameters or some boundaries on the amount of

information that you actually need to collect, you can save a lot of money on the unit cost of the device. And then what we tried to do is to make up that functionality in software. So to varying degrees of success, but those are the principle economic thresholds that we found was a two to five X increase in cost when you cross that threshold and then a completely separate ... The $5,000 range, that's about accurate. We are looking at about $5,000 installed. So, you know, take that into -- you take that into account.

We have a completely different model though, however. We don't sell the actual devices. We sell the data. So, we lease the data, or rather we lease access to the data and we run the devices. So that was the marketing, the cloud slide that I

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went over with you.

MR. COTTON: Our initial investigations really have found that those CoT sensor fall into more or less four tiers. There's the laboratory tier, that's greater than 50 gigs. There's a midlevel tier that's somewhere from 10 to 30; then there's a low-cost tier and an ultra-low-cost tier that has to do -- that utilizes a lot of these programmable chip sets.

And just like any product out there, I think that there's a correlation between costs and RF performance metrics.

Now, you know, we recognize that a lot of the programmability that's offered in the lost cost sensors can be used to basically enable some of the capability that comes in the box of the high-end sensors. And that's really what we're going to start working towards is really trying to utilize some of the programmability of those boxes.

That being said, there are some very important RF metrics that need to be characterized, one of which is the dynamic range of these ...

dynamic range. And that basically gives you the window to measure in. And the 3.6 gigahertz scenario, for example, these transmitters are a million watts of power. So you can't just stick some limited range --limited dynamic range in there, but you're going to smoke it.

(Laughter.)

MR. COTTON: I mean, we brought in the $80,000 box that we used out there and we cut it off in frequency so that it was only coming in to the co-channel band. We still had overloads, measured overloads on there about a dozen times over the course of about two weeks. So that's in taking good care with a high-end box, we still encountered overloads. So it's important to keep track of those measurements.

MR. GUPTA: I think one thing you're going to see over time is that the price of the RF sensors

is going to drop as, one, you get more volume out of them and, two, like technology improves. But one of our goals is eventually to have like a sub-$1,000 scenario where we can enable it. And one of the big

reasons and drivers behind that is that if you start looking above the 3.5 gigahertz range, you're starting to look at point to point communications and number of sensors that you would need and number of antennas that you would need to actually be able to measure say by five years range is one every 15 years.

So in order to do a measurement in an area like say, you know, take Tysons Corner, you may have to actually set up an entire network, measure for a period of a month, do some analysis on it and then take that same investment in hardware and move it to someplace else and do that same measurement unless you would want to actually have that there permanently ...

Then there's also the additional cost of the actual database hosting where you're talking about a lot of data if you're talking about the raw data going up to these databases. So someone's got to pay for that and so you have to have an investment there. And I'm sure that Mike's looking at it right now in terms of what that's does entail or include in

our picture.

I've got something called Azure in my back pocket. I think Mike mentioned that the last time we had a call. It's a nice thing to have, but it doesn't solve everything. So you've got to look at the various components of the costs.

The general laborer, the basic hardware, like the antenna, the cabling, those things aren't going to change. It's the RF sensor and basically the storage.

MR. ROBERSON: Actually, it's an extremely complex question that you asked. As I'm sitting here thinking about it, the sensor itself, at that level, we have $11 sensors. And we have $80,000 sensors. We have antenna systems that are $175 that do go to six gigahertz but they're omnidirectional and they're not entirely even. And we have boxes that are very specifically tuned to both directionally and to a specific bandwidth. So the tricky part of this whole question is, what is it that you want to see? Are you interested in seeing broadband? Are you interested in seeing time discrete elements like when

we do our work with the folks in the public safety arena with land mobile radio? If you want to see discrete activity levels you have to be scanning at a very, very fast rate. So there's always a trade-off

of do I want to spend a minute going through the whole cycle or do I need to be there in subsecond timeframe to be able to see discrete activity.

The other key element is this whole business once you get through the sensors and the filters on the front end and mask those high wattage kinds of outputs like FM radio or television or those kinds of things, once you've gotten through that side then you have the whole cost of installation. I painfully discovered actually as we worked with Microsoft to help put their first system up that in some places like downtown Seattle it costs $500 a month to put anything on the roof, and it doesn't matter what it is. This is a little sensor. You know, we're not broadcasting, it's not a television tower. Okay. We'll cut it to $400.

(Laughter.)

MR. ROBERSON: But, you know, there's a

significant cost associated with just roof rights on many buildings. And then finally you would get into the network infrastructure. When you're dealing with -- we do not have the luxury of having a (off mic) behind us. We actually -- we have a 100 terabyte system, but it's a specific installation. When you're connecting to the Internet we discovered that to be able to afford access we needed a ten gigabit link from our 100 terabyte system into the Internet. And that is not cheap either. So there are so many

different elements that you have to deal with and so much that you need to think about based on what you're really trying to see. And there's so much -- so many difficulties that have been created by people making declarative statements about what they're observing when really you're seeing one thing when somebody else wants to see something else. I made those caveats in the slide, half of which disappeared. You really have to consider that.

I think for the comments that Marja made with the European group that was looking at this, this was one of their big concerns that when people

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came forward and talked about what they were doing in the spectrum space it wasn't clear to the regulators that they would be able to derive the value because of the very specific things that they wanted to see in specific bands. So it's, again, a very complicated question with a lot of --

MR. TENHULA: That's why we're here. That's why we're having everybody help with these issues and how they address the policy-related questions. Now, I'm going to turn over the floor in a second.

Do you want to do the Phil Donahue approach? Do you want folks to line up at the mike to answer question -- ask questions for the last bit?

While you're doing that, and raising your hands for questions, I'll our European colleagues

about the cost question kind of a bit of what Dennis was talking about. Because in the U.S. the whitespace decision involving, you know, the database approach versus sensing approach, a lot was hinged upon, in my opinion, unsubstantiated allegations of costs involving the sensing approach while there was

no quite indication of what the incremental cost of the database approach would be either for such devices.

So did the cost element -- has the cost element been integrated into the policy discussion as well within the U.K. and Europe generally about sensing? Is that one of the reasons it may have some cold feet about it?

MR. SCHONE: I think for regulators Europe (off mic) too much really about the cost aspect as long as it is indicated towards the operators. And that's what we currently experience. The model which is applied is quite complex. And we will also see that the U.S. (off mic) we must not forget the databases are currently under excellent no-load. If you are talking about millions of such data, the frequency assignments for our when you are in totally different scenario and we will face when computer power necessity which is completely different from what we have currently. And that is exactly what I meant earlier when you're looking into such a (off mic) of power as could be necessary for the U.K.

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approach which will really drive costs to a new dimension.

And by the way, the U.K. regulator now has in his approach also a measurement type of -- or kind of sensor by forcing the device really to return the assigned channel which so far would be possible in the communication protocols which are fine. Also in the U.S. approach (off mic) mandatory so far at least my knowledge of it.

MS. MATINMIKKO: Cost is one issue, but that is not discussed so openly, I think, as in Europe. The other thing is that there's always the performance/cost tradeoff for when allowing sharing. (inaudible).

MR. TENHULA: Questions from the audience?

PARTICIPANT: Yes, the question for the panel, it's about granularity and what we're doing now and what you think would be possible. Dennis, you mentioned directional antennas. I'm just wondering, are we sensing the spectrum with scanning phased arrays or directional antennas that are steerable in order to get granularity in space and

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maybe fuse the data more at the sensors? So that's one question.

And then the second question is, is

technology available today in all of your measurement systems for spectrum monitoring if you were, say, looking at the Wi-Fi band or looking over a 20 megahertz channel, or today's LTD, do you have enough granularity to determine when an additional user -- just one additional user comes on -- is that too difficult to measure with the techniques today?

And then, thirdly, what -- I knot depends what you're measuring, Dennis alluded to it. There are many different factors, but what would the panelists say are one or two most important parameters or statistics that you found in characterizing spectrum usage or interference? Is it the amplitude probability distribution of raw power spectral density in a bandwidth or is it time rate of change or power level? Maybe you could give some insight into what are the one or two key technical parameters you found?

So just to summarize, directionality, are

we using it? Number two, can you detect one user additional in a wide-band spectrum with modern techniques; and third, what are the key one or two parameters?

MR. ROBERSON: No, no, and it depends.

(Laughter.)

PARTICIPANT: Good answer.

MR. GUPTA: I'd agree actually. It's pretty accurate. If you're talking about one user,

unless you're constantly monitoring that and you've got the right number of sensors in a given area, I don't think it will do that. If you start going down that path and saying, okay, got three sensors in an area or two sensors in an area, and then I've got -- I'm constantly monitoring a specific area spectrum what's coming out in IT recently, they can actually sense when a person is breathing. You can sense a person's breathing, when they stop breathing, you can basically sense an LTD.

MR. CAULFIELD: I noticed that you guys are using discounts. We use also an omnidirectional antenna and mostly because of the geographic

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diversity you need to be in front of the beam for those higher frequencies. We don't look for single users. We have in FDM networks. So, for example, one fun thing to do is to watch Dulles tower and Dulles ground you can know -- you can tell when new planes are coming in simply by watching the charts. You can see that in FDM, but that's a completely different scenario.

