



## Challenges in Sharing Weather Satellite Spectrum with Terrestrial Networks

March 27, 2015

Choate Room, Carnegie Endowment for International Peace  
1779 Massachusetts Ave NW, Washington, DC 20036

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**Victoria Samson:** Thank you all for coming. My name is Victoria Samson. I'm the Washington Office Director for the Secure World Foundation. The Secure World Foundation is a private operative foundation that helps solve sustainable use of space. We look at how basically space can better our lives on this earth.

Our interest in this topic is whether or not the access to space will be interrupted, and [inaudible 00:47] optional. I'd be very curious to hear what our very big, very expert panel has to [inaudible 00:53] on these issues. With that, because of timing, I'm going to go on to our speakers. You should have the bios in front of you. I would like to add, this event is being recorded for the record, so FYI you can use your cell phone.

We're going to go down the line, have all of our speakers give their initial remarks. Then there'll be time to Q&A afterwards. First of all, Carol Anne Clayson.

**Carol Anne Clayson:** Thanks, Victoria. Thank you for hosting us, I am the AMS representative, who's co-sponsoring this event. I'm grateful to be here with you today. The data from satellite measurements makes a very significant contribution to many [inaudible 01:31] products that are used by government, companies, and individuals.

These weather products include, not only general forecasts, but more immediate and urgent watches, warnings, and advisories.

Whether we are talking about America weather prediction model outputs, face weather events, weather information for emergency managers, the relay of hydro- meteorological data from geographically remote land, sea or stream sensors, or images seen on the evening television weather broadcast, or on Internet websites, all utilize the radio spectrum to bring operational science data from space to the Earth.

Many federal, state, local, and [inaudible 02:08] , and private sector users depend upon the direct broadcast of data from geostationary weather satellites. However, we don't know exactly how many direct broadcast users exist, because receive- only satellite ground stations may be purchased by anyone without a license, and generally, for most users without the protection from radio frequency interference that a license generally suggests.

Uses for this broadcast may include, for example, a primary method of severe weather warning, especially after the ground power or communications infrastructure has been impacted by the weather event, or the redundant communications path needed to create fine, sensitive operational federal or private sector products.

As an example of users of a direct broadcast, Alaska and Hawaii need satellite data due to the shortage of surface weather stations. The data collection system users receive data in this band for hydrologic forecasting and flood warning. Space weather data from those is received exclusively in this spectrum. These are three of many examples.

Many people are using products that were created using the direct broadcast in either a primary or a backup mode and this group of users are very likely unaware that these products depend upon being able to receive the satellite data. We will hear about these and other examples of products that many people across the country use every day as well as other effective products that at some time someone may need to receive warnings of imminent danger.

Why is the spectrum and thus the ability to receive data in these wavelengths in danger of interference in the first place? Put simply, the commercial use of smartphones and tablets has skyrocketed. Movie downloads and streaming of large amounts of data have become ubiquitous in today's world.

To meet the demand for ever- more spectrum- intense uses, such faster and greater streaming of data, or simply more wireless features, the commercial broadband industry requires more and more segments of the radio spectrum.

Spectrum is a finite resource and most of that spectrum is already occupied by multiple users. From November 13 of last year to January 30, the US Federal Communications Commission conducted a spectrum auction to share two bands nationally with commercial broadband wireless users.

To understand some of the market forces at work, we note that a small orphaned segment of spectrum currently used for downlink of the post- satellite data and direct broadcast of such properties as FY- 3, [inaudible 04:39] , and Saral brought over \$2.4 billion, while a more desirable pair of DoD spectrum yielded over \$42 billion during the same event.

It is too late to impact that auction, but we mention it here so that the community is aware of the

inherent market value of these spectrum. The sale of the spectrum thus provided an immediate and large source of revenue to the government, and so future sale of such spectrum are ever-more likely. Demand is such that more bands are under consideration for future auction.

These new candidate bands include the GOES/GOES-R broadcast downlink band used to send all level 1b imagery and level 2 data, relay of data collection systems from terrestrial sensors, space weather downlinks where those signals are, the low-rate information transfer in the emergency manager's weather information network, EMWIN, with high-rate information transfer are all in this spectrum.

To make that band viable for sharing with commercial users, the NWS radio [inaudible 05:39] would have to be moved to a new band. Another band under consideration for sharing are the next-round radar spectrum.

These future band candidates are likely to be selected by May or June of this year, after which a short public comment opportunity would occur, prior to the final band selection for the subsequent future auction. We as a community need to raise awareness of the impacts of these actions, and explore how we can best mitigate, live with, or adapt to these changes.

If meteorological users believe this change to the weather infrastructure could affect them in any way, participating in those public comment opportunities is essential. Inputs from a few hundred users will likely make little difference, but significant comments from a multitude of users in different segments will be heard.

Our goal today is to raise the awareness of the user community on what selling of the spectrum may mean to them, to industry, and to the general public. It is our hope that by doing so we might be able to work together to find out how to best move forward both our community and the larger population.

The panelists today will provide some context and understanding of the scope of the issues. We are very pleased to have them with us today so please give them your attention. First up, Dave Lubar.

**David Lubar:** Thank you, Caroline and Victoria. My name is David Lubar and I'm the radio spectrum management specialist from the Aerospace Corporation. I support GOES-R weather satellite development programs on spectrum issues. I should add that the views expressed in this presentation are my own. I'm not speaking for NOAA or the Department of Commerce on radio frequency events.

Slide one that you see will give a little background. Since the early 1970s, NOAA weather satellites had featured a direct broadcast capability that was available to anyone who had a ground receiving station. Those capabilities had created an evolved architecture where federally licensed satellites broadcast to a wide variety of federal and non-federal ground receiving systems in the L band radio spectrum, specifically from 1675 to 1695 Mhz.

The GOES-R broadcast architecture is a busy slide, which I'm not going to brief. I just want to simply note the industry sectors of non-federal users, which are listed at the bottom in orange

color, which receive satellite data, and to the right, the data collection system and the Emergency Managers Weather Information Network users group.

End users benefit from data sent to federal facilities, non-federal end users directly and the private weather enterprise. Let's just talk a little bit about it. Services on the geostationary operational environmental satellite, or GOES, include the following.

Number one, a broadcast downlink. A full-resolution, calibrated, near real-time data and images from each instrument on the spacecraft observatory to federal and non-federal users known as GBAR today and GRB on the new satellite series.

Second, a data relay system known as DCS, which carries about 750,000 messages per day of river, stream, and tidal gauge data and other types of environmental sensors to federal, state, local, and tribal and private users.

Number three. A highly reliable broadcast of near-real time products from the National Weather Service into a one-meter size ground receiving antenna, with low-cost equipment which may be battery-powered called the Emergency Manager's Weather Information Network, or EMWIN. EMWIN is intended for use by first responders and state, local, and private emergency managers.

Lastly, number four, a broadcast of reduced subset of GOES imagery and other meteorological data for federal, state, and local and private use known as low-rate information transfer or LRIT today and which will be known as high-rate information transfer on the GOES-R satellites.

What's shown in green on this slide are the federal services that I just mentioned and it shows you where they are on this spectrum. Perhaps this radio spectrum data is a bit tedious for our audience. However, it will help set the stage for the balance of this panel discussion.

I'd like to point out a favorite phrase that I use. If one considers the term millibars and the term megahertz. They're both three syllables in length. They both begin with the letter M. Otherwise, they really don't have very much to do with each other. Many end users will not necessarily know that the data, which is used to create selective meteorological and hydrological products, passes through this radio spectrum.

End users may not know physically where such data is received directly from the satellite by an earth station. Knowing both of these facts are important as stronger terrestrial commercial signals begin to create radio frequency interference to reception of those direct broadcast meteorological data.

Contract, there's meteorological uses, as Caroline said in the intro, but the growing demand for broadband for broadband wireless radio spectrum enabling smartphones and tablets.

I'm fairly confident that everybody in this room has one or more wireless devices and that many people watching this delayed video broadcast on the Internet will be viewing it on a smartphone, a tablet, or an Internet-connected wireless with us. As consumers move toward services that

require additional bandwidth, it is clear that more spectrum will be required to serve that usage.

Because of this demand, the administration tasked the federal spectrum regulator in 2010 to identify 500 MHz of federal radio spectrum, which could be shared or repurposed for use by the commercial broadband wireless industry within a stated timeframe.

Ideally the spectrum that is currently used primarily for federal agencies would be newly made available for non-federal applications if and when viable alternatives can be found for the federal services. Bear with me for a bit of spectrum specifics before we address how users benefit from data shown in the spectrum.

Today the slide shows the bands used by the current GOES satellites. You can see it above the line on this page. In 2016 to the 2030 time frame, or actually beyond that, in the 2030 timeframe, what you'll see is the GOES-R application, the new generation of weather satellites that launches in one year from now. While we have both sets of satellites in operation, you're going to see both of those services in that band.

