Session 4: National Space Weather Strategy and Action Plan Update

Speakers

- Mr. Steven Clarke, Director, Heliophysics Division, Headquarters, NASA
- Dr. Jeffrey Love, Research Geophysicist, Advisor for Geomagnetic Research, USGS
- Mr. Kenneth Hodgkins, Director, Office of Space and Advanced Technology, US Department of State
- Moderator: Mr. William Murtagh, Program Coordinator, Space Weather Operations Research and Mitigation (SWORM) Subcommittee and NOAA Space Weather Prediction Center

William Murtagh: Session four on the "National Space Weather Strategy and Action Plan Update. As many of you know of course in October 2014, on behalf of the President John Holden, President Chief Science Advisor working very closely with Tommy Dickinson ordered the development of a national strategy and action plan, recognizing a reliance of advanced technology.

Technology vulnerable to space-weather and recognizing how much we learned about extreme space-weather's potential impact on this technology. Recognizing overall the importance of some kind of cohesive national strategy to address this concern, we embarked then on this initiative to develop the strategy and action plan.

At the same time as we were directed to do that, we were directed to form the SWORM, Space Weather Operations Research and Mitigation Task Force.

Today, we have already had quite a bit this morning, references and some detail on the activities of the SWORM. Now we are just going to do a little bit of a deeper dive. We brought together some of the key members of the SWORM or was the SWORM Task Force.

Of course, now from the executive order from the President is now the National Science and Technology Council, Space Weather Subcommittee. We brought the senior members of the Subcommittee here with us today to give us an update on the implementation of the action plan.

A lot has happened over the two years and as much as we can in any public forum, we want to keep everyone advised in just where we are and where we are going on with the implementation of the action plan.

With that, today are our speakers. We have Mr. Steve Clarke. Steve, of course, is the Director of the Heliophysics Division at NASA. Also, have Dr. Jeffrey Love, he is an advisor for the Geomagnetic Research Geological Survey of USGS in Golden, Colorado.

From the State Department, Ken Hodgkins, he is Director of the Office of Space and Advanced Technology. Without further ado, we'll jump right into it. I'll ask first for an update from Steve Clarke from NASA.

Steven Clarke: Thank you, Bill, and good afternoon. I'd like to thank the US Air Force and the Secure World Foundation for hosting the NSWAP this year and certainly, shout out to Mike Bonadonna for doing a fantastic job of coordinating this and getting it kicked off the right way.

At the risk of some duplication of what you've heard, probably a number of times this morning, I'm going to talk a little bit about the Space Weather Strategy and Action Plan but mainly focus on the progress that we've made as a body. First, under the task force and now under the Subcommittee.

As you've heard this morning, probably more than once, the Strategy and Action Plan was released in October of 2015 followed by the executive order 13744 which was signed by President Obama in October of last year.

Essentially, in section 3B of the executive order, it established the Space Weather Operations Research and Mitigation Subcommittee underneath the NSTC.

Along came the Space Weather Research and Forecasting Act out of the Senate which also codified underneath the National Science and Technology Council, this Interagency Working Group on Space Weather which we call SWORM.

I think you heard earlier too that we believe the House also now is looking at bringing forward their version as well.

As you can see, we do have excellent support from the administration, the new administration and with Congress to continue this important effort. The SWORM is underneath the Committee on Environment, Natural Resources, and Sustainability, CENRS.

Here's a breakdown of the various Subcommittees underneath CENRS. We have the three co-chairs. Louis Uccellini is the one standing member co-chair from the start of this.

Rachael Leonard is the General Council at OSTP and Robert Kolasky is the Acting Deputy Undersecretary for National Protection and Programs at Department of Homeland Security.

I do want to give a shout out, as was mentioned earlier too to Tammy Dickinson and to Caitlin Durkovich from DHS who, along with Louis, really got this thing kick started across the finish line. Now we're into a new administration and we're continuing on.

Thank you to all the co-chairs for that and our new co-chairs as well.

Underneath the co-chairs, you see the departments and agencies. That's where all of the agencies have their principals. One of which, of course, I'm the NASA Principal. The Exec. Secretary is Michael Bonadonna. The working groups for all the various goals and actions.

You've seen those cover pages of the strategy and action plan a number of times and I think you've also seen the six strategic goals in the action plan. What I'd like to do is move forward and give you a progress summary of how we've been doing in each of these goals.

In goal one, which you heard a little bit about earlier on the benchmarks for space-weather events, there are a number of actions under there which are about 75 percent submitted or on track.

I think Steve Volz showed a different graphic with similar metrics, but what I want to show here is that the phase one benchmarks which was out on the Federal Register and public comments were incorporated. We're close to having that submitted to the Subcommittee actually in July, next month, which is right around the corner. That's going very well.