In (off mic) environment, that's not something that we're looking for. The sensors that our system uses don't peak into the signal like that. It's certainly possible to identify that if you are going to do some basic demod, you're going to do some channel surfing that way.

From a statistics perspective, our folks

want to know, is the band suitable for use? If it's unlicensed and it's occupied, how occupied is it? And if it's unlicensed or rather available, are there unlicensed devices in the band, or even not in the band, but located nearby that could potentially enter into the band? And then on the flip side, are there transient licensed users that have incurred into the

band to block it?

So our folks are using this more for sort of gross occupancy as opposed to the fine-tune -- fine-tuned occupancy rates.

MR. COTTON: We more or less use omnidirectional antennas and just take in what we can from the environment across the whole thing. In time, I think, yeah, we can -- there are sampling devices where you can pick out -- heck, I could pick up really thin pulses from a radar pulse. So you can schemes these things however you want to do it. It's just a matter of how you do the signal processing.

I think in terms of the statistics that's really complicated and I think that's why we're dividing up into three groups here because I think the statistics are different for whatever you want to do. For instance, for the policy group, you know, I would imagine that Tom Power would like to be able to sit at his computer and point a button and get a report -- a bandout sensor report over like a year's worth of information underlocked to identify

underutilized band of some kind. You know, and he

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might be able to bring that meeting and they'll say, well, that's last year's stuff. Next year is going to be different. I mean, he can pull out another, you know, long-term statistics are important. And its band occupancy really is that really important measurement.

APBs, I mean, when you start talking about coordinating spectrum usage, then you're talking about much more -- detail on a much finer timeline and much more recent type of usage. APBs, you know, give you the distributions of what you measured. I think it's more of, you know, percentage of usages across the band that you really want to take a look at.

MR. TENHULA: All right. We have time for one quick question. Wendy?

PARTICIPANT: Phil Dorka. My question is, are any of you considering using airborne sensors? And if so, what do you see as some advantages and the challenges?

MR. SCHONE: It always depends on the case of what you want to do. An airborne sensor can have

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enormous advantages when you, for example, want to

measure a satellite beam because normally you are not able to depict the uplink. If you're at the uplink you are able to identify it. It's also interesting, for example to get the propagation characteristics off a tower that we choose normally would have find the problem. But what is useful in every case one is very doubtful, it is more appropriate if you have comparable load on time because the aircraft or you have to bring in new electricity, whatever. So it's also a time question.

MR. TENHULA: Anybody else?

MR. ROBERSON: Sure. The airplane question was actually one that we were discussing on Friday, Mark Gibson was here and Mark McHenry and several others are owners of airplanes and love to have the opportunity to do this. And for me, having colleagues in Dartmouth here and in NSF, I would be delighted on behalf of Illinois Student Technology to be in receipt of an airplane so that we can do these --

(Laughter.)

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MR. ROBERSON: Because they have enormous value and being more serious. There is huge value in having the unobstructed view of the spectral range. But you actually need all of these different precepts. You need individual sensors. I don't know if 50 meters or, you know, but some places, yes, you need them very, very tightly located. You do need

beam forming for Ted's point. You do need our tall buildings, you do need long-term, you do need short-term.

What is critical with all of these different techniques and different observation platforms and a huge research topic is the fusion of the data. Because that's in the end what you need. You -- it's like the blind children and the elephant and the different perspectives of what an elephant is based on where you happen to be standing next to the elephant. But the key is bringing them all together and being able to make sense out of all these measurements.

But back to the question, the airborne aspect is a critical component to the collage that

you need to bring together to really understand the spectrum usage.

MR. TENHULA: All right. Our time is up and we're going to continue all these discussions and great questions at lunch and in the breakout groups. And I appreciate this overview from the panel. That was very good and please join me in thanking the panel.

(Applause.)

(Whereupon, at 12:03 pm

A F T E R N O O N S E S S I O N

(4:20 p.m.)

MR. ROBERSON: Well, good afternoon, you have survived to the final session. Count yourself fortunate.

(Laughter.)

MR. ROBERSON: Actually, I really appreciate everyone's contributions through the day.

It's been already a great day. At least we can hope it has been for you as well. Our challenge for the final hurrah of our session today is to bring together the working groups that have labored so intensively over the last couple of hours and come up with actionable research projects for us to move forward with and now we will try to bring those all together, first hearing summaries from each of the three working groups, and that would be for the benefit of each of the three summaries for the two groups that were not part of that organization, so that we're all on the same page, we'll accomplish that fairly quickly. And then our goal from there will be to take those actionable research proposals that have come out of the groups, put them up as a summary, solicit any that come from the group based on the fact that we're now together, you have this great proposal for the group that you were not a part of that you want to make sure that we log, and we

would like to have that log. Bring that all together and then at the end the grand finale is to try to prioritize the research proposals that have been

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submitted so that we have a quick consolidated list and some of them I've hopefully even somewhat anticipated may be cross-fertilized by the groups coming together.

So that's our path from here to the end. We will try to do this expeditiously as well because we do have an hour and a half, an event which you are all invited to participate in. You'll hear more about that. For those of you who don't know what I'm talking about right now, but there is an event to follow and we'll have that opportunity to debrief and socialize and all the rest at the end.

So, let me start out with the leaders and a quick review of the leadership. And they're arrayed before you in order. So if you're still trying to connect names with people, starting with John at this end and John at that end, that was helpful, wasn't it?

(Laughter.)

MR. ROBERSON: John Hunter at that end, John Chapin at this end. We have the groups ordered, and therefore, the first group we're focused on

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policy. The second group we're focused on enforcement. And the third group we're focused on operations and we'll have those reviews.

But let me quickly describe the backgrounds of our moderators. John Hunter is currently the Director of Spectrum Policy at T-Mobil. Prior to this effort John spent four years on a tour in government and it truly was a tour. He spent time at NTIA, at DOD, and at DEA. He is also heavily involved in clearing the AWS1 spectrum working with T-Mobil.

John has 15 years in the industry and has worked in a wide variety of engineering and leadership capacities. So he is well-versed and well-appointed to join our effort today.

Working with him as co-moderator for the policy endeavor was John -- John -- we've got too many Johns -- Howard McDonald and John -- I keep going with John. Howard McDonald --

(Laughter.)

MR. ROBERSON: Who I actually know really well for about 15 years. Joined the Defense Spectrum

Organization five years ago and he does have 20 years of experience in supporting DOD as a contractor. He is currently the branch chief for the advanced access branch responsible for evaluating emerging techniques and technologies to identify their impact on the DOD and its operations.

His current focus is on dynamic spectrum access which seems to have some value here. And that focus on policy-based spectrum management. So, again, terrific background for Howard with this group.

For Dale Hatfield, Dale has already been introduced to us today. But Dale is amazing is the general way of introducing Dale.

(Laughter.)

MR. ROBERSON: But he is senior fellow at the Sillicon Flatiron Center for Law, Technology, and Entrepreneurship and an adjunct professor at University of Colorado. But he's so many more things as you heard this morning. His involvement in all aspects of spectrum oriented and wireless in general oriented activities within the government is now

legendary. Besides all that, he's a great guy and a good friend.

Next Tom Dembrowski. Tom is a senior engineering advisor with Wiley Rain, LLP. He has been involved in the law firm for some time providing technical advice and guidance for a variety of clients. He also sits on the Commerce Spectrum Management Advisory Council along with Dale and I, and is a very, very well-written, well-spoken individual having observed this and experienced it within the context of CSMACK, but also in other areas.

Peter Stanforth is CTO and cofounder of Spectrum Bridge. He is responsible for managing intellectual property and development and all aspects of product development and operations at Spectrum Bridge. He's been involved in a number of organizations. Prior to that he was cofounder and CTO of Mesh Networks. He has been involved in a number of forums that have advanced the cause of wireless and he is currently very heavily involved in moving the whole notion of not only TV whitespace,

but the use of spectrum in an efficient and effective way.

Finally, John Chapin is a program manager at DARPA. He is well-known for his efforts around radio map and more recently his work within the context of radar. And he is moving this whole area forward. Previous to his time at DARPA, he was visiting scientist in the research laboratory for electronics at MIT. He has had numerous engagements in this whole field and in particular was the chief technology officer for Vanue in part of its inception.

So that's an abbreviated version of the backgrounds and biographies of our team. And with that, let me turn it over to our first of our working group and John and Howard, I'm not sure how you have coordinated your output, but please take over and tell us what your group covered and in particular

what your proposals for the group is to our actionable research proposals for us to pursue.

MR. HUNTER: Well, it was an interesting discussion, of course, you know, a lot of compassion

on a number of fronts. People expressed their views as to that value of monitoring the spectrum environment and how that can inform policy decisions on a number of levels.

I think, you know, I started off, you know, talking to the folks about this monitoring is more of kind of a trust type approach. And I think some of the things that are ongoing now, particularly in light that we got by proceeding, there's a number of things that are going on there that I think help inform how we would, you know, shape policy around that particular band. But I think as a group we walk away and merely trying to understand if it's actually what you're trying to solve within each particular band. Should it actually drive the overall effort as opposed to a more robust in putting up an antenna and trying to collect everything without having a good set of parameters to actually learn from as to how you set up your equipment.