Now, you notice the red panels on this slide indicate current commercial use. This particular piece of spectrum directly below the GOES-R spacecraft is being leased today by Lightsquared LLC for tower-to-smartphone broadband communications. The band right next to it is under a legislative proposal in the president's fiscal '15 budget to make that 500 MHz also available for broadband use.

As I said, you see below it in yellow the radio [inaudible 12:22] from the National Weather Service. The plan presumes that the radio [inaudible 12:27] will be moved elsewhere in the spectrum. But this band still overlaps the hydrological and other data relayed through space due to the DCS system that we talked about.

As was mentioned in the intro, this is the band that was just sold at auction. The Federal Communications recently completed this auction and the 15 MHz of current-generation polar weather satellite data throughout the US and possessions sold for approximately \$2.4 billion.

Another block of formal federal spectrum that has nothing to do with meteorological satellite operations has sold for about \$42 billion at the same auction. The 1695 to 1710 band is shared under US regulations and my presentation does not take issue with that fact.

Sharing spectrum is one way to help support the significant commercial demand for wireless services. However, the balance of the GOES-R and GOES broadcasting, 1675 to 1695 MHz, is currently under evaluation as a potential candidate for a future broadband auction.

These completed auctions and the ones currently in planning have not yet fulfilled the administration's goal of finding 500 MHz of radio frequency bandwidth produced by smartphones and tablets. Therefore, further assessments are ongoing to pick the next band or bands at frequencies currently in use by the federal government to be sold at a future auction.

Studies are underway that should result in a decision on which frequencies to recommend for the next auction by May or June of this calendar year. One of the facts this panel hopes to demonstrate today is that 1675 to 1695 MHz radio spectrum is already shared with non-federal

users.

By virtue of the evolved infrastructure, where NOAA provides space-based federal transmitters and the ground users include significant non-federal applications through state, local, tribal, and private-sector entities. In addition, many segments of the US economy depend upon the federal products created from data received in the spectrum to ensure their own economic success or safety of life and property.

We do not intend to dwell today on the intimate details of radio spectrum management, but there is a high likelihood that strong terrestrial signals will create undesirable interference through earth stations receiving the weak signals coming down from the GOES weather satellites in space.

Satellite signals are intentionally low in power output to avoid creating the interference or conflicts with terrestrial communications. If stronger signals are nearby in frequency it may be possible to reduce that interference into the earth station with electronic filters and planned coordination zones, resulting from the current auction, for example.

However, if both services share the same band, the same spectrum, filtering provides no benefit. The desired weather data will be reduced along with the undesired broadband wireless signals.

Now, if you look at the broader picture, weather has a significant impact on the United States. Recent studies led by the National Center for Atmospheric Research finds routine weather events can create an annual economic impact of as much as 485 billion in 2008 dollars. Natural disasters add to those numbers. The US has sustained 178 weather events since 1980 where overall damages or costs reached or exceeded \$1 billion, including CPI adjustment to 2014.

The watches, warnings, and private-sector products for some of these events utilize the data transmitted in the frequency bands we are discussing. I don't know how interference through direct broadcasts might alter those economic impact figures.

I do know that the direct broadcast radio spectrum is utilized by many different non-federal users, such as the private sector weathering of products, in-house meteorological departments, water managers, and hydrologists, emergency managers, and local jurisdictions to enable warning sirens for tornadoes and severe weather, and non-federal users that depend upon time-sensitive, high-availability federal products, such as space weather balloons.

Additional discussions on this topic may found online from a panel discussion that was held on January 7th, 2005, at the American Meteorological Society's 95th annual meeting. The slide gives the Internet link. Thank you for letting me define a potential interference issue which may impact non-federal end users, products, and services.

[applause]

**Victoria:** Next, we have Mike Johnson. [inaudible 16:56]

**Mike Johnson:** Thank you Victoria. Thank you for the opportunity to speak today. If we could cue up the movie. I'm Mike Johnson from the National Weather Service Office of Science and

Technology. I have a few slides, but I got this image this morning from our partners at the University of Wisconsin Cooperative Institute for Meteorological Satellite Studies.

Let me give a little context here. It really drives home the point that I'm going to try to make in my quick presentation and I think some of the other speakers are also going to try to make the same point. That point is the importance of high- reliability and low- latency timely data. This is a volcano that erupted two days ago in the Kamchatka Peninsula. You can see the plume erupting and quickly we'll move through that.

I'll point out on the larger scale here, we have...air traffic over the Pacific typically follows a grade arc that goes right near this area. Volcanic ash is particularly a dangerous phenomenon for aviation. Also note...you might not be able to see but I'll just point out, it looks like the bar is not viewable, but I'll just point out that this is from the Japanese Himawari satellite, which was launched in October.

This satellite, the imager is a near- clone of the GOES- R satellite that you're going to see launch next year. The time and the resolution out there are a phenomenal improvement over what we have right now. This entire sequence is every 10 minutes. You get a scan and this particular view is a visible half- kilometer grid resolution. It far surpasses anything that we have right now.

If we can go over to...If there's anybody that...since I just picked this up this morning, this comes from the [inaudible 19:32] blog. I didn't have time to put the website on it but anybody interested, I can leave that website. It's a satellite real- time blog that's available. All sorts of real interesting phenomena that come up and that we use in the meteorological community.

I'm Mike Johnson, Office of Science and Technology at National Weather Service. I'm going to defer a frequency- type discussion to experts. My presence here I think is just to talk about what the impacts are at the National Weather Service. I show this slide because on the right- hand side it says the primary operational concept for GOES- R. That shows a downlink onto these two sites, Wallops and the NOAA satellite operations facility.

We have various ways of communicating to our Weather Service offices incentives. On the left - hand side, the point that I'm trying to make here but really emphasize is low latency - - that's very important. You can see from the example that I just showed, if that's evolving on a scale of 5 to 10 minutes, and that's something you're not going to predict in advance, you need to have as much advance warning as you can. Any interruption in that type of service would be a high impact.

Then high- reliability. You need communications systems that are very robust. National Weather Service is installing the slide I just showed, the primary up system. That's here in the Washington, DC, metro area. But you can see we have some very critical sites that are distributed all over covering areas of interest in the US.

For that reason, if there was any sort of comms disruption of our normal paths, we built as a redundant capability direct broadcast antennas at these sites. There's seven of them. We have a few Himawari antennas. That's in a different band than I think we're speaking to you today, but I

put that for its purpose.

Now, I'll talk a little more specifically about what each one of [inaudible 22:28] does. Alaska Region headquarters, we currently have those direct broadcasts and we're going to install a GOES-R direct broadcast capability and possibly a Himawari capability as well.

Aviation Weather Center - - that's in Kansas City. We are going to have three antennas there, one looking at east, one looking at west satellite, and then a spare. We provide spares because of the criticality of not losing the data.

National Hurricane Center, if you noticed in the previous slide, is in Miami. If you happened to have a hurricane that disrupted communications to the Miami area, you definitely need a backup capability to provide communications to that site.

Pacific Region Headquarters. I think I'll lump Pacific Region and Alaska Region together, because they are really satellite-centric warning services for the weather enterprise. There are really few observations over the Pacific and up in the Arctic. Satellites are critically important. The example of volcanic ash, the example that I showed for Himawari is a good example.

The Space Weather Prediction Center. They're in Boulder, Colorado. The Storm Prediction Center is in Norman, Oklahoma, and we're installing antennas here in the Maryland area at the Maryland Center for Weather and Climate Prediction in College Park. We have a Himawari antenna and clone. The equipment provided to you in the next three slides just generally summarize what each one of these sites does that is critically reliant on geostationary data collecting.

Alaska Region. The Alaska Region Volcanic Ash Center is there. They put out warnings and advisories covering the area that they're responsible for, which includes looking at volcanoes occurring along the Russian East Coast. You can imagine that a lot of that - - the plume activity actually affects east and into the Alaska area. That's a fairly active region for volcanoes. They have a large marine, fire, weather, and public broadcast monitoring area.

Aviation Weather Center - - they're responsible for warnings and forecasts for domestic and international aviation, so they rely on and they're going to increasingly rely on the very high-resolution data that's going to come from GOES-R and Himawari.

Hurricane Center - - I've already spoken to their role. I think most people are familiar with what the Hurricane Center does.

The Pacific Region, they cover all the weather enterprise elements that the web service is responsible for, specifically marine aviation, tropical, and the Pacific Hurricane Center is there. EMWIN as well, so public money, income taxation.