On goal two, the Enhanced Response, on the Response and Recovery Capabilities, which Department of Homeland Security, mostly FEMA is leading most of those actions.

We have a greater than 90 percent completed or on track. Improving the protection and mitigation efforts, about 85 percent completed or on track. The improving assessment modeling prediction of impacts on critical infrastructure, about 75 percent.

Overall on the first four goals, you see here, we're 75 percent or better on the actions that came out in the action plan almost two years ago. On goal five, and Louie talked more about this, this is where the R2O2R resides. We're about 75 percent complete there and submitted or on track.

When I say submitted, the final products or responses to those actions have been submitted to the Subcommittee. They are in queue for review. Completed means the Subcommittee has already reviewed them and they're considered complete. No further action required.

On track means that we're on schedule or we've adjusted the schedule and gotten previous approval from the Subcommittee to move those due dates based on resources or whatever needed to be moved, and that means we're on track.

On the last International Cooperation, they probably get the gold star of all the six working groups, they're greater than 90 percent completed, submitted, or on track for those goals.

The real takeaway here is that significant progress has been made by all of the working groups and the goals across all of the agencies that are participants. There are 99 actions in that action plan and in just a matter of 20 months, we've made this significant progress.

It's really due and I can't underemphasize this, the enhanced and dedicated cross-agency collaboration.

A lot of the agencies have worked together in the past ad hoc or for various common focus areas. Certainly, the Space Weather Strategy and Action Plan brought all the agencies to the table and in my years. I've never seen the agencies working so well together.

We're continuing to have that collaboration increase as well. Overall, this has, I think, been a fantastic national effort by the government agencies.

Some significant accomplishments coming out of the workgroups I wanted to talk to you about. On the benchmarks, I've already talked about nearing the completion, the phase one benchmarks and that the final will be submitted next month to the SWORM Subcommittee.

GPS data release. In the executive order, the DoD was asked to release GPS combined X-ray dosimetry data that they have been collecting since the GPS constellation has been flying.

In fact, DoD has released the data through Los Alamos National Laboratory and NOAA is receiving this data and they will be publishing the data through the National Centers for Environmental Information at their website at the data.gov.

I will tell you, it doesn't stop there. We are continuing discussions with DoD and with Los Alamos about obtaining other data on other platforms such as the geosynchronous orbit. We expect to work through those agreements as well. This has been a very successful collaboration.

Research-to-Operations-to-Research, you heard a lot about that this morning. There was an R2O2R plan that was put out on the Federal Register for public comment. Those comments were received and adjudicated.

All of the commenters were contacted and all of their comments discussed and that final plan is going to be submitted to the SWORM Subcommittee next month as well.

I did want to highlight, and Louis had mentioned this earlier, about the NASA-NOAA R20 MOU which was signed in late May.

We have a kick-off meeting Thursday as he mentioned, where specific tasks are now going to be set in motion. They've been planning meetings to get us to this point. Milestones will be set up with reporting back up to Bill Lapenta and me on the progress.

Everyone is eager to start working this. We're going to start looking at additional research models that can have some operations applicability and how we can enhance and mature those models to then transfer over to the operations folks.

We're currently working with NSF as well to finish up an MOU to incorporate R2O between the ground-based observations as well with NSF and that's moving along nicely.

The FEMA concept of operations, I think, Kenyetta talked a little bit about this this morning on the first panel, the Federal operational concept and response checklist is in development, and this is working across all of the government agencies. This is nearing completion as well. The checklists and the CONOPS will be submitted to the Subcommittee for review.

On the International Cooperation stage, there was a "Space Weather as a Global Challenge 2017" event, May, at the Embassy of Italy. We had over 100 participants from 20 countries.

The Department of State obviously coordinated that. Shout out to Chris Cannizzaro who's in the audience for getting that set up. Various topics were discussed. Highlighted research, observation services, UN activities and industries perspectives -- all were shared.

We're seeing increased interest from all around the globe on the space weather. What we're doing here in the United States, how they can participate, how it can help their countries as well.

There will be a SWORM website where there will be publicly accessible data related to the Subcommittee activities. That is nearing completion as well. It's going to be sworm.gov website. It's not active yet but we're very close. Once that's approved to go live, it will go out for beta testing for two weeks.

Comments will come back from folks that access that website for any potential improvements. Folks will be able to track the progress that we're making actually on the web as well.

Speaking of the International Cooperation, we do have an upcoming forum, The UN/US Workshop on the International Space Weather Initiative, which is going to be held at Boston College at the end of July, beginning of August.

Again, you can see there's increased interest, increased number of forums that we're working to work with our international partners, because this truly is not just a national effort. It is a global effort. Certainly space weather can hit anywhere on the globe at any time.