So with that in mind, you know, you wanted to keep the discussion band agnostic, but I think you do have to be grounded in the fact that it's the

incumbent systems that are going to actually drive any meaningful information you're going to get out of it.

So, you know, going through the process, you know, we talked about how monitoring would inform policy, but some others felt that, you know, and I tend to agree, you know, that policy also informs the testing that goes into this. I think if we look back at the work that went into CSMACK working group studies, there was a lot of information that was put out there. And there wasn't a lot of time, I would add, to really ensure that you had enough information about the electromagnetic spectrum environment that could actually help inform the type of analysis you're putting forth; particularly in a predictive model. You know, I know there was a big debate that we had during those discussions was around clutter, introducing clutter into the model, talking about terrain, things of that nature. And where, I think monitor would have really helped that process is if you're actually collecting empirical data and you start to realize it and then compare it with the

predicted model and you see the differences, it can really inform the process.

So, yes, I think monitoring it goes hand in hand with the whole testing effort. I think it's

very important as to how you shape policy going forward. So where we kind of left it, we do have a pilot project that's underway out at ITS with Mike Cotton and team. Kind of left it, you know, we would kind of use that as a straw man for discussion and then put some framework around it through the CAC, forget the acronym there, but the Center for Advanced Communication. So kind of lettered some of the work that's going on there to kind of put some framework around it.

So, Howard.

MR. McDONALD: A little bit of what John described is framework. What we talked about was this concept of a forum. And we really didn't get to what that forum would be, the scope, the charter, who the members would be, but I think we're going to ask the Wizard SSG to discuss that concept with the forum a little more. Using the three and a half gigahertz

pileup that Mike Cotton is working on as the beginnings of some broader set of monitoring ideas, if you will, because to pile on what someone said this morning, monitoring without a context would be difficult. So you need a specific policy decision question in front of you and an analysis to help inform that policy decision and the monitoring is a piece of building that technical basis as part of the analysis to make the policy decisions.

Then the last thing is the Center for

Advanced Communications. We think that that organization should be leveraged to do the things like what are some monitoring best practices that could be shared amongst the monitoring community, if you will, with -- we use the term, certification as a four letter word for folks in the room. But some way to benchmark monitoring capabilities from the prospective of doing monitoring that has some acceptable validity too.

MR. ROBERSON: In terms of the actual proposed -- this is very good discussion. Did you have actual research proposals? I'm almost tempted

to pick up and walk around here because you guys are both looking at me, and I wanted you to look at the audience.

PARTICIPANT: Dennis, why don't you use that mike that you used before.

MR. ROBERSON: Or, I'll go sit next to Raymond.

PARTICIPANT: Here, this gives you some flexibility.

MR. ROBERSON: Yeah, then you won't have to look at me. I can also read this which is terrific.

MR. McDONALD: So research and development ideas, so without contexts for what monitoring would do that was somewhat difficult for me. We talked about some research in terms of data analytics that

say we're going to be monitoring spectrum over a long period of time, over a large geographic area. Now, how much data will that generate? So we need some additional research in the area. How do we reduce that data into something that policymakers would be able to understand .

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MR. HUNTER: Yeah, and I would just add, I think it's, you know, really trying to shape the effort if you're trying to take on too many projects, and I think you can get a lot of information coming at you without really solving what you're trying to put forward which is a framework to leveraging monitoring capability to inform policy.

You know, some of the projects we talked about were one was yours out in Chicago. We talked about the Dr. Chapin with DARPA and the radio map project. And all of those are very good efforts that have their place. But I think with respect to trying to answer a specific policy issue that you're trying to solve, we thought it would be best to focus on a single effort at this particular point in time, but then kind of ground it within the CAC to put a framework around it.

MR. ROBERSON: Okay. So that would be your -- sort of your one encapsulated recommendation and --

MR. HUNTER: Yes.

MR. ROBERSON: -- from an action

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standpoint?

MR. HUNTER: Yes, the action part there that we took away is we're going to leverage to pile it on 3.5.

MR. ROBERSON: Uh-huh.

MR. HUNTER: -- that ITS is working on. And then we'll add more structure, I think, to the overall framework as we learn more through the Centers for Advanced Communication.

MR. ROBERSON: Okay. Very good.

We'll actually -- I was going to let everyone go through, but if they're clarifying questions on what's been said, we'll do clarifying questions now, but I do want to solicit your active participant in generating the actionable research items. But if they're clarifying questions, this would be a good time to ask them for the policy group. Any clarifying questions?

MR. SUBRAMANIAN: One thing, did your group -- what are the key policy issues from a spectrum and the sharing spectrum perspective? They're not important while policies need to be

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established. Was that discussed and did you come up with any specific. This is what is not understood. These are the items, like, for example, standards for

example. Any policy things that you discussed that can lead to further research in this case?

MR. McDONALD: So issues that we discussed include quantifying spectrum occupancy, validating some of the propagation assumptions that went into, for example, the CSNACK studies and how could monitoring better inform and validate existing propagation capabilities. Opportunities to share in terms of quantifying the temporal and spatial aspects of spectrum use for incumbents. Unfortunately we didn't get the chance to translate those into specific action -- other than the data analytics --

MR. SUBRAMANIAN: But at least this is good. This is good. This is a good lead.

MR. ROBERSON: Good. I will point out and I would point out the obvious. We are capturing -- in front of you what we're hearing, and as you observed none of us are perfect at this. If you observed something. No, no, no, that's not really

what was meant by that last statement. Please call that out too as we go so that we'll capture this. Although we do have a complete recording of the session as well. So every word that you say will be recorded.

(Laughter.)

PARTICIPANT: I'm curious, you're bringing up propagation models -- I said, you keep bringing up propagation models. There's a number of them out

there, but a lot of those are well validated and well established. And a lot of them provide being able to ensure empirical data to refine those laws. Is that what you were discussing to do or --

MR. HUNTER: No, that was actually a very small subset of the discussion. I think -- I mean, kind of where I was going to identify the example I gave there was more -- you're absolutely right. I mean, we used well-known established models as part of the CSMACK process. But there are a number of things that you can incorporate into those models that the group just didn't have enough time to come to agreement upon. And so we highlighted the fact

that through monitoring, actually collecting some empirical data, system data, not only of the incumbent systems, but also the handsets, the UEs, that you really can see how clutter and terrain really would make an impact in the overall analysis. So that's what we were trying to highlight is this is an example where I think monitoring can inform the predictive model process.

So, and also I think on the -- you know, you were asking about the policy issues, per se. And I think Bruce Page had asked early on, was the mantra of the group to talk about how monitoring can inform policy; which is exactly right. So we focused a lot on the different types of monitoring capabilities and kind of just left it, it's really the incumbent

operations that are really going to drive some of those policy decisions. Monitoring will just inform.

MR. ROBERSON: Okay. Seeing no more hands for clarifying questions, we'll move to our second working group, or focus group rather.

MR. DEMBROWSKI: Yeah, I'm going to go first. I'll talk a little bit in sort of summary

fashion about what we discussed and then Dale will talk about the actionable items that came out.

We had a very active group. We thought at the start that everybody was going to look at us very quietly, but after the first couple questions everybody started getting rolling and it was really a very active discussion. I think the main focuses were on number one, everybody agrees that enforcement is a very important part of this. I think there's a definite -- I won't say difference of opinion, but some strong opinions about how do you handle policing for spectrum in these environments. And so number one, I think everybody believes there should be some flexibility that it doesn't need to be sort of top down managed by the federal government, there's a role for third-parties to play, there's a role for the two parties that are engaged with each other to play with one another and not involve the government in any fashion.

I think the opening questions we came about were how do you manage that. You know, what is

the federal government's role. I'm not sure we have

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the answer to that, but we certainly have some follow up questions to get to that.

I think falling into that, I think we also said, you know, we have the federal government sharing with commercial entities and how does that work? Where is the hammer? Certainly when you have a commercial agreement, it's pretty obvious how you sort of resolve disputes, you can go to court, or you can have arbitration. But when you have the federal government with a commercial entity, how will that work if both parties think they're following the agreement and have reached an agreement and then who resolves the dispute? Do you then go to NTIA and FCC jointly, or is there some other way to sort of agree in the agreement as to how you're going to mediate and figure out the agreements.

Another follow-on point we got into was intentional, malicious interference versus sort of interference, but maybe nonmalicious interference and having a hierarchy of how you manage interference resolution. So we talked about folks that are unintentionally interfering because they didn't know

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they were doing things and that's sort of one bucket

of interference first, and those that are willfully are going about interfering and having a different approach with those folks and how you would start with those who are nonmalicious interferers with a lighter touch and possibly moving through a hierarchy of worse pain, if you will, if they continue to be more malicious in their involvement and interference.

And I think the final point, at a high level summary I want to talk about was in talking about how we manage the spectrum from the software and hardware side. We had an active discussion about whether we should lock down software if you're in a shared network or not. And if you are going to lock down the software, what part of the software do you need to lock down and what would be the ramifications to the end user and/or other folks that want to use the software and modify the software. And can we actually pick out where to modify or not, which is sort of stealing some thunder from Dale because we're going to get into some actionable items based on that.