Space Weather Prediction Center. I'll say a little bit more about the Space Weather Prediction Center. That's in Boulder, Colorado. That's somewhat unique, in that the derived products that come from the GOES-R are going to be produced onsite in Boulder, directly derived from the direct broadcast. That's different than every other product off of GOES-R. They're more reliant



on direct broadcast signal than other sites.

Then the Storm Prediction Center, which is in Norman, Oklahoma, and they look at convective learning or convective watches, and I think most folks are familiar with what the Storm Prediction Center does.

Finally NOAA's, the site here in College Park, there are three sectors that are primarily interested - - the Ocean Prediction Center - - they do many forecasts outside of the coastal areas of the continental US. The Weather Prediction Center, hydro- meteorological guidance. The Climate Prediction Center, they're less of an impact but they're also located. They're more week two and beyond forecasts. DP is not likely to be a large impact for them.

Then [inaudible 27:36] central operations, which includes the Environmental Monitoring Center, which is the site for the national weather models, which is of course reliant on satellite data.

In summary, the Weather Service is installing direct broadcast antennas at seven critical locations and eight if you include Guam. Capability is essential to high reliability and availability of the data. The Weather Service missions at these sites cover the weather enterprise missions [inaudible 28:20] . That's what I have.

**Victoria:** Next we have Mike Steinberg.

**Mike Steinberg:** Thank you. Thanks for having me here today. I believe I'm the only one here from America's weather and climate industry. I appreciate the opportunity to provide some thoughts from that perspective. AccuWeather and many other companies make extensive use of weather satellite data we see from a variety of sources around the world via settled distribution mechanisms.

Let me give you a little background. We use this data with production of our suite of weather forecast warnings and other content that's delivered to consumers and business. The upper picture that you see is our global headquarters and forecast center in State College, Pennsylvania. Those rainbows are there every Tuesday, by the way.

[laughter]

**Mike Steinberg:** We also have research and operations centers in Montreal, Wichita, Edward, Oklahoma, and a sales center in Rockefeller Center in New York City. Now, the weather picture...this shows us a dot there for each of the data calls we serve in one day as red dots. In total we serve more than 9 billion data calls for 1.5 billion people worldwide people each day. With our content available in over a hundred different languages and dialects.

We think that makes us the world's most elite weather forecast provider, at least we like to think that's the case. Our content's available for all digital media, including smartphones, tablets, wire and mobile Internet sites, digital signage, through connected systems like connected cars, smartphones, connected appliances. There'll be a lot more of that as we move over the next few years.

Through traditional media we provide forecasts and other content to nearly 2,000 radio and

television stations and newspapers and of course to their audiences, and we provide customized services to more than a thousand businesses and government agencies through AccuWeather enterprise solutions. We serve with that portion of our business 77 of the Fortune 100 companies and 54 of the Fortune Global 100 that we provide various custom services to.

To do all of this, we rely upon and receive a large amount of foundational data from NOAA, National Weather Service. That includes their satellite data. We're a very proud [inaudible 31:01] weather- [inaudible 31:02] nation ambassador, and we directly provide actionable weather warnings to business and consumers globally. We do make all our own forecasts, but we also make available and pass on all of the NOAA and National Weather Service warnings and other forecasts and statements.

We also have agreements with dozens of national net services all around the world, various state and local agencies and a number of private- sector data creators, all of whom supply us with important data that we use to generate the forecast for the whole world.

The issue of allocation of the radio spectrum and impacts on companies in the American weather industry is an important and interesting one.

On the one hand, this one, we recognize the continued need to evaluate and optimize federal radio spectrum assignments and allocations as consumer electronics, mobile technology, and the Internet of Things experience explosive growth - - sector growth that in fact results in significant growth for the American weather industry, as new devices and platforms arise all over the world.

On the other hand, at this point, this growth cannot put in jeopardy the core delivery methods that are used by governments and America's weather industry to receive, collect, aggregate and deliver foundational weather data because what those do is they provide mission- critical lifesaving weather products. We cannot, as a weather enterprise, unite in our common goals of saving lives and improving the quality for the world's citizens around us to occur.

Quite simply, these radio spectrum we're discussing are currently utilized for critical purposes that have significant value to the world, saving lives, protecting property and growing the American economy.

We're one of the many non- federal entities that leverage multiple receive- only ground stations for the reception of real- time weather satellite data. What we do, is we actually have multiple downlinks at multiple facilities, as well as direct high- speed line connected to the known gateway of Suitland, Maryland, multiple NOAA port systems, Internet and a whole variety of methodologies that we use to ensure that almost no matter what happens, we have all the data reliably and on time.

Today, we leverage G4 data streams from the current GOES satellites and in the future, will be leveraging the GRB broadcast, in order to use real- time data from the Gozar satellites. Satellite branch stations are important for the speed and reliability of the real- time data retrievals. The Internet is also an important delivery method. While we do use that as part of our redundancy strategy for the redundancy and reliability of delivery, users really cannot rely on one method to

get their critical data.

Additional complete data stream of imagery and sounder data is available on an equal basis to all users via broadcast. These issues are increasingly important as we move toward Gozar with the availability of huge volumes of data, externally useful for ours and others' critical operations, and completely new data elements, such as the Global Lightning Mapper capability.

There have been some suggestions previously of creating buffer zones around key federal sites though amid interference, but that doesn't solve the issue because there are many others in America's weather industry and the academic community, who reliably need this data for mission-critical operations.

I certainly don't claim to have all the answers as to how we address these issues, so I'm looking forward to our discussion today of the ongoing discussions and collaboration addressing these potential radio spectrum directly and collaboratively, as a community.

Within America's weather enterprise, the private, public and educational sectors have worked together successfully in a number of areas and have been increasingly partnering for the benefit of the economy and public safety over the past decade. I think as we work collaboratively to ensure the decision makers are aware of the critical use of this information transmitted via these parts of the radio spectrum.

I list some questions here that I think we should consider as to how we move on with this. First of all, how do we get the message out to a wide variety of potentially impacted users to help us gain their support? How do we present the message coherently and simply enough to make it resonate with other decision makers? How do we effectively educate and engage legislatures, the FCC, and other decision makers, both individually and collectively as a community?

How can we leverage the existing weather organizations, some of which are actively involved in educational and lobbying efforts to help with these issues?

Those would include NOAA National Weather Service, Weather-Ready Nation and Weather-Ready Ambassadors Program, American Meteorological Society, National Weather Association, the American Weather and Climate Industry Association, National Council of Industrial Meteorologists, and the Weather Coalition, among others.

What are the best venues to educate and build support within the user community? National Weather Service Partner's Meetings, NOAA satellite conferences, AMS webinars and readings or other possibilities.

Finally, given the national debt and deficit of the current political climate, I think a new source of revenue is very peptic. We need to keep in mind that even though the use of this data and its current trade mission may be critical, the government might decide to sell the spectra, regardless of our view of the value it things in its current use.

What level of back-up plan do we need in place, if that does happen? That's the end of my prepared remarks. I look forward to our discussion.

**Victoria:** Thank you. Robert Mason.

[applause]

**Bob Mason:** Thank you very much for the opportunity to be here, Steve. This is a very important issue to us. We want to share some of our uses of the GOES satellite, DCS and how we have a right to use it and stream gage.

Before I move ahead, just let me point out that you're looking at a photograph of the Mohawk River and Mohawk Falls. That little shelf on the bottom left is USGS stream gage.

**Audience Member:** [inaudible 37:51]

[laughter]

**Audience Member:** Now, it's falling.

**Bob:** Now, it's falling. Now, you see the Mohawk falls. You see a little stream gage at the bottom. Those are the devices that we'll be concentrating on.

Just a word about the USGS. We're not a particularly large organization. We're much smaller than the Corp, Weather Service or NASA. About a billion dollars in our budget. We were set here to describe and understand the earth and to share information about it. We're actually in the information business.

The three things that we do a lot of, we do a great deal of research. We do a little bit of assessment. For instance, we [inaudible 38:28] for floods. We do a lot of monitoring. This is the piece that I thought would be most interesting and certainly, most applicable to this particular conference.

Going on, this is some list than some of the monitoring that we do. This is a just a pull- down we did one day of the various kinds of parameters that we monitor. Those parameters include things like water quality, salinity, temperature, different kinds of metals, pesticides or end water around the country.

Most importantly, they also include straight flow or discharge, as I've highlighted it here. Some 8,000 gage stations around the country monitor 24/7 streamflow in rivers ranging from Mississippi to the smaller tributaries. It can be as small as a fraction of a square mile. I took that to Baton Rouge on the Mississippi.

As I said, one of the more important to those, at least in my business, is streamflow. Streamflow information is used in a variety of decision making. Some of it is design- oriented, so if I build a dam and how far should it be and how high should the bridge be. Folks don't often appreciate that a lot of the transportation specialists depend on passage over water, over rivers. Figuring out how high the bridge should be, is something that requires a lot of data to do.