As we engage our international partners, they're looking at how we're leading this effort here in the United States and how they can participate as well.

In summary, the National Space Weather Preparedness is supported again by both the Administration and Congress. The Subcommittees was established under the NSTC which is providing that continuity of all the work that we've done since the inception of the strategy and action plan.

We've had a lot a significant progress made. I say despite budgetary challenges, there have been no real increases for any of the agencies from a resource standpoint to work these actions. Again, this has been a highlight of this collaboration across the agencies as well.

As we move forward, certainly there will be some additional resource needs and we'll continue to work that with the administration with OMB and so forth as we move forward.

Enhanced cross-agency collaboration, I think I've talked about that and the strong international interest.

With that, I'll leave time for my other panel members. Thank you.

[applause]

William: Thanks very much, Steve. Turn it over to our next speaker. Jeff Love from the USGS.

Jeffrey: Yes, hello.

I'm going to give you a whirlwind tour of the benchmarks that have been developed for Space Weather Action Plan Goal One for extreme space-weather events. This subject involves a frightening diversity of physics. Stretching from the sun, the solar winds, the magnetosphere, the ionosphere, and I'd like to emphasize even the solid earth underneath our feet.

There's five different goals led by five different people. I was the goal lead for goal one, which is about geoelectric fields. Elsayed Talaat led the goal on ionizing radiation. Rodney Viereck on ionospheric disturbances. Doug Biesecker, solar radio bursts, and Tim Fuller-Rowell on atmospheric expansion. I'd also like to emphasize a whole lot of other people were involved and I think all of their names are on this long list.

Space Weather Action Plan Goal One, again, developing these five different benchmarks for extreme events. The goal is to develop 1-in-100-year metrics of theses extreme events to try the best we can to define what that means.

1-in-100-year event and also to consider and hopefully obtain theoretical maximum estimates for the most severe benchmark measure that could be obtained for these five different event types.

Phase one was basically completed at the end of 2016 and it was focused on a quick turnaround analysis using existing data and methods to make the best estimates possible for these five different benchmarks.

A document has been put together, it has been reviewed and we received public comments. It has been revised. It will soon be published by the National Science and Technology Council.

Phase two is scheduled to be completed in 2018 and it amounts to a more rigorous analysis of these five different benchmarks.

To put together a 1-in-100-year event estimate, there are some significant challenges. In particular, we haven't been measuring some of these phenomena for 100 years. In many cases, we have data that stretch for several decades, 40 to 50 years.

Sorry, am I talking too loud in this? Am I? [laughs]

It sounds really loud to me. To analyze 40 or 50 years' worth of monitoring data to make a 1-in-100-year estimate, you need some additional information. You basically need a statistical model, and the estimates you make, they are then dependent upon the validity of that statistical model and the short duration of data that you have.

Another way and a method that's sometimes used in some cases for developing these benchmarks, is simply to look back across the sparse historical that we have of extreme events. In particular, people like to ask about the 1859 Carrington event which was certainly an intense event. It is however an event that wasn't very well recorded.

It's an interesting benchmark but it isn't always quite so useful for coming up with quantitative type benchmarks or the type that we are striving for under a goal one of the SWORM assignment. In some cases, we use some of the extreme events that were realized during the International Geophysical Year.

We have data. Sometimes we have statistical models but on top of that, we also have to convert those data into quantities that are useful for estimating effects of space-weather.

These models, generally speaking, incorporate a complex interactions between the Sun and solar wind, geospace and the solid Earth. Sometimes, we also rely on auxiliary empirical relationships.

Moving on to the first goal, which is about induced geoelectric fields, the objective here is to develop benchmarks for geoelectric fields that are induced in the electrically conducting Earth during intense magnetic storms. This is incorporating basically the physics of Faraday, Ampere and Ohm's law.

Those three laws put together summarize geoelectric fields that are induced in an electrically conducting medium. These estimates are important for evaluating the vulnerability of the electric power grids, and they are needed by the private sector in particular to respond to requirements by regulatory agencies.

Summary of the geophysics in this cartoon schematics shown below. Geomagnetic field variation is realized by solar terrestrial interaction above our heads. It induces electric fields inside the Earth. The efficiency of that induction depends on the electrical conductivity, structure of the Earth. That can be described in terms of an impedance.

It's basically a filter of an inputted signal, the inputted signal being the geomagnetic variation and the outputted signal being the geoelectric field variation.

In developing this benchmark, we have combined two different datasets -- magnetotelluric survey measurements of the Earth's surface impedance, that relationship between geomagnetic and geoelectric field variation.

We combine that with the statistical analysis of geomagnetic field variation obtained from a long running magnetic observatories, including those operated by the USGS.