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So I think that's the top level, high-level summary and then we'll talk about sort of ideas we had with the forum.

MR. HATFIELD: The last thing we did in the group was ask for suggestions for actionable items and I'll talk about four here. That could probably be expanded some depending on how you break

things down.

I think there was pretty strong consensus that what Tom just mentioned is the software/hardware hardening issue. We seemed to get an awful lot of traction that that needs more research. And that my impression was, as I said, that was pretty unanimous, I think. So that's what Tom and I set out there, we said, let's put them in order. And that only reflects our order. But that was one of the specific research items that we talked about.

The second is going to be, I think, surprising in the true interdisciplinary fashion there is -- there's a need for some social science research.

(Laughter.)

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MR. HATFIELD: And what it is, is trying to understand better the motivations that drive people to cheat. In other words, to hack their device, or whatever. And if you understood some of those motivations better, the thought you would be in a better position to be able to figure out how to ameliorate those.

So looking then again, how can we figure out ways of motivating or demotivating people in terms of their willingness to play by the -- play by the spectrum rules. And part of this was driven by just the discretion with a lot of discussion. We felt like there wasn't really much hard information,

you know, that we all sort of had opinions. But there was not much in the way of hard data. So that was another one of our recommendation would be to undertake some sort of a research project truly interdisciplinary looking at those types of issues.

The third is one that's sort of dear to my heart is the going further in terms of the -- in the direction of crowd sourcing and particularly where devices on sort of a secondary basis are able to

gather information that can be used on the enforcement side. We have so many smart devices out there, millions of them, that have all kinds of capabilities that demonstrated to its speed test program, for example, that you can do things, crowd source or there's sort of a basis there for you to. So the idea would be that there would be some research to try to extend that idea a little bit further, put a little bit of meat around it so it could be something that the Commission then could perhaps actually implement through rules.

The fourth one -- who is it -- oh, gosh, he's copyrighted, I think, or trademarked it -- Shockey. He has this thing the answer is money, what's the question?

(Laughter.)

MR. HATFIELD: And there was discussion about, gee, we really think that monitoring can play, should play, and so forth, a really critical role.

But where is the funding? Where is the funding going to come to it?

Now, you could probably question whether

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that's really this type of recommendation you're looking for, but I think there might be an academic sort of paper that would look in other sectors the economy and so forth of how funding is done for these sorts of activities. And just to make sure that we're not overlooking some ideas, individual device fees, for example, was talked about as a possibility and so forth.

And then as part of that, or at least I lumped them together, is one way of course is getting -- you can do two things; you can get more money, or you can reduce the costs. And so part of that could also include trying to reduce the cost of doing the enforcement so that we don't have to ask for as much money and there's some sort of an appropriation in a sense.

So that was the four -- I hope -- actionable items that we came up with.

MR. ROBERSON: Great. There are questions. Okay.

The one, the only.

PARTICIPANT: Thanks, Dennis. Dale, on

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the part about the social science, did the group sort of pick somewhere on the continuum between felonious behavior and sort of children goofing around where that is, or should this social science research really look across the spectrum of hacking?

MR. HATFIELD: I'm not sure we really got that. I'm not sure we really got that far. My old college professor says that a well-defined problem is half solved. So --

(Laughter.)

MR. HATFIELD: -- the first step would be to try and define the social thing that would certainly be included. That's why I think you certainly want to include it.

MR. ROBERSON: One thing you might cover is the discretion was the example that's grown out of the school teacher.

MR. HATFIELD: Yeah. The example that -- the kind of classic example, if you will, is the school teacher who installs the cell phone jammer in the classroom. And, you know, he or she does it for very good reasons. You know, you don't want the kids

not focusing on their studies. There's no evil intent here. There's no meanness or anything, or badness in a sense. They're trying to really use something that could help not realizing, of course, that, you know, that could jam somebody else next door trying to call 911. It can jam a call coming in

or whatever. And so that seems to me, anyway, if we understood some of that better. You know, the solution to that might be just more education.

MR. HUNTER: One of the things to note too on the social science side and to Jim's question too is the other thing that was discussed was whether we should be looking in addition to how society would react to hardening up the software or hardening up the hardware. So that's the other piece of the sort of the social science experiment that we also thought would be a useful thing to look at as well. Because while we're all in a room talking about it, I actually asked a few times, I said, are we sure? This is something that the public would actually appreciate. And I think there were a few hands that raised and said, no, I don't think so. You know,

government involved in my device is not a -- something that doesn't scare a lot of people. So --

PARTICIPANT: Especially those from Idaho.

(Laughter.)

MR. HUNTER: I was going to leave that out.

(Laughter.)

MR. ROBERSON: Any other clarifying questions?

(No response.)

MR. ROBERSON: Okay. Let's move on to our third focus group.

MR. CHAPIN: I was thinking I would project this, but it seems like it's being fairly useful for the notes to be taken real time here. So I think I'll do this verbally.

MR. ROBERSON: Okay. Your choice.

MR. CHAPIN: But there is a 20-slide briefing which has been e-mailed --

(Laughter.)

MR. CHAPIN: -- to you, Dennis, and to Wendy. So I hope that you will get the additional

information out of that and not limit yourself simply to what is conveyed verbally right now.

PARTICIPANT: So we should have had a dual screen, I guess.

(Laughter.)

MR. CHAPIN: Yes. All right. The first thing, this is actually a small point, but, one that popped up a couple of times it's literally just terminology. We had some people stand up and say, there's going to be -- when we talk about implementing spectrum monitoring into flex spectrum monitoring, the word "monitoring" conveys all sorts of meanings that create a great deal of privacy and public interest concerns. And I raised my hand and said, well, we had this debate a year and a half ago related to the DARPA program. And our PR folks came back and said, call it spectrum characterization not spectrum monitoring and you will avoid that problem.

So, perhaps we as a community would like to start using that term. I will donate it.

(Laughter.)

MR. CHAPIN: If that is of interest. But

that was the first point. But it was just a small one, but perhaps significant.

MR. ROBERSON: Your government at work for you once again.

(Laughter.)

MR. CHAPIN: Okay. So our focus group we split it into three. This was work done in advance of the meeting. We split it into three subtopics and we split our group into three subgroups which met independently, came together at the last instant and provided inputs. So you will have sort of three disparate inputs that aren't truly merged together yet from our side.

One of them was a discussion of how you would use spectrum monitoring information to support a broad set of goals.

The second one, how would you implement monitoring in a cost effective and appropriate way?

And the third --

PARTICIPANT: Characterization.

MR. CHAPIN: I'm sorry. Characterization. I'm reading off my slide here.

(Laughter.)

MR. CHAPIN: Hey, the group hasn't voted yet to change the name of what we're doing.

And then the third is, how does this interact -- this process or that is capability interact with other societal priorities like privacy and security and so on?

So let's talk about each of those groups in turn. First of all the usage issue. Actually I'll turn that over to Peter. It was his group and he can speak to it more correctly.

MR. STANFORTH: What's interesting is there were some very common recurring themes that came back and forth in here, but specifically to this aspect, as the discussion got quite heated and covered quite a lot of opinions and areas, it was obvious that the challenges of defining what to measure and how to measure it were really impossible to characterize on a macro level, but we really had to look at the specific bands. But trying to decide what to measure and how to measure relative to say an airborne radar or shipboard radar in one band was

very different than it might be in another band. And then if the policies were different, then that also came to be an impact as well.

So essentially we decided if you're going

to make any real progress you're going to have to sort of divide and conquer this.

The second thing that probably characterizes a lot of the debate was around when you're monitoring there are different reasons why you might monitor. The three that were the best way to describe what we came up with were whether you're monitoring for access, for occupancy, or enforcement. Because depending on what you're looking for, or so what you're trying to do, the way that you ... what you look for would be quite different. So, again, you've got to decide, am I looking to monitor who is using it from the point of view of have I got co-existence issues with other similar users, or am I looking for an enforcement issue because somebody is using the spectrum that shouldn't be.

So, out of that came the feeling that if we did focus on a band that product output

conclusions could be got to quite effectively and very quickly.

And then the question came about and was another hot topic was in a sense of trust. You know, if believe and if we're going to monitor, what measurement, can everybody believe that this is reasonable and after a reflection of what's going on.

And as a subset of that, actually tied a little bit to ... we're talking about was this notion that if you start with the assumption that I don't

know you, therefore, I don't trust you, and therefore, I'm going to tell you very little. And if you earn my trust, then I'll tell you more and let you know more. And we can get into a lot of detail about how you might earn trust, but the notion that somebody might be more trustworthy and therefore be helped more, we get more information was one of the keys there.

And then the last piece of it was what we call data availability which again wraps back into everything else which is, if you're collecting this data, who should have access to it, who shouldn't

have access to it and the frustration is that the notion of, you know, a lot of times the data is available in one source and not another. And I won't mention names but it was, you know, brought up that the Navy won't tell us when the fleet is leaving ... the local newspaper will tell you.

(Laughter.)

MR. STANFORTH: ... I won't take credit for that, but that lot was sort of a sense of, you know, sometimes we know these things, yet we're not supposed to know. And if we're going to go and do measurements, then we're going to know more. But, you know, whether we should know in the first place or not is something that wasn't really resolved and I think comes down more to a policy issue than it does a technical issue.