There's a lot of need for information on streamflow for monitoring the route of operating water treatment or waste water treatment plants. Those sorts of things go on 24/7. Those are things that have immediate impact, so it's very important for our streamflow information to be available, to

be reliable and to be timely.

We take great pride in doing all of those things. Then again, we have DCS to make that happen.

This next slide is just a summary of some of the characteristics of the stream gaging network. You see here again, around 8,100 gage stations around the country. They're all real-time. Most depend on GOES satellite. I'd say 98 percent of them do. In a recent evaluation of the federal networks of a variety of observation systems, the stream gaging network ranked out pretty well with 120 or so we were looking at, the stream gage network comes out around number 13.

It's fairly important to a variety of agencies and a variety of uses. The network runs us about \$160 million a year. But, here's what's really important, for some 850 state and local agencies that help us fund that network, we actually take the money from others to do this work. They're very happy to provide it.

I've provided a little bit of a funding background down at the bottom. See, about half of the monies that we need for operating the network come from state and local agencies. It's something that has an impact down at the ground level, where citizens are dependent on their local communities, their counties, their states for one service or another.

The picture in the right corner is a picture of the network. In this case, I'm using a report that came in yesterday to illustrate the current water conditions, as of yesterday, relative to this time of year. If you look up there, you'll see things that are green that are more or less normal.

Things that are dark colors like the blue band paralleling the Ohio Valley has high flow. They're running very high, as is the Northwest. You see in the Southwest there's a drought going on. All of this from an innocent picture in one not so little place, one part of our system, where we've integrated it all.

Again, it's very important to us to have something that's uniform in terms of communications. GOES provides us that. We don't have to type data from one type of radio to another and pass it through some sort of system patchwork in that sense.

I wanted to just to show you a diagram. I won't try to explain it, but I will say that there a number of back-ups that are included in the GOES process. We do receive data from a number of downlink sites. Those sites themselves are what I think are most important and most concerning to me, will we be able to continue to operate them without having interference, should we share the spectrum.

Here are just a few comments about our GOES usage. In this, you'll see that the GOES system is fairly important to the USGS. Sometimes, the USGS is fairly important to the GOES system. We're by far the largest user of the GOES system via DCS.

We have a number of channels reserved for our use. We find that at a fairly low level. By that, I mean it's a fairly inexpensive system. It makes it possible for us to do stream gaging at a relatively inexpensive cost. For the same amount of money that we pay in gear, we might wind up paying a subscription for somebody else for a month, if we had to, around, say, a cell phone or something. It's important to us, too, to have the system.

I wanted to mention just a few things that compare and contrast the strengths and weaknesses of GOES. Among those, I just mentioned them. GOES is a very reliable system for us compared to the cost. There are some weaknesses that we'd like to be able to address. The most important of those is that it's not a two-way communication stream. We're not able to talk very much with our gaging stations. We'd like to be able to.

There are a few things we might be able to do to improve our efficiency. We're concerned about the impacts of sharing or selling off the spectrum, particularly in those places, where we have downlinks and I'm trying to illustrate that in this illustration here, that they might be interrupted or interfered with.

**Audience Member:** Next page.

**Bob:** I'm sorry. I'm not advancing up here, am I? Trying to run the projector, I can't see the slides.

Here are a few questions I'm parting out, very similar to what you had before. Given that GOES is a fairly weak signal, are we able to rely on it, if we have to share that spectrum? Are there ways of buffering or filtering, as we heard earlier, the GOES signal in a way that preserves their continuity and clarity for us to use to pass on?

Given that our signals are fairly low power, they have to be for us. The stream gages operate by associating stations all through solar panels and 12V batteries. They're not connected to a power grid. That's very important for us not to have to overtax their systems with a transmitter.

With that, I guess I'll pass it on. Thank you very much for your attention. I'm looking forward to the conversation.

[applause]

**Jack Brown:** Good evening. I'm Jack Brown. I'm the Director of the Office of Emergency Management in a very small county across the river from here, Arlington County. I think we're one of the most densely populated counties, but geographically, we're one of the smallest counties in the country.

We're about 26 square miles, but if you take out Reagan National Airport, the park land, the Pentagon reservation and Joint Base Myer and Henderson Hall, and all the other federal footprint, we're down to 16- 16.5 square miles. We're pretty small.

It's a great place to live or play. Come on over and spend your tax money.

[laughter]

**Jack:** Spend your money, so I can collect tax revenue. We love our visitors. We have a lot of visitors through the many sites in Arlington.

I'm not really hear representing Arlington. I'm going to talk about an Arlington-specific incident. I'm here representing my professional organization, the International Association of Emergency Managers. While I'm not an expert in GOES DCS, I'm a user.

My colleagues around the country, in fact, around the world, use platforms like this every day. We're very concerned that any impact to the capabilities that we have. Certainly, the commercialization of the spectrum, does cause us some concern.

I think working with our professional organization and some of the other first responders like the police chiefs, the International Association of Chiefs of Police and the International Association of Fire Chiefs. I'm a member of that organization, as well. I think maybe we could leverage some of those partnerships to raise those concerns.

I was going to show you a little video clip, but I don't think I'm hooked up to the Internet. Anyway, back on June 29th, 2012 throughout the day, we knew that there was going to be some pretty serious weather through the national capital region here. I'm going to say around 10 o'clock at night, I was going fly by our emergency management duty officer that this was a pretty serious storm coming our way.

In fact, he suggested that we open our Emergency Operations Center. I said, "What time do you think it's going to hit?" He said, "It's going to hit in the next 15 minutes to half hour." I said, "Absolutely not. I'm not going to put people into harm's way to go activate our EOC, if you will. Let's just let the storm go through."

We had sent a number of alerts to our residents and visitors to let them know of the impending weather. Stay inside. Seek shelter. Put aside some things. If you're not signed up for your local emergency alerts in your community or work, please do. In Arlington County, it's called Arlington Alert. You go to our website, [www.arlingtonalert.com](http://www.arlingtonalert.com) and sign up for it. It's really, really simple and very valuable information.

As you can see, the derecho - - I'd never heard that term until after the storm hit...Can I stand up? I'm horrible sitting and speaking. Actually, I'm a horrible speaker.

**Victoria:** We'll give you a mic because this has been taped down.

**Jack:** I'm vertically challenged anyway, so I'll just walk around a little bit.

[crosstalk]

**Victoria:** Do you need a mic?

**Jack:** Oh, absolutely. OK.

You can see it covered 650 miles. This storm actually started off around Iowa. It's around 350 miles wide. By the time it got here, we're looking at hurricane force winds, which we're not really used to here in DC. Every now and then, we get some storms that might have gusts that high, but this was a very, very powerful storm.

We had had some other storms over the last few years, microbursts and things like that to cause some serious damage, but this one really packed a punch on us. I know this is the end point.

Situational awareness around this is key. Every incident that we have, we always go back and look at what was the information that we had prior to the event, if there was any? How do we

share that? Did the right people get the right information at the right time? We have issues with communications, infrastructure. This particular storm actually one of the cascading impacts of it was the impact to our 911 system.

We use a carrier that everybody's familiar with. I'm not going to rat them out too bad here. They had a failure of a couple their generators. Actually, our 911 system in Arlington County was down. That didn't happen until about 7:30- 7:45 the next morning, Saturday, the 30th. It had a huge impact on our community.

We activated our Emergency Operations Center. That was a full activation for us. A lot of times, we'll do things virtually. We'll just people call in on conference calls and we'll use a web- based system to communicate and collaborate. For this one, we brought people in.

Power restoration. Two- thirds of our county was without power, some for up to eight days. Huge. It was hot. It was summer time. We have a lot of folks who were in various levels of assisted living, everything from private homes all the way up to hospitals, nursing homes, assisted living facilities. If you look at Arlington County, a lot of high- rise buildings.

We had a couple of our high- rise structures with some older folks, interim folks, where the generators had failed, power had failed in there, and it was pretty hot on the 10th and 11th floors of some of these buildings. It was terrible.

Some of the other things that we learned from this is the need to always have a handle on your staffing, particularly the first responders, police and fire. They always step up to the plate, but it really does get down to personal preparedness at every level, not just the county with all of our capabilities, but down to the individual level, individuals and families and schools and businesses. Just, it's so important for all of us to be prepared.

Then, a lot of debris gets created, when you have these kinds of storms. When you're in Arlington, where do you put it? Where do you gather it? Where do you aggregate it at? What are you going to do with it, when you can't just dump it somewhere? A lot of that.

There were a lot of good things that happened that we learned and we want to capitalize on. First off, our internal and external communication system amongst each other within the county, but also with the public. With the power down and a lot of our communications mediums - - people couldn't turn on their TV - - hopefully, they had a battery- operated radio.