MR. CHAPIN: Second subgroup was implementation. That's the one that I chaired. We focused on the following question: Which problem is critical and will not be solved without federal R&D investment?

Everybody went around the table. We had a

lot of ideas and then we grouped them together. We came up with three broad themes. The root theme is how to measure better. And there's a lot of detail in the briefing that I'll pass along to you. But if you were to put out a lot of sensors and do that in an ad hoc way and not be sure that what you're doing is useful, you end up with a lot of noisy data that doesn't help you answer your policy questions or get spectrum access or anything. You can't trust it.

So research on how to measure better. That's the root. And then to derive things that depend on what comes out of that, but could be carried out in parallel.

One is this notion of the system of monitoring systems. If we're going to scale to national/international we're going to have a lot of different systems that protect different parts of the problem. And this is the machine to machine interfaces and standards, the various kinds of things that only the government has the neutral position to help push forward to ensure that we end up with a scalable and effective solution.

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The third one that also derives from how to measure better is reducing the cost of sensors. This is a small one compared to the other two. We didn't have nearly as much support in the group for that. There were some folks who brought it forward because there's a bit of a chicken and egg problem. ... market for sensors, perhaps private industry wouldn't invest in getting them down to -- costs down to the point that you can put a lot of them out there. But that one should be taken as a small recommendation.

The big recommendation is how to measure better and the system of monitoring systems.

The third subgroup was on the interactions with other societal priorities. And John Peacock chaired that group. I will speak on his behalf.

Let me know if I get something seriously wrong here.

They saw an inherent tradeoff between spectrum efficiency and the other societal goals of privacy and security protection. Information that is the exact information you need for diam spectrum

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access at the same time can unintentionally reveal unimportant -- important information.

So the research topic here is how do you

limit that information while preserving spectrum efficiency? There are regulatory means and there are technical means of doing this. The group talked about lots of methods for obfuscation. And there are different uses of spectrum data which impose different threats. That was the focus of their discussion.

So now I'm going to go onto the concrete actionable particular recommendations. I'm going to start with the usage group. We had two here. The first is the AWS-3 auction. The observation is this is a place where some form of sharing is going to likely be needed. And users who want access may actually help deploy the sensor network and auction revenues could help fund it. So that may be a good target of opportunity to think about.

The other usage project potentially would be to deploy monitoring in a couple of verticals. And the one that we discussed a little bit was public

safety. So the goal here would be to deploy monitoring that simultaneously gives you data of high policy value, and also use it as an opportunity to improve your monitoring methods and systems.

So, for example, one of the key questions for a public safety spectrum use is the rate at which it ramps up when an emergency occurs. And if we were out there with monitoring equipment to measure those ramps and get the statistics on that, and get the

ramped down statistics and the usage statistics, that would provide a basis for more effective sharing approaches.

So those were our two usage projects that we came up with.

On implementation we have a little bit long of a list, so I won't read the whole thing. But we felt it was important to get out there early and test often and we saw on multiple opportunities that could ... substantially for federal R&D support. For example, should we deploy monitoring in the wireless test city? So in addition to being the place for testing the usage of the spectrum, could you also

take advantage of that same infrastructure for getting the monitoring test bed out there.

Another thing to consider doing would be to actually link a monitoring test bed to your dynamic sharing access test bed in a more safe environment, not in a test city where you could crash things, but in an engineering test environment which is a bit more of a controlled spectral environment and a bit safer. So two opportunities there.

The third one would be to do that linked monitoring and sharing anywhere you want, but just do it in an underutilized spectrum band like 60 gigahertz. So now you have an opportunity to play around without causing harm to folks.

On the measure better side, we talked

about a number of research ideas here. Again, I think very useful and interesting suggestions which I would encourage the chairs to look at post facto.

But in terms of what a research goal might be, if you were to create an NSF or a DARPA program in this area, one suggestion for the goal would be to be able to create a model in the computer that can

recreate or predict the statistics of the interference environment that you would measure in the real world.

Now, I think I heard this from somebody else on the table here, something very close to this. The point is that if you can build a computer system or a model that is able to -- based on some measurement inputs over time -- continually track what's going on in the real world and predict what you would see if you went out into it, then you know that you have found the final parameters that you have to measure.

Pierre DeBrees has been circulating around an idea along these lines, by the way ... I'll say that some of us have seen. It's on his blog, so anybody can read it.

In terms of -- we had a couple of smaller ones, but things that were fun. One of them was that you know that DARPA recently has the spectrum challenge. So should we have the sensing challenge?

And the winner is the person whose

technology enables identifying the usage of the

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spectrum and the holes most accurately, get some fairly complex measurement environment.

And then on the interaction side, a little bit less concrete, didn't have a chance to really sit down and talk with John and his cohorts about what would be actionable here, but the general areas that would be interesting would be to pick a realistic system that uses spectrum today and go and analyze its privacy and security needs in some detail to start providing the kinds of ground truth that we can use to generalize about the interactions between spectrum monitoring and other societal needs.

So I'll stop there.

MR. ROBERSON: Great. A lot of work. Any questions about the contents from our third group on operations?

(No response.)

MR. ROBERSON: I'm not seeing it.

All right. Now we'll move to the next phase of the process which is to engage you all in sorting through some of the actual recommendations. And now the challenge for you is to see if you can

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pull them and put them on a separate page which we'll

give you a moment to do.

PARTICIPANT: Be gentle.

MR. ROBERSON: Yeah, definitely be gentle. But this word .... But first of all, we're going to do that is in a process. First of all, those of you who were a part of the first group, the policy focus group, any comments that you would wish to add to what's already been presented by Howard and John?

They did a perfect job of representing the entire time.

MR. HUNTER: Mine has 20 slides.

MR. ROBERSON: Incredible.

(Laughter.)

MR. ROBERSON: Okay.

PARTICIPANT: Ten of them we brought in with us today.

MR. ROBERSON: No comments from the group?

(No response.)

MR. ROBERSON: The same for the second group on enforcement? Anyone from that group that would like to add comments to what has been presented

by Dale and Tom?

PARTICIPANT: Turn left.

MR. ROBERSON: Turn left. Okay. Dirk, we got it.

(No response.)

MR. ROBERSON: And he was part of the group so that actually --

(Simultaneous conversation.)
MR. ROBERSON: The third group, the operations group; any comments from members of that group, particularly John Payha, who is not paying attention, but that's okay.
(Laughter.)
MR. ROBERSON: Any comments?
(No response.)
MR. ROBERSON: Well, this is incredible. I actually thought there would be -- this would be a considerable time where there would be a lot of input.
All right. Now we'll go to the somewhat more expansive point which is the opportunity for people not in the policy group to voice your views.

Several of you have talked about needing a cloning machine because you wanted to participate in all three groups or in two, at least, of the groups. This is your opportunity to participate in the policy group for those of you who are not part of the policy group and point out the normal things like why in the world didn't you cover, fill in the blank, or whatever your particular focus is that you feel ought to be covered as part of the focus on monitoring and big data in the context of our focus and policy.
PARTICIPANT: Yes, this is an overarching comment. I didn't really hear any discussion of accuracy and I think you walked around it. But I

think that's very important for all three committees, and it's certainly context oriented. And that to me is an R&D question.

MR. HUNTER: Yeah, we actually did talk about accuracy. I think Mike illustrated that the sensor capability and some of the things that ... to the 3.5 initiative when we were measuring radar emissions. So that's going to have a very different impact whereas if you're monitoring, say disparate

systems in 1780 to 1850 ... reports. It was discussed in the group, we just didn't have that here.

MR. CHAPIN: Okay. For the policy group what I'm interested in hearing is -- well let me start a different way. Inherent in policy is debates. There is going to be a debate. There is going to be people who have different points of view and want different outcomes. The goal of the spectrum characterization would be to inform those debates. People in the debate are not happy with the direction that it's going are going to attack or challenge the spectrum characterization data that's pushing ...

So my question would be, from the policy perspective, what aspects of the spectrum characterization need to be really good to stand up to that kind of pressure? If you think about the debate that's going to happen at 1755 or ... and so

on, can you help us to understand what we need to do better on the implementation side or from the research side so that those policy debates don't just

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simply evolve into argument about what the data means?

MR. McDONALD: I'll answer that question in a macro -- ... in a micro, whatever, the idea of being best practices from the Center for Advanced Communications is a step to start addressing that. At a micro level -- we didn't talk about this, this is my own personal opinion. I think monitoring in the absence of context may drive a lot of those give and takes and arguments over what the data is actually telling you.

And, John, I'll return the favor and be -- the scenario you put forth with looking at a public safety event and the ramp up and ramp down and all that, I think it was anecdotal when it actually occurred, someone from the public safety organization said, you would have expected a ramp up on all the public safety frequencies during an event. But what may happen -- may have actually happened, is the control channels were completely saturated, so there wasn't an opportunity to fill up all those channels. So, you know just looking at data, I agree, there are

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going to be arguments over how to interpret that theory. You need to bring the context in there and the operational aspects of what that data is telling you is key to that.

MR. HUNTER: Yeah, I think just to add to that, one of the pieces we talked about is you've got to build that trust. And I think that that starts with collaboration. I think if you're out there doing monitoring, you're trying to solve a particular issue. You know, right now in some respects, I mean, there is a level of collaboration, but it's not where it needs to be in the context of trying to drive policy. So, you know, so industry just embarked on a monitor effort, you know, were we get work out the -- working with the DOD about a year ago we also characterized the UE missions in the Q4 of last year. So, you really have to get by. And I think from the incumbent operators to really make sure that you address all of the upfront parameters and assumptions that go into whatever your test plan may be. And we did some of that. Certainly I think with respect to some of the transparency of information, particularly

around the sensitive or otherwise classified systems, I think, need to be maybe in a smaller group for both sides to have a better understanding as to what you're trying to do.

MR. ROBERSON: Good.

PARTICIPANT: I just want to say a few

words.

(Simultaneous conversation.)

PARTICIPANT: I just wanted to say a few words to John's question and really it ties to the model that you were looking to develop. So, we've done some work about modeling spectrum usage in terms of random processes and in particular renewal processes. And you use that sort of set up to basically describe the spectrum usage as ones and zeros and then you can push that on to -- push the matter forward to get to actually competence intervals on the data on, for instance, a band occupancy or channel occupancy mean estimate. So I think basically what I'm saying is, when you make these measurements you can put confidence bars on there which depends on how long you're measuring for

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and how many independent samples that you have. And so I think that that sort of framework is needed to present the data.

Obviously there's a lot of assumptions that go under those mathematical models and things like that. But I think that there is a need to address that in the research as we go forward.

PARTICIPANT: (Off microphone.) from the A systems and also ... so we were having this debate in sensing for a long time and it's really nice to ... in the room ... sensing and monitoring. One of the things that we -- I mean, one thing that I ... how

can we make this a really commercial success of this whole sensing system; you know. But just the Internet ... we had some discussion in our group, I mean, just like, for example, if I put a solar panel on my house and I put the energy back into the system, the grid ... the same as I ... sensor for a $3,000 sensor on the top of my house and destroy my roof and get those ugly ... could I get this ... information and I put it back into the grid, can I get some money out of it? How can we make it a

commercial success with any house all over the U.S. and all over the word for a sensor and give us this information. So, I don't understand that on how that can be made possible and whether it's going just to ... system or is it going to be going commercial ...

MR. ROBERSON: I'm not sure whether that's a -- which one of the groups that really was?

MR. DEMBROWSKI: I'm not sure by group but I was going to say in the enforcement discussion we did talk a little bit about that sort of incentive approach. And one of the thoughts was, by having those that have used the network and ... getting whether it's a grant or some sort of incentive for either providing secondary data, noise ... measurements ... bit error rates that they're seeing on the network. And by providing that and/or identifying bad actors on the network, there could be some incentives brought that way. And that was one

way we were looking it, you know, in terms of enforcement of ways of bringing some financial payouts to folks. So we didn't -- we brought the ... but everybody decided not to is the wrong approach.

(Laughter.)

MR. DEMBROWSKI: Wrong word.

(Laughter.)

PARTICIPANT: All right. Well, I'm Joe Winfield from Argon. Hear a lot of discussion today about opening up the 3.5 gigahertz of band to share with Navy radar, sharing with commercial users, but I haven't heard very much from the Navy perspective. What I was wondering -- this sort of a policy question -- is what can be done -- I'd imagine the Navy would have some concerns about that. What could be done in terms of test analysis ... were to address this sort of ...?

PARTICIPANT: (Off microphone.)

(Laughter.)

MR. McDONALD: I'm not Navy.

PARTICIPANT: John's no longer at NTIA.

MR. McDONALD: And I wasn't involved in some of the preliminary exclusions or activities, I suspect personal opinion that monitoring may help gather the -- you know, create the technical data to revisit some of those exclusion zones in terms of

what assumptions were made and possibly reducing the size of those exclusions ... open up more spectrum, more spatial ... for other users -- other uses of 3.5 gigahertz.

PARTICIPANT: Just kind of sharing observations that's been kind of bothering me with a lot of discussions. It will never be possible to know spectrum utilization for all frequencies in all places at all times.

(Laughter.)

PARTICIPANT: A lot of the ... you get on your measurements is exactly the problem; right? And I feel like some of the discussion is, well, we don't know everything, so we can't proceed. And a perfect strike for knowledge is a prerequisite for doing any dynamic sharing or whatever you want to call. We should all pack up and go home. I'd like to see a discussion about what's good enough knowledge. And with good enough, what do you need to do in terms of revenues and verifications to get there?

But we will never know everything in all places in all times. And I don't know what the bar

is, so it's very, very hard to receive it ... have thoughts along those lines.

MR. DEMBROWSKI: I'll do real quickly on the enforcement side we did talk about along those

lines because what we were thinking about was a lot of discussion was centered around the shutting down or hardening of the software. And also, how do we make sure we're getting the bad actors when all these good actors are here. And the thought was, well, we have control of the good actors, so we can shut down the good actors, and that way we would identify the bad actors.

So there was a bit of a back and forth on that. And someone said --

PARTICIPANT: Open the doors of the prison and --

MR. DEMBROWSKI: Exactly. Exactly. You know, exactly.

(Laughter.)

MR. DEMBROWSKI: So the real back and forth was, okay, if we can at least do that, that should be good enough to at least test and see if

that does enough to keep the neighborhood a nice neighborhood. We made an analogy to neighborhood watch. We are now creating neighborhood watch where everybody self-reports on each other and hopefully keeps a nice community. And let's see if that works in sort of an enforcement model for spectrum sharing. And let's not worry about the bad actors and the fact we can't find jammers, we can't find that emission spurs, we can't find every single guy who doesn't identify himself as a hacker to us and holds a sign

out that says I'm a hacker, to move forward at least take a step forward even though we don't have all the answers right now.

MR. STANFORTH: So first I'll probably agree -- excuse me, agree with you entirely. You know, we got to earn the trust of those incumbents. I mean, a brief story about the TV whitespace. When I first went and did something, the broadcaster stood up and they put up a big black and white slide of two trains that have smashed into each other.

(Laughter.)

MR. STANFORTH: Saying, look, these people

do this and this is what will happen.

(Laughter.)

MR. STANFORTH: Four or five years later, and that itself is a crime, actually the biggest users and the biggest commercial user of our system today, our whitespace system are the broadcaster. Right? Because it took a while, but we finally convinced them that we actually did know what we were doing and that we knew what we were supposed to do. And we actually had a system that better understood their use of the spectrum than they did. And so they come to us looking for answers. But it didn't happen overnight and Ira's sitting there in the back and I remember Ira with a full head of hair when we started.

(Laughter.)

(Simultaneous conversation.)

MR. DEMBROWSKI: But I'd love to do something tomorrow, but I think we have to do something, we have to get the incumbents involved and do something with them now because otherwise we'll be talking about this in another ten years.

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MR. ROBERSON: Okay. Our time is fleeting, so what I think we -- I think we'll go ahead and open it up for questions, because the questions seem to not be centered so specifically on policy. So we'll now ask questions that go across. So you can choose to ask those questions that you have and we'll go for about ten more minutes on questions.

PARTICIPANT: (Off microphone.) Hi, this is Glen from the NSF. So the NSF fund several places where we're doing spectrum sharing. We don't distribute those data in any ... format for nonastronomers, but you can imagine that ... on what we would assume to be a perpetrator would be something that we shared our data ... with other services. And so that would be a way of developing. We can't triangulate ... I'm really curious about who is keeping that data? Is it sort of everybody has their own database and is there any progress on sort of ... uniform location?

MR. ROBERSON: Great question. John?

MR. CHAPIN: I will say that -- as I said,

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one of our key discussion items for the government to potentially be involved in funding was the whole system of monitoring systems topic. And what you're describing there is exactly the kinds of issues that the government would appropriately be involved in sponsoring the development and ... representations met those exchange protocols. And I do recall Dale's comment from earlier today that he was aware already of fairly significant amounts of monitor data ever being developed in the silos. Perhaps the folks who have that data would be interested in sharing it if there were common ways of doing that so that it wasn't -- or it was a high valued effort on their part to take part in that format. But, yes, we agree that that's an important area for progress.

MR. DEMBROWSKI: And didn't we also discuss that in the enforcement discussion as well, to see whether there was some mechanism, either the federal government involved, or the commercial parties involved, everybody involved, to sort of aggregate monitoring information, but we also discussed the issues associated with folks wanting to

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share that data in some cases because not everybody wants to share that data.

MR. ROBERSON: Other questions or comments

or -- now moving into the point that you can see that maybe you can slowly scroll up the set of proposal there. The group can look as well ... suggest enhancements to the list of questions. We'll look to add to those questions or answer the ones that are there which is basically what you just did ...