We actually operate an AM radio station. We're getting ready to add FM capability to that. If people have battery- operated radios...We were communicating with people via AM radio.

We also leveraged the community through our community emergency response team to actually go door- to- door, particularly to the vulnerable populations and to the folks that might be on the other side of the digital divide and actually hand out flyers in English and Spanish to tell them what was going on, what they could do to stay safe, and give them as much updated information as we could.

Again, personal and organizational preparedness are key. Of course, we say this in our EOC all



the time, be happy and be flexible because most of these operations like this go over an operational period. We use 12- hour operational periods. We went from one o'clock in the morning on the 30th to midnight on the July 4th. Our EOC was activated 24/7. That's our campaign operation for us.

Warning. National Weather Service. As I said, we got a lot of weather information throughout the day. I think in retrospect, for me as the emergency manager, it would have been nice to know more about the ferocity of this particular storm.

We knew it was going to be bad but for me personally, it didn't really click until about a half hour before this thing hit, how horrible this was going to be. I've already dimed out Verizon there on the on the coder system there.

[laughter]

**Jack:** I've got to give them a lot of credit. They've done a lot of work since we had this particular incident. There was a number of investigations done conducted by the SCC, the State Corporation Commission in Virginia.

The Governor of Virginia actually appointed some elected [inaudible 53:40] folks like me to an investigative body to work with Verizon and try to keep this from happening again.

This was actually human error. They didn't check the generators. They should have checked their generators. They put systems in place, and they have communicated much better with us since then.

For us, intersections, it was huge. People are driving up and down the streets, and there's no traffic signals, so our police chief got out there. We used every communication medium we had. We told everybody, "Treat every intersection like it's a four- way stop sign." Please slow down. Please be careful out there.

We didn't have any fatalities in Arlington. Fairfax County did have a couple of fatalities as a direct result of this storm. One was electrocuted. One was crushed by falling out of a tree. Again, our 911 service was out for four days. What do you do when you don't have 911 in the community?

We told the citizens to basically, go to the local firehouse. Our fire stations are pretty closely grouped together in an urban community like that. Flag down a police officer. We actually left firefighters and police officers in the fire stations to be the 911 center.

They were using their portable radios to call back to our ECC here, Emergency Communication Center, to dispatch resources. Then a couple days into it, the Community Emergency Response Team said, "Maybe we can take over that task for you," and they did.

We actually used citizens with radios, in the fire stations to be the 911 center out in the field. That worked really, really well. In fact, somebody walked down into the station down in Crystal City, and said, "By the way, the Harris Teeter down the street. I think there's a fire."

We sent resources down there and got it out really, really quickly. I think I already talked about

the generator maintenance, Verizon. It's so important that systems provide, not just redundancy, but [inaudible 55:44] checked, and if we had the system's system checked. Again, Verizon's done a lot of great work.

Power restoration, a lot of folks don't understand why their power's not coming back on when the people across the street, when their power's coming on. That just happens. We got a lot of questions.

We actually did a lot of community education for our power grid, how it's set up, and why one area's going to come up maybe before your area comes up. A lot of people, they still don't want to hear it, because they see the lights on across the street. I think our power company, Dominion Power, did [inaudible 56:23] work, because when they're out there restoring this power, their worker safety is of utmost importance.

They can't start, sometimes, working on it until some trees are removed. We're not going to start removing trees around a live wire, so there's a lot of coordination that has to occur between the power crews and the public works people that are actually working with the down trees.

Vulnerable populations, again, our human services folks, we're in all of these facilities, communicating with them constantly throughout the lifecycle of this event, making sure that people were safe, making arrangements if we needed to evacuate people. A lot of folks were evacuated to family members.

We worked with everybody, the facilities, and the family members to take care of folks. We didn't lose anybody in any one of these facilities. We did learn a lot of lessons about that. Some of the shelters that we would normally use really weren't available, though, because they didn't have generators.

We've done some things since then to make sure that some of our facilities that didn't have generators, now have generators. We've worked with some of these assisted living facilities to make sure that they have power generation redundancy as well. Communications with power companies, excellent at management level.

One of the things we found out in the field is sometimes the crews didn't communicate as well as they could, and that may have slowed up some of the progress, so we're working with them. We actually institute, or we incorporate the folks in the field in our command system, that we use very much like when we're coordinating the activities in a fire, or law enforcement event.

We've done much better since then. A lot of damage, and no fatalities. 1.6 mil in private property damage, 872,000 public property damage, and in comparison to the snow events of 2009 and 2010, about half. It's very hot out there, lots of phone outages, really, really hot!

60 percent of our county was without power, some of it for up to eight days. Dominion Power brought in workers from around the country, and actually Canada. We had all the power back on and restored in the county by July the 8th, so a lot of great work by a lot of people.

The slides right there, those two fellows in those yellow vests, those are community volunteers. That's the Community Emergency Response Team. We have over 500 trained community

members in Arlington County that are for response.

They work in the neighborhood so they're the first ones out there. They're the first of the first responders, if you will. They're trained in everything from utility control - - how to shut off power, shut off gas - - to first aid to light search and rescue to firefighting, you name it.

They're actually trained by our fire department and my staff and emergency management. After the directions we put them in a little bit of a non-traditional role by making them emergency communications dispatchers.

We're very, very proud of them. Our community came together. Arlington County has dozens of civic associations and the folks really do band together, and it really is about people helping people, so all of our county facilities are open.

As [inaudible 59:50] said, if they had power, we opened the doors, we brought water in. Just to get people out of the heat and just be nice to them. It was a mobilization basically of the entire county - - our parks department, our department of environmental services. Crews were out there 24/7 doing everything they could to get the debris removed, to get the power back on and restore the county back to some sense of normalcy.

To me the real stars of the show were the human services folks who were working with the vulnerable population in the assisted living facilities, the police department and the fire department, and the folks at Public Works who were out there cutting all those trees.

All told about 416 of our staff worked numerous 24/7 shifts during the recovery, totaling about 40,000 hours. We used every platform we have from pieces of paper in fires to our AM radio station to our Arlington Alert System to news broadcasts and news conferences with the local media to get as much information, including town hall meetings, to get information out to the public, because that's really what it's all about.

In my humble opinion, any large emergency really is going to be driven by the public. The public can make or break our response. People often say, "No, it's all about fire and police."

You know what? They're trained. They've got the equipment. They have the training. But if the community doesn't act appropriately...let's say it's a dirty bomb. The community decides they're going to run to all the local elementary schools and get the kids out. They can actually inhibit the ingress and egress of public safety assets.

We really need our community to be prepared, be informed. We look at them as partners, not as liabilities. We increased our subscription, our Arlington Alert...actually it's a little bit higher than that now. We are linked in with Twitter and Facebook. We send stuff out over every platform that I know of just to get information out to folks.

Again, lessons learned. If they come in, we use that...it's called the National Incident Management System. We use it every day, not just in Arlington but throughout this region and throughout this country. We do find, because we have a huge turnover, that a lot of folks in our community are not prepared.

It's not actually on their radar screen to be prepared. We're continually working. We're never done with the preparedness efforts here. September's Awareness Preparedness Month around the country and we always have activities that really reinforce that during the month of September. We also do it throughout the year. That's all I've got.

**Audience Member:** [inaudible 01:02:41]

[applause]

**Victoria:** Last but not least, Mark Mulholland.

**Mark Mulholland:** Good afternoon, and thanks Victoria at Secure World and Carol Anne and AMS for holding this panel and bringing this important issue to light. It's really a great opportunity to even be in the same room with some of our customers that we've heard about. That was really great. I also realize that it's about quarter after one and the melatonin from the fabulous lunch is kicking in.

[laughter]

**Mark:** I'll try to get through this fairly quickly. I'll bring the perspective as the guy who's had to bring the technical world together to make sharing of NOAA satellite spectrum work as best as we can within the realities of the 21st century consumer and the laws of physics. It's not working or do I need to push it?

**Victoria:** You need to turn it on.

**Mark:** Is that better?

**Audience Member:** He's not...Hit the button.

**Mark:** Yeah.

**Audience Member:** There you go.

**Mark:** OK? I'll stand closer. I'll spend a few minutes providing my own perspectives on the recently concluded polar satellite spectrum auction in conjunction with a couple of other bands and its impact on our satellite operations.

There are key lessons learned while preparing for that auction that most certainly apply to any future auctions. Although we didn't collaborate, I think I may have answered at least a couple of the AccuWeather questions.

The first questions you might ask are, why us? Why did they take our spectrum and want more? The IEEE published a really good article containing this chart back in October 2010 that answers these questions. The answer is actually pretty simple. Both NOAA and the broadband industry want the same band for the same reasons.