MR. TENHULA: So my question is to get to the ten billion foot level and look at this as a problem that is a resource management problem or a resource monitoring problem. And there have been other resource monitoring problems that have been solved. Air pollution, water, stream monitoring. There's huge federal programs and state-level programs as well to monitor stream flows. There's -- to monitor air pollution, there's tons of other resources... traffic we see -- we go across the rubber hoses all the time. You know, I'm sure they're monitoring us; right? That replaced a human being, you know, that used to count the cars that

went by. So there's all the fricking monitors out there, you see them in these orange things with two wheels on them anchored into the thing, you know, wondering what that's monitor; right? You see a camera on that and ... can that -- can those experiences somehow be leveraged, find those guys and put those programs together, Al's or whoever they are, and get the lessons learned from them and say, you guys been monitoring these resources for a long

time with likely a lot of federal dollars, how'd you do it?

So that would be my question. How do you reach out to those kinds of --

MR. ROBERSON: That could be a research topic. Any comments from the panel?

MR. McDONALD: So I think to repeat what someone said, half the solution is defining the problem. I think those monitoring systems you referred to have a well-defined answer we're looking for. And I'll go back to the monitoring for the sake of monitoring. It might not get too far without some question that we're trying to answer with monitoring.

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MR. SUBRAMANIAN: I think one of the things we've just been talked about is from a spectrum usage measurement ... and what are the policies that need to be associated with handling data, how you store the data, how you share the data. I think that's a huge thing which is really not understood. There seems to be necessity for doing it, but then how it is to be done. I think that discussion ...

MR. CHAPIN: Yes, again, we did discuss that in the implementation group. Question like how long should you retain the data? That's a research question. And what -- how much obfuscation do you do on the data before you start? It means it's spatial or temporal, is it averaging, or de-identification.

There's a lot of things that come into that. We didn't have any answers, but it seemed clear that that was a critical question.

MR. ROBERSON: So it's a key research topic we need to make sure --

PARTICIPANT: It goes in the other action section.

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PARTICIPANT: One other comment about monitoring is I work with an agency where if you went and monitored live spectrum usage, it might be one day out of 365 that we would actually be up on a particular channel in a particular area. So there would be a conclusion drawn from that I don't need that. But I need it when I need it. There's no other substitute for that when you're at an apportion base. You have to keep ... and incumbent users' mission in context of what you measure.

MR. HUNTER: Yes, Stan, just a comment to that. I think you were well represented by the FBI in our working group. So they made that very point and I think it's a valid one. You certainly need to look at operational missions and how that spectrum is utilized from the onset.

MR. ROBERSON: Final chance? Rangam is going to take it?

(Laughter.)

MR. SUBRAMANIAN: I'm guess this must have ... the big data and the intensive computing, it's an

extremely important issue along with the data usage

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initiative. How important it is and what kind of interdisciplinary research just connecting these three needs to happen. I think it's a humongous problem that needs to resolve. Because ... I don't think the whole spectrum sharing issue can be resolved. Mainly you're talking about a wider spectrum ...

MR. CHAPIN: I guess I'll take it again. Our group discussed about that in terms of the total cost of ownership. So it's not just the sensor head, it's the data reduction and the ... that sits right behind that that sucks down a gigabyte of data per second and does something with it. It's the storage, it's the processing, it's the people, it's the deployment and the maintenance. The total cost of ownership is what you have to focus on getting to something that is in line with the benefits that are provided to the nation's problem with sensor ....

(Simultaneous conversation.)

MR. DEMBROWSKI: Yeah, we also did it in enforcement and I think in addition to sort of the equipment costs, we also talked a lot about the

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personnel costs because you have an enforcement

issue. You can do as much automation as you want to, but at some point you're probably going to have to have boots on the ground that are actually going to stop people from doing things. So there's a person cost in terms of actually shutting down issues, so at some point --

MR. ROBERSON: Okay. Not seeing any more hands raised, we'll move into the lightning round to close. And the lightning round is that we have a set of questions and I'll have the group read through the question and make any modifications that you would like to make as to the actionable research questions or proposals.

(Simultaneous conversation.)

MR. ROBERSON: And please, the whole audience take a look at what's there because what we're going to do at the end is to actually rate these by the time-honored raising of the hands.

(Pause.)

MR. ROBERSON: This will obviously give us a straw vote. Not a final, but I had some more

exotic technology that I was thinking about, but we'll just use this for now.

So, Howard, John are you okay with what's written?

MR. McDONALD: The second one, leveraging the pilot, the WSRD SSG will work on talking about what entity or organization -- forum, if you will --

would do that leveraging, creating the charter and the scope of what ... forum might be.

PARTICIPANT: (Off microphone.)

PARTICIPANT: (Off microphone.) -- data analytics as well.

PARTICIPANT: (Off microphone.) Do you have data analytics in yours?

MR. CHAPIN: The analytics? No, we did not put the analytics themselves.

MR. McDONALD: I think that's one research area -- data analytics. Make sense out of ... data were collected ...

MR. ROBERSON: Do you want to add ...

PARTICIPANT: No, that's fine. I just wanted to make sure it was captured in a little more

detail.

MR. ROBERSON: Okay. You might number those one through three. I'm not sure, is the first one a question. The first one is a question.

PARTICIPANT: No, the first one isn't a question.

MR. ROBERSON: Make sure the second one is a question. Which ones are questions?

PARTICIPANT: The last -- the third one is the question. The fourth is the data analytics we discussed. The first two are just bits of things that I pulled out.

MR. ROBERSON: But is the third a question

from your perspective? A research question?
MR. SUBRAMANIAN: The second is a --
(Simultaneous conversation.)
PARTICIPANT: It's an action.
PARTICIPANT: It's the last one that's the research area.
MR. ROBERSON: Well, the third from the last is also -- would seem like a research question. But it's -- you're specifying who is going to do the

research. It's still a research question; right?
The best monitoring practices, you're researching to understand what the best monitoring practices are. It's preassigned who you would pick to do that. So maybe we could number those one and two under the center there. Because we're going to vote so I can have something to point to.
Okay. Group two, let's go down to the --
PARTICIPANT: Dennis, is data analytics the specific thing Mark talked about this morning or is it data analytics in general? Is it lower case data analytics or is it upper case?
(Simultaneous conversation.)
PARTICIPANT: I'm trying to remember what --
PARTICIPANT: In other words, he talked about something, a Ph.D. up a Harvard Business School is doing very specifically in something called business analytics 3.0 which is very specific --

PARTICIPANT: Yeah, it was not that.
PARTICIPANT: Okay. So we're probably -- we may want to lower case it so we're --

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PARTICIPANT: I just want to add something to that. That the ... (unintelligible) and essentially looks at ... context that help to understand what we've only begun.
PARTICIPANT: I've not heard big RF terminology.
PARTICIPANT: That's a new word that we came up with.
MR. ROBERSON: At the wind forum that I attended.
(Laughter.)
MR. ROBERSON: Okay. Group two, and hopefully you're working it. Any --
MR. DEMBROWSKI: Well, we're trying to figure out how to rework that first one there. Because the point we're trying to get at is, yeah, in boundaries of --
PARTICIPANT: Trust boundaries.
MR. DEMBROWSKI: Yeah, boundaries of trust and research in terms of that. Yeah.
PARTICIPANT: And hardening of platforms so you can trust what they'll do.

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MR. DEMBROWSKI: Exactly. Exactly.
MR. ROBERSON: In particular members of these groups, please, be prepared to chime in.
MR. DEMBROWSKI: To be able to trust what they will do. To trust what they will do.
PARTICIPANT: Okay. To trust what they will do.
MR. HUNTER: I guess an example of thinking of our maps, kind of the evolution of DFS in the context of the new paradigm that's coming out with -- what comes to mind is 802.11AC and how you evolve that. I mean, obvious DFS is not without it's faults. But I think to the news point about how good is good enough. It's obviously a very successful platform and it's ... that we are seeing some challenges as we evolve that.
MR. CHAPIN: If I understood Dale and their group appropriately, the real issue is that you don't want software hackers to be able to break into devices too easily and change their behavior. So you want one that had some high confidence that unless somebody with great resources attacks the platform,

it will continue to behave in the way it --
(Simultaneous conversation.)
MR. CHAPIN: -- is that correct?
PARTICIPANT: And you don't want your ... to be larger than necessary because you may hurt innovation.

PARTICIPANT: Balancing.

MR. DEMBROWSKI: And I think in the third one, what we're really talking about secondary data collection from the devices themselves, the third question there. So it's -- so get rid of the "further in terms of" so how do we use crowd sourcing?

To gather secondary measurements data.

And for use on -- so get rid of particularly down to the -- keep the "for use" on the enforcement side. There you go. I think that's -- I think the other one is fine from our perspective.

MR. ROBERSON: Okay. Any --

PARTICIPANT: I would like to talk about the last one a little bit. This is regarding question four. I mean, there is a question of where

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the funds come from, but it's a broader context about studying the cost of implementing enforcement systems of different kinds. So it's an issue of right size and costs to the enforcement problem as well as the question of how do you fund enforcement mechanisms ....

MR. ROBERSON: I think this was something you said earlier Dale.

(Simultaneous conversation.)

MR. ROBERSON: Reducing the cost or providing the funding, those two complimentary --

PARTICIPANT: Some combination of the two;

yes.

PARTICIPANT: Yeah, so reword it.

MR. ROBERSON: Okay. Go ahead.

PARTICIPANT: So a research question might be modeling the costs of enforcement and determining sources of funding implement; how does that sound?

MR. ROBERSON: Yeah.

Okay. Great. Any final costs from group two?

(No response.)

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MR. ROBERSON: Okay. Let's roll up to group three.

MR. CHAPIN: All right. The first one you could just say, AWS3 auction, you can delete the rest of that.

PARTICIPANT: The key there was that we could maybe use auction revenues to fund some of the research.

MR. CHAPIN: All right. So just leave that there.

Yeah, that's fine. The second one, the deploy monitoring in a few vertical ... data of high policy value.

This is a question to Dennis. The next one really is -- those are three detailed suggestions. I don't know if you would like us to split them apart for the voting or leave them.

(Pause.)

MR. CHAPIN: I'm wondering for implementation those are three separate things, do you want folks to vote on them separately as three or one?

MR. ROBERSON: I think so. Yeah.

MR. CHAPIN: Okay. So --

MR. ROBERSON: So let's number one, two, and then divide the implementation into three, four, and five.

PARTICIPANT: Yes.

MR. ROBERSON: At the semicolon -- link becomes four. The link is five. The next link is five.

MR. CHAPIN: Or it should be link monitoring and sharing experiments.

And then measure better. Number six is measure better. And I should say there are about ten really interesting things that we didn't list there.

(Laughter.)

MR. CHAPIN: No, I didn't give them to you either verbally. And then seven is interaction down below.

Yeah, seven is actually the sensing challenge, I guess. So if you could go back up that semicolon. Yeah.

(Pause.)

MR. ROBERSON: Okay.
MR. CHAPIN: Yeah, that is all we shared verbally.
MR. ROBERSON: Any comments from the group about these research questions, the operations group obviously overachieved, but they divided and conquered the three groups so that they --
PARTICIPANT: ... research and the big data computing section. No, I'm saying you ... issues research and the big data ...
PARTICIPANT: I'm not following what you're saying --
PARTICIPANT: I'm saying, we ... class, how you treat the issues with the class and unclass ...
PARTICIPANT: Classified and unclassified data. But I don't know where you want that.
MR. CHAPIN: So, Ray, number eight I think is what's our concrete and actionable recommendation was to pick specific systems and analyze them in detail which includes the security ...
MR. ROBERSON: Okay. We're going to make

this really quick. The interrupt was that we thought we had additional time. We have been informed that it is expected that we will be out of this area at six o'clock. So in order to facilitate that we're

going to do very quick voting. The voting will be each of you have three votes. And we're going to vote as quickly as we possibly can. Go to the top. Three votes only. Look at the list. Hopefully you were paying very close attention. I was going to read through them, but we don't have time to do that.

So, how many of you would like to vote for group one, proposal one?

(Showing of hands.)

MR. ROBERSON: Two people.

Okay. Put a two by that.

PARTICIPANT: Just a question. How do the votes then get -- are we picking how many of these questions in the end? Are we taking all these questions in order?

MR. ROBERSON: We're going to see how -- you each have three votes, so your priorities are three and we'll see how the voting comes out. The

way I grade my classes, you know. Figure out --

(Simultaneous conversation.)

MR. ROBERSON: Fairly straightforward.

Don't cheat, that is on honor system. Three votes only.

Okay. So data analytics. One, two, three, four, five, six, seven, eight, nine, ten, 11, 12, 13, 14, 15, 16 and 17, 18, 19, 20, 21, 22, 23, 24 25, 26, 27, 28, 29, 30, 31, 32, 33, 33, 34, 35, 36, 37, 38, plus or minus.

(Laughter.)

MR. ROBERSON: Okay. Group two, research proposal one. Voting. One, two, three. Boy those are slow coming. One, two, three, four, five, six, seven, eight, nine, ten. Okay. Ten.

Group two, number two, votes up, hands up.

(Showing of hands.)

MR. ROBERSON: One, two.

How come you voted on every single one, Mark?

(Laughter.)

MR. ROBERSON: Okay. Group two, number

three.

(Showing of hands.)

MR. ROBERSON: One, two, three, four, five, six, seven, eight, nine, ten, 11, 12, 13, 14, 15, 16, 17, 18.

Okay. Number four, group two, number four.

(Showing of hands.)

MR. ROBERSON: One, two, three, four, five, six, seven, eight, nine, ten.

Group three, number one?

(Showing of hands.)

MR. ROBERSON: Hands up?

(Showing of hands.)

MR. ROBERSON: Zero.

Oh, one. Okay.

PARTICIPANT: Plus or minus.

(Laughter.)

MR. ROBERSON: One.

Okay.

PARTICIPANT: Wouldn't that be a statutory change?

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(Laughter.)

MR. ROBERSON: Group three, number two, vote, hands up.

(Showing of hands.)

MR. ROBERSON: One, two, three, four, okay, come on. Hands up, please.

(Showing of hands.)

MR. ROBERSON: One, two, three, four, five, six, seven, eight, nine, ten, 11, 12, 13, 14, 15, 16 -- 16.

Number three, group three, number three, implementation. Hands up.

(Showing of hands.)

MR. ROBERSON: I'm learning to wait a little while. You guys are slow with that. One, two, three, four, five, six, seven, eight, nine, ten, 11, 12, 13, 14.

Number four, hands up.

(Showing of hands.)

MR. ROBERSON: One, two, three. Okay. Three.

Number five, link ... hands up.

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(Showing of hands.)
MR. ROBERSON: I am seeing no hands. You've already exhausted your votes. Okay. Zero.
Number six.
(Showing of hands.)
MR. ROBERSON: One, two, yeah. One, two, three, four, five, six, seven, eight, nine, ten, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23, 24.
Okay. Number seven, getting close to the end.
(Showing of hands.)
MR. ROBERSON: One, two, three, four, five, six, seven, eight, nine.
And the final one, final vote. Those of you who have not exhausted your vote, this is your chance.
(Laughter.)
MR. ROBERSON: Number eight.
(Showing of hands.)
MR. ROBERSON: One, two, three, four, five, six. Six.
Okay. Thank you all very, very much,

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especially for doing something very complicated in a very short period of time. And I will now things off to not Bob Barker.

(Laughter.)

MR. ROBERSON: Byron.

MR. BARKER: And everybody give Dennis a round of applause.

(Applause.)

MR. BARKER: He did a really great job with the timeframe. I know our battery is starting getting low during the end of the day.

MR. ROBERSON: Not mine.

MR. BARKER: Yeah, you got a reception to go to. Speaking of the reception, just for everybody here, you're welcome to go to the reception. It's over at Stafford, the main Stafford place building in the atrium area there at the restaurant that's right there co-located in the atrium. It starts at six o'clock. I know Van is here. Since we're kind of running short of time, we've got to get you guys out of here. The intent is to bring together the forum here with industry,

academia, with the government side to talk about an opportunity for collaboration through a stand up of an industry consortium. And it provides another opportunity that Van will discuss in his opening remarks at the reception.

Just one little caveat with the reception, for anybody that parked in this building, the Stafford Two, you're going to -- and if you're wanting to go to the reception, you're going to have

to move your car because after seven o'clock they shut it completely down. I'm one of them, so I'm going to have to move. The easiest is to move over to Stafford Place.

PARTICIPANT: Move over to the Ballston Mall and it's like a dollar for three hours. We'll take care of it. That's probably the easiest, it's just right across the street. And I apologize for that. They told us differently as of today they changed that. So we thought you were going to be able to get out ... parking ticket, but now they're saying after seven o'clock it's there until tomorrow. If you can move your car, my suggestion is just to

cross the street, the Ballston Mall. Very inexpensive and then you can just walk right back across.

MR. BARKER: So just to finish up, I just want to close. I felt like what we've done today, with what I had said at the beginning, kind of a challenge that we need to look at ways that makes us more effective, makes it a more meaningful and sustainable and insanely affordable. I think we've gotten some ideas of how we can look at that, some research projects that can be explored and that we could help in influencing that through our process and planning through the administration, through our nitrd construct. So I think it will be -- with our influence through STP because we represent ... to STP

with Tom who is here. So I think we've gained a lot out of today and the discussion. So a really good forum that we had today.

(Applause.)

MR. ROBERSON: I also want to say, we're already in the brainstorming session thoughts of our next workshop. I just want to kind of plant a seed

to kind of expect something probably six months from now or so to looking at possibly ideas like to discuss about incentives because that's a hot topic right now. And we even have an offer by Stevens Institute to host it up at New York City on Wall Street. So that kind of ties in somewhat there. So just kind of keep that for food for thought and we'll maybe expect that.

So I want to thank everyone for giving your time.

Yes, Dennis?

Oh, yes, the report, folks, particularly Dennis, the planning committee team, Bill Horn from NASA is going to be heavily involved to digesting all this information and putting together an overall findings report from this workshop. We should expect it probably to be out in the next -- I don't want to put any straight hard deadlines, but probably in the next couple of months you could say.

So kind of expect that. And that will be published on our website on our WSRD website.

MR. ROBERSON: We'll send an e-mail to let

you know. And it will include, as an appendix, all of John's charts.

(Laughter.)

MR. BARKER: So, I need to get you guys released so you can get on out of here. We won't be caught by security.

So thank you, everyone.

(Applause.)

(Whereupon, at 5:54 p.m., a meeting was concluded.)