The arrow shows the approximate location of the frequencies in which most of NOAA's weather satellites transmit data. These frequencies are located right in the middle of the broadband sweet spot as depicted by the red block at the top of the chart. NOAA's sweet spot is also in the red

block.

We both want frequencies that aren't bothered by things going on in the atmosphere or inside buildings. We both want transmissions that penetrate buildings. For example, none of you want to miss that important text that's coming in while you're listening to all of us up here on the platform.

We both want our signals to travel in a straight line and not follow the curvature of the earth. We both like this band because broadcasts in these frequencies are not affected by bad weather, especially a heavy rain.

Finally, equipment that operates in this band requires small antennas. Imagine trying to use your smartphone if you had to carry a big antenna on your back all the time. If weather satellites and commercial broadband providers like to use the same frequencies, what's the tiebreaker to decide who stays and who moves somewhere else? A simplistic view is to follow the money.

I've compared the current budget submittals of all US civil space agencies conducting remote sensing and earth science missions. This includes NOAA, the land sat portion of USGS - - I probably should have included data collection that would bump you up about a billion at least, that Bob mentioned - - and various NASA earth science and climate spacecraft.

As you can see, the net revenue generated from the recent auction of frequencies at which most of these satellite programs operate was about 10 times the combined budgets of the three agencies operating these satellites and building future ones. If money were the only criterion we would be shutting off weather satellites right now. Fortunately that's not the case. We've been working on a scheme where we share the frequency bands.

Spectrum auctions are here to stay. My previous chart demonstrated the value of spectrum to the broadband industry and the enormous amount of money they paid for 65 MHz of spectrum before building a single tower, signing up a single customer, or hosting a single selfie. The demands for bandwidth will continue to be insatiable, not only by the public but also by other huge economic sectors.

Pick up the paper almost any day - - sorry, read the website on your smartphone - - and you will most likely find a story about new ways that the medical, transportation, or agricultural sectors plan to consume broadband. The laws of physics and economics say that the available bandwidth can only come from the spectrum currently occupied by government users such as NOAA.

Commercial broadband providers and equipment manufacturers are much more able to quickly respond changes in spectrum use or public demands than government agencies. For example, all of your iPhone 6s will be obsolete before the end of this year.

Satellite and ground systems generally require about 10 years on average to design and build, have very long lifetimes on orbit, and last many years beyond their design lives. As a result, we are locked into the same designs and product distribution systems for decades.

In one of the early spectrum-sharing meetings in 2010, I had another government colleague

comment to me, "What you NOAA people do with direct downlinks is so '70s." Guilty as charged. There is the general expectation that government systems can simply move to a different frequency to give up spectrum.

But while it may be straightforward for systems exclusively used by the government, such as military or law enforcement agencies, redesigning systems such as NOAA's that connect to the non-federal sector such as we heard today can result in significant cost and operational impacts. The next two charts illustrate these costs and impacts using a very familiar example from the not-so-distant past.

How many of you guys remember the digital TV converter boxes and coupons? I ordered my two. How many of you bought converter boxes for your analog television sets? Full disclosure - - I bought two of the Insignia ones from Best Buy.

How many of you bought brand-new flat-screen high-definition television sets costing a couple thousand dollars and the new digital home theater systems you had to buy in order to be compatible with your new television? How many of you built these costs into your family budgets? I won't ask how many of you incurred consumer debt in the process.

Spectrum auctions, as we experienced during the digital television conversion, cause users - - us - - to either spend money we hadn't budgeted to spend or to continue to receive television broadcasts or simply decide that we weren't going to watch television anymore.

Present and future auctions of weather satellite spectrum will require significant changes, perhaps costly ones, among our user communities if we are going to continue to provide the timely and accurate weather data our citizens deserve.

Not quite done with the digital TV story yet. After you bought all those new television and home theater systems, how did you get rid of the obsolete hardware that you...?

[crosstalk]

[laughter]

**Mark:** As you can see here somebody came up with a low-cost solution and simply dumped three analog television sets alongside the road in a rural dirt road in western Loudoun County, Virginia. I don't recall anyone offering coupons for a free disposal at a local landfill or holding special disposal days in local communities.

Instead the program was designed such that dumping televisions along the side of the road is an option. Just these three televisions polluted the landscape, still present injury hazards to humans and animals, and may contain toxic chemicals that can leach into the ground. Will we have adverse consequences in the weather satellite sector? We'll shortly find out.

As we proceed down the path leading toward sharing of NOAA's older satellite frequencies, several lessons learned resulted that I think are important to take into the future. Some industry standard analyses used to calculate interference characteristics and ultimately the size of the protection zones were shown to be outdated or sorely in need of revision. It is up to us to

demonstrate through testing that these standards do in fact need revising.

We were grateful for the participation of many domestic and international individuals and groups in the public comment period for the polar spectrum sharing. We can do better encouraging more parties to respond and actively participate.

We found that most regulators and policymakers understood that GOES provides nightly weather images and that rebroadcasts such as EMWIN are essential to the success of first responders. We were less successful explaining the more abstract concept, such as the criticality of ingesting polar satellite data into numerical weather models.

Ironically, all of this happened before Hurricane Sandy, which demonstrated the value of model accuracy. Thanks to many forecasters and broadcast meteorologists, terms like GFS and the European Model are now household words inside [inaudible 01:12:24] .

Regulators and policymakers declared that non-federal users would not be afforded protection. Those users, unfortunately, weren't that organized and vocal enough to effectively push back.

We, eventually, did an OK job protecting our critical polar sites, but we need to do a better job defining the role that non-operational science and non-federal users play.

Deloitte, in a 2014 study for the broadband industry, examined complexities involved with sharing a band with government incumbents, such as NOAA. This graphic kind of looks like a Myers-Briggs Personality Profile, and, actually, it's not all that far off.

The least complex sharing arrangement and, consequently, what we're using in the polar world is the lower left block, near the intersection of the horizontal and vertical axes. Static and continually defined is the most closely aligned with the polar spectrum protection zones.

Critical sites are fixed in location and transmission characteristics are known. That's actually fairly straightforward to be able to share those bands, at least, with the protection zones.

At the completely opposite end of the scale is a situation we will face if those spectrums are ever auctioned, because N1 in those rebroadcasts is used by federal, state, and local governments for severe weather and natural disaster events.

We cannot establish fixed protection zones because we do not know when, where, and for how long first responders will deploy. They will be highly dynamic in terms of geography and time.

According to the Deloitte study, this type of sharing arrangement is the least desirable for the commercial broadband industry. Does this mean that the regulators and policymakers will leave us alone? Does this mean that the broadband industry will decide that it's too tough and look elsewhere? Will the future administration and congress direct us to take measures to make this band more desirable? Time will tell.

When the sharing of the polar spectrum begins, NOAA's customers most likely to see interference are non-federal users receiving direct readout products from polar satellites. Geography is everything.

If you're lucky enough to be located inside, or very close to, a protection zone, you stand a good chance of remaining mostly interference free. If you are located within one of the top 100 broadband markets but outside a protection zone, you have a high likelihood of experiencing interference, especially during periods of heavy broadband use. If you are lucky enough to live outside one of the top 100 markets, your probability of receiving interference is reduced.

Where are the top 100 markets, you ask? There they are. I'll also point out that nine of the protection zones for the polar systems are located within areas comprising the top 100 broadband markets. There's a lot of incentive for the private sector to make sharing work, because they certainly want access to potential customers in these markets.

As we move ahead into the future, perhaps involving those products and services sharing, there are a few emphasis areas I think we can take ahead.

First of all, I applaud AMS's willingness to be a visible and influential focal point. Your spirit and influence encompasses the halls of congress, right down to broadcast meteorologists who can bring this issue into every American home.

Ironically, AMS can also communicate the message by the very broadband systems who desire access to our spectrum.

I encourage you to emphasize the whole scope of potential impact of first responders that cannot do their jobs protecting and serving their citizens without an uninterrupted satellite reception from GOES and GOES- R.

I would also urge you to capture these ideas in nontechnical terms that the general public can understand. I encourage you to seek out any and all opportunities to speak and publicly participate in comment periods and in forums like this.

I know it's a tedious job to routinely search the federal register and regulatory [inaudible 01:16:39] websites, constantly, to discover relevant notices that require a comment. If you find that person, pay them as much as they want.

With the resources available to AMS, I would consider conducting simulations that could demonstrate impacts of interference that GOES and GOES- R satellite broadcasts. I would call this exercise "A Day Without EMWIN." This could be modeled like Department of Defense exercises, or "A Day Without GPS," or "A Day without SATCOM."

It would be interesting to determine if EMWIN and other products corrupted by interference would have made a difference in warning about this week's severe weather in the southern US.

To wrap up, we in the weather recognition business must ensure that we remain ready and become even more ready, from the satellites, radars, balloons, and extreme gauges that provide forecasts and warning data, right down to state and local government first responders in the private sector, and the broadcast meteorologist media.

While the temptation to focus on enormous auction revenue numbers is great, we must not forget that we owe our fellow citizens the very best and accurate forecasts and recovery operations



possible, because we have seen, time and time again, uninterrupted and survival of communication is the backbone of weather recognition. Thanks, and I look forward to the discussion.

[applause]

**Victoria:** Thank you, Mark. We have about a half- an- hour left, and so let's see if anybody has questions. If you'd wait for the mic to come to you and identify yourself.

Actually, to start off, I have a question for the panel. It seems that there is an agreement amongst the panelists that, like it or not, auctioning is probably going to happen [inaudible 01:18:33] .

One of the issues we discussed, or one of the questions that we were thinking about is what are our options for mitigating this type of interference? What do we have for those who request a backup plan for this sort of thing? Also, panelists, mic is on/off when you're talking [inaudible 01:18:50] . Any thoughts?

**Panel Member:** From a technical standpoint, having a signal in the same frequency band as your earth station is a different problem than having it next door. Next door, you might have some opportunities to reduce it.

I'm afraid users that are non- federal, that wouldn't be in any kind of a zone that would keep signals away from them, which is the main, really, way to solve the problem, are going to have to come up with a solution where their antennas are located remotely, perhaps shielded in some fashion.

But it's going to be very difficult because of the user awareness not only of how you get your data from an earth station, it's about the same level of user awareness that is if I asked everybody in this room, "What frequency does your cell phone operate on right now?" because one, you probably do not know, and two, they are software defined radios and as some of the spectrum is sold, it could change. Mark?

**Mark:** I would just add to that that as I mentioned earlier, we designed and launched the satellite systems with about a 10- year lead time. If you look at the acquisition and launch schedule on our website for the GOES- R series, we launched the last GOES- R and it reaches and sends emissions sometime around 2040. I'll be 86 years old when that happens.

The satellite guy in me is a big fan of things like relay satellites, of things like [inaudible 01:20:36] antennas, but that requires a huge investment. The argument that you get is, "Well, just send the stuff over the Internet."

I think it would be a pretty hard job to run primary and redundant Internet lines from all of the [inaudible 01:20:54] pages around the country, or from rims of volcanoes that we don't know might erupt, back to one of the NOAA centers. Satellite communication is used because it's survivable and because it works, and because you don't have to rely on the ground infrastructure.

**Victoria:** Anyone else?

**Robert Peters:** I'd like to make three points...

**Victoria:** You have to identify yourself.

**Robert:** I'm Robert Peters. I'm with the GOES- R program [inaudible 01:21:33] communications. One of my standard examples is the Disk Network wanted to establish terrestrial applications about 10 MHz away from our telemetry.

If you compare the ratio of their power to the power of the signal we receive, and the distance, it's comparing the diameter of a grain of sand to a distance roughly halfway to Mars. This would be 10 MHz away. There's no way you can filter out that kind of signal on the ground.

My second point, [inaudible 01:22:18] is already receiving interference from Hell Square from Newport News. That's about 130- 140 miles away, and we're considering [inaudible 01:22:29] . That wasn't encouraging. A lot of EMWIN uses the earth stations mounted on the back of a pickup truck, and it would be hard to say how you could protect that.

I'd like to ask USGS, how would we engage 850 users? That would seem to be a good resource we should try to engage.

**Panel Member:** Do you want a response?

[crosstalk]

**Victoria:** Turn your mic on, Bob.

**Robert:** Those users are very well wired into the use of the game stations, and they're very active. When things go down, they complain very loudly to us.

In the past, we have notified them that the spectrum sales were occurring, and many of them have responded with concern to STP, or to perhaps the congressionals. I would assume we would do the same in this case, just to point out that it's occurring, and seeking their input on the whole process and any specific ideas they might have for us, USGS, as to how we might address the problem with other sorts of technologies or other strategies with communications.

**Panel Member:** I think Bob's answer kind of relates a valid point, that in many cases, these meteorological or hydrological products are they themselves an intermediate step in the process and the person that will be affected by the floods, or affected by drought, or the aviation user that receives space weather data that needs to reroute their flight.

There is one more step in this process, and if the information has a benefit to a sector of the economy of which that particular sector could be impacted. I think it's hard for us to convey to them, to translate this into how does interference back here [inaudible 01:24:43] understood whether infrastructure affects someone here, but I'm afraid that in many of these cases it appears that it does.

**Victoria:** [inaudible 01:24:53] ?

**Panel Member:** You said that it would be difficult. It may be impossible to get that across to

people because we rationalize a lot of things. I can rationalize, "Oh no, I am not going to get a flood where I lived, but I use my cell phone every day, and I would love to have more data, faster bandwidth."

That is going to be tough. Education is important, but I suspect it needs to be a little higher level than the general public if it's going to be effective, although we need to do it at every level. I agree with you there.

**Victoria:** This does raise the question. How do you get policymakers educated about this issue?

**Panel Member:** I mentioned earlier about the responses to the notices to the rule making for the proposal at the time, Polar satellite auction. Somebody in our operations office had the brilliant idea to send a notice out on EMWIN.

[laughter]

**Panel Member:** At least the people who used EMWIN that turned it on would see that. Polar users, it was hard to put a post-hypnotic message in a satellite image.

[laughter]

**Jack:** When I looked back on it, we got on the order of a couple hundred comments into the SCC website. You compare that with the tens of millions of comments that got over the rule making on net neutrality.

Somebody knows how to get the job done communicating and we didn't do so well the first time.

**Victoria:** Take advantage of the fact that the link...Oh, this is a secure world. My question is can we talk about the little awareness of other users around the world, including customers that are already using your products. I assume that some of them don't know how dependent they are on this data.

**Mike Steinberg:** What we have done is while loss of certain products could impact the accuracy and quality of some of what we do, generally the products are transparent and the users are transparent to that. If we were suffering a major loss of something, we would notify people that could potentially impact the quality or accuracy of what they get.

As a general rule, I don't think very many people are aware of that. Someone had mentioned the various models, the European model, how people are aware of that, but it's taken many, many people and many TV meteorologists and others years before people recognized that. I suspect that as reasonably weather aware people, we probably think a lot more people recognize those that really do.

**Panel Member:** Jog my memory, I came across the AMS Conference, about 2011. When all of this spectrum stuff was beginning to happen, I sat in on a presentation from the vice president of the Weather Channel. You could still find the audio of the presentation. She was talking about how their outreach to the public had changed over the years and what they were doing as a company to get ready for the smart phone era.

I am sure you at AccuWeather probably had the same conversations. In the private sector, they can do things that we can't do in the government like keep persistent cookies and log onto your site.

I remember her saying, "Well, people don't watch the Weather Channel anymore on television. They don't sit down and watch the weather." That's why even back then they were talking about going to more series.

She said, "We now understand people aren't going to sit home at their desktop and look at weather.com. They're going to look at their smart phones." They reached that understanding four, five years ago.

She also said that they had collected enough data to know that the average amount of time that people were on their weather app was about a minute and half. She said, "We're convinced that people check the weather before they head out in the morning and decide whether they need to bring an umbrella."

When you get into the models and the soundings and all that stuff that really good intense meteorology and science that goes into producing that decision to take an umbrella, that's part of the understanding too. In a lot of ways, we're victims of our success.

**Mike Steinberg:** We've had the same thing. Sure, we have a number of people, thousands and in some cases millions, who send us tweets, to get all our tweets and communicate very actively, but the vast majority of people just want to know, "Hey, should I wear a coat to work today. Is my team going to get rained out on Saturday? Am I going to get killed by a tornado tomorrow so I got to find a place to hide?"

They want to know how it impacts them and most people also, unless it has a major impact. It's hard to get them to take action.

What we really need if we want to have an impact is a multi-tier approach. Organizations like the AMS and the AWCIA do have various relationships, and sometimes have government days where they speak with legislators and others explaining from our perspective what's needed. There are groups that put together numbers.

For example, on the federal government maybe we will be able to get how many billions of dollars from offering this spectrum. I wonder what kind of study we could put together to show "Here's the impact it will have on forecasting and warning quality. Here's the impact that deterioration will have on public safety, on the economy, on business, on infrastructure."

It's great to say, "Hey, if I sell this I get 2.4 billion in cash tomorrow and maybe that storm will miss everyone anyway."

**David:** To add a little bit to your thinking there. International question. One example it's been the emergency manager's weather information alert is often a tsunami warning. Many island entities [inaudible 01:32:28] protectors. Although the spectrum issue today and 1675 to 1695 MHz is so much a US domestic issue, there are many that depend upon direct broadcasts as well as EMWIN, throughout the Americas.

It goes without saying that although almost all the member nations of the world meteorological organization offer forecasts and have satellite images on their pages. About eight countries and/or entities that fly and operate weather satellites around the world. All that data is freely shared.

Although our infrastructure here is fairly sophisticated, it may not always be the case in some of the other countries that you may be inquiring about.

**Panel Member:** Let me add to what Dave said. My experience has been that dealing with both the weather satellite world as well as the spectrum world, both domestically and around the world, there are very few times, if at all, where those two communities actually talk to each other.

There are great organizations that deal with weather satellite problems like CGMS, the Coordination Group of Meteorological Satellites. There are great groups of people both domestically and internationally that worked satellites spectrum issues for weather satellites and other types of science satellites.

The only way that CGMS finds out about spectrum issues is if I get to write a paper every year. You would be surprised how many times that weather satellite person from another country or another agency will talk about the spectrum issue. Then they'll say, "Well, here's your spectrum representative to this international group." I have to pull out name and contact information. They say, "Oh, yeah, he works right down the hall from me," at the same agency.

Getting the satellite and the spectrum groups together to talk about these common issues go a long way.

**Bob:** To the point of engaging our users and trying to get them to be spokesmen for protecting the sharing or the impact that frequency sharing might have. It's somewhat analogous to the aircraft accident that happened in France. That condition apparently existed for a long time before something happened that dramatized the impact of not having two pilots or two people in a cockpit.

I draw the same sort of analogy to this condition. We could probably operate for some period of time under frequency interference and the public would see no impact. It's those rare occasions. That's why the rare occasions that would only happen if you had primary communications break down, at the same time you had a critical time dependent event happening that would bring that to light.

It's really hard to sell that.

**Richard:** Richard [inaudible 01:36:13] from [inaudible 01:36:14] Satellite. I want to see, Dave, if you could expand on the international impact. Are there lessons learned that we could gain from other countries, other regions that dealt with the spectrum density issues and sharing and so on, especially for the Far East [inaudible 01:36:32] that are here?

**David:** Richard, there are a number of technical factors in each case that is a little bit different. Many people's concept of spectrum sharing and interference segregation may differ depending

on whether you're a [inaudible 01:36:50] operator and you're trying to keep your signal from interfering with something else that is similar strength that's on an adjacent channel, versus a satellite operator that's thinking of getting interference through a transponder in space. I have problems helping you to [inaudible 01:37:07] .

All the specifics are a bit different. The other thing that complicates this problem a little bit is, the laws of electromagnetics and propagation prediction capabilities differ greatly. You can pick different commonly accepted in engineering terms of propagation models, you get widely differing answers as to how close a particular strong signal has to be before it's going to cause harm to your receiving system.

The receiving system is the RF or analog frontend amplifiers and antennas and those components and then pretty much everything else behind, at least these days, are digital. There is a range in which it functions properly and there is a correction capability often built into that, which can fix problems only up to a point.

I don't know if I can contrast, Richard, internationally, but I could give you a similar example if you have a satellite television. You have an extreme rain event or a serious snowstorm. You're watching the signal and then all of a sudden it starts to pixelate and you see some splotches in it. That's because the digital correction can't keep up with the interference.

Pretty soon, boom, it's gone. You look up at the screen and it says, "I'm sorry, your service doesn't work."

I am afraid digital systems are not so much degrading as it's what point does it clean go away? That's the factor here that light users not have to discover after the spectrum has been sold, after someone installs and makes the investment in both the spectrum and the infrastructure. Wait a minute. It doesn't work.

There is a very similar situation that has occurred recently between the electronic news gathers and the LTE signals in downtown New York City. Something that they have been working on because one of the electronic news gathering channels is very close to one of the news services and it's causing their receiving antennas interference.

After they tried to work together, there was a very detailed legal filing in the last few week from their law firm, from WEUC, through the SCC to try to resolve the issue.

There are a lot of aspects to this problem. There is probably no simple one answer.

**Victoria:** Back to the recent question line [inaudible 01:39:24] . Does the [inaudible 01:39:27] spectrum have a definition what interference is? Or is me that...You're shaking your head yes.

**Bob:** Dave will have to help me on this. They define harmful interference, 10 DB above the noise threshold. Is that right?

**David:** I'm not sure to the best of my knowledge that there is a legal definition of harmful interference.

**Panel Member:** 10db is the point in which you can tell somebody to shut down who you think

is interfering with you if you can find them. What catches me about that term is harmful interference. It doesn't mean no interference.

There are times where you can get interfered with by someone else operating according to their license. It happens. I'll cite one example that I still haven't figured out.

I live about four miles from the Leesburg airport. Every Saturday morning about 8:30 or so, if we're still hanging around, we have WTOP on, there's some general aviation pilot that I hear him calling the tower over WTOP.

That certainly isn't in band interference, so there's some sort of harmonic or some sort of atmospheric propagation that causes that interference. The important thing is I know it happens about 8:30 every morning so I can plan around it if I am home at 8:30.

**Audience Member:** I'm Mangesh Sannala from the embassy of India. I represent the Indian Space [inaudible 01:41:16]. My question is, we saw that unfortunately the central focus on the frequency of [inaudible 01:41:27] broadband users.

The other broadband users versus the weather satellite users coincide. Given the money involved and the perhaps more and more applications is going to be out on broadband, we don't see in the near future the central focus for that broadband users is shifting from them.

My question is have you given a thought of coming with the weather satellite products that use frequencies other than this frequency? Instead of us going away from rather than expecting them to not to encroach in our range.

**David:** I mentioned about how long it take to design and build a satellite system. If you use the time line of the last GOES - R reaching its end of mission around 2040, that means you need to start designing the son or daughter of GOES - R sometime in the late 2020s.

In the late 2020s, you need to make a prediction on what the broadband industry is going to look like in 2040. I am not sure I even know what the broadband industry is going to look like next week.

When I made the comment earlier that they change a lot more quickly [inaudible 01:42:53]. It's a losing battle to keep up.

**Panel Member:** Since that 2040 is just the deployment, you really need to predict out through 2060.

**David:** That's right. We'll be stuck again.

**Paul Tower:** My name is Paul Tower and I work at Lockheed Martin. We support the Air Force weather program called Mark IVB. That supports not only the Air Force, but also other branches of the military.

We have sites not only domestic, but also international that support geostationary and polar meteorological satellites. Most of those are [inaudible 01:43:39], but we went through the whole and they were selling off the spectrum of the polars. Filling out all the data that they required,

stressing how they were going to impact us.

Since that time, magically all of a sudden we're seeing interference all over our satellites, especially in the L bandwidth. I wanted to stress [inaudible 01:44:07] along with it, we're ramping up for GOES-R and obviously the concern is there that it's a hardware that we're going to face impacted the same way we're impacted right now.

We're seeing very poor data [inaudible 01:44:22] passes. It's a huge concern we have, for sure. I wanted to stress the fact that we're seeing it now with GOES-R and how it's impacted us there.

**Victoria:** Any final questions?

**Panel Member:** I'll add some more pessimism to this.

[laughter]

**Victoria:** Great.

**Panel Member:** On the question of a margin [inaudible 01:44:58], ITU normally does their coordination that the interference should be 6db below the thermal noise level. What we're being asked to do now is accept interference that completely uses up our implementation margin.

Since we're, especially in those articles using highly coded length as pointed out that means we're looking at a gradual degradation. We'll lose the signal completely if the interference is slightly greater than predicted.

**Panel Member:** I would like to say it's difficult to convey in engineering terms to the general public. I think you hit it quite well. It's not that you're going to have a satellite image with some blotches in it, which in itself I suspect it would be difficult for a meteorologist to try to get situation awareness.

It's either going to be there or it's gone. It's one thing to be a federal user, maybe you have protection from a regulatory standpoint of a zone. Of course, the zones, we're talking about a keep away region that people can, perhaps penetrate, if the math is right.

But those are all populations, those are all based on assumptions. The laws of electromagnetics are going to do what they do and the proof of the pudding is when you turn it all on and it works, or doesn't work.

Our objective is really to try to get the word out on something which probably wouldn't make you a very popular cocktail speaker at a party. But the place we discovered this problem is not when it happens, after everything is in place.

The place is understand how the data comes to someone that you need it from, whether it's ideological data that a local district needs for their flood management, whether it's information into private or public numerical weather prediction.

Whether it's information that an emergency manager in tornado alley needs, now is the time to understand that this sharing may come at a cost. It's difficult to figure that out, but it's very



important that we think about it.

**Victoria:** I think that's a good way to end this discussion. I'd like to thank AMS for co-sponsoring this event with CQ World. Please join me in thanking our panelists.

[applause]

**Victoria:** This recording and transcript will be up on our website promptly in the middle of next week, so feel free to check back if there's any [inaudible 01:47:41] . Thank you very much.

Transcription by CastingWords