The magnetotelluric survey is being sponsored by the EarthScope Program, which is a National Science Foundation Project, which is managed out of the Oregon State University. The analysis that went into this estimate of the geoelectric benchmark displayed here as map is the multiagency project, shown there on the right. All the different agencies there involved.

This map essentially shows the amplitude of geoelectric field variations. It would be realized at different locations across the United States over a 10-minute period of time on a once per century time scale.

The geoelectric field amplitude there, shown on the lower left of the diagram, measured in volts per kilometer. You can see that it spans a couple of order of magnitude.

That granularity and that range and the induced geoelectric field is due primarily to the complex solid Earth and the complex impedance that we have as a result of conductivity variations in the structure of the Earth.

We anticipate, this kind of product will be useful for evaluating the robustness and the resilience of electric power grids.

Second benchmark I'd like to discuss is ionizing radiation. The objective here was to develop benchmarks for solar energetic particles, originating from solar flares and coronal mass ejections. Three different types of benchmarks actually developed for this particular project.

Radiation belt particles that are contained within the magnetosphere and cosmic rays, that originate from the outside of the solar system.

All of these can affect human health and interfere or damage technological systems that are in different orbits around the Earth, also including high altitude pilots. It can affect the health of high altitude pilots and passengers as well.

The analysis basically combined historical data and model data. It developed a spectra for different types of radiation in different locations around the Earth, including geosynchronous Earth orbits, putting together proton spectra, low orbiting Earth satellites, putting together power spectra for those particles as well, and spectra for the radiation that can be experienced by high altitude aircraft.

Also different standards were developed for the radiation belts, geosynchronous orbits, and high altitude orbits, and cosmic ray particles as well.

The next benchmark, ionospheric disturbances. Ionospheric disturbances can adversely affect radio signals that propagate through the upper atmosphere. This can disrupt communication, navigation and

any kind of signals that are basically radio waves. Surveillance capabilities over a large areas on time scales ranging from minutes to hours.

The objective here was to develop benchmarks that characterize ionospheric radio absorption and a duration of absorption periods as a function of frequency. Total electron contents in different ways -- the slant, vertical and rate of change -- and the ionospheric refractive index, and the peak ionospheric density and the height of that peak.

This diagram here represents the complexity of this assignment. You can see there's a lot of different phenomena involved. I would say, to some extent, it's very difficult to define these benchmarks. There has not been sufficient information or adequate modeling to develop benchmarks for this.

Of all the benchmarks, this one certainly remains a work in progress. There weren't specific benchmarks that were developed for this particular objective.

The next benchmark, solar radio bursts. Solar radio bursts are large enhancement in solar radio noise produced by the Sun. They are often associated with solar flares. They can affect the large range of radio frequencies and last up to about 10 minutes or so. They can interfere with radar communication, tracking signals, and GPS signals.

There's a good set of historical data that quantify this. These data have been analyzed statistically, basically analyzing the statistics and extrapolating using the power law. We do have a good quantified benchmarks for this particular value for 100 year estimates.

We can see from this power law fit to the data though that the extrapolation has been made to the extreme events is possibly not very consistent with the data. There's some additional analysis that needs to be done. It's admitted in the analysis that the estimates are probably overestimates of the extreme event benchmark.

The final goal is for upper atmospheric expansion. The atmosphere can expand and it does so in response to ultraviolet radiation from the Sun, including solar flares. It can also be heated by precipitation of particles and joule heating that's realized during magnetic storms.

Atmospheric expansion leads to increased drag on satellite that can change their orbits, increase position and certainty and essentially reduce the orbital lifetime of satellites. It's an important issue, especially for low orbiting satellites. In addition, it can also interfere with the tracking of orbital debris, space junk that is required for collision avoidance.

Tim Fuller-Rowell and his team developed a good set of benchmarks for this. I would just describe them here in tabular form, showing the percentage of expansion, increase in density that can be realized at three different altitudes for five or six different phenomena.

Some cases are significant increase in the density. It can be realized at the altitudes for low orbiting satellites.

Want to summarize a few points here. I would like to say that we have worked really hard on the physics but this analysis would certainly benefit from additional analysis, which puts this into practical terms.

If we talk about the atmosphere expanding on certain percentage, we'd like to know, and tangibly, what that means for satellites. How many satellites would be affected? That would be an interesting quantity to know.

Similarly, for some of the other benchmarks. For example, for the geoelectric field, there remains a substantial amount of work to take these hazard maps that we've developed and to translate them into the actual tangible effects on power grids.

The development of these benchmarks highlights the importance of long term monitoring, geophysical surveys and physics-based modeling.

Though the benchmarks were developed essentially independently, I think we all realize that during an extreme space weather event, there will be many extreme types of phenomena that will be realized. These different benchmarks are actually correlated with each other.

There's opportunity there for a statistical analysis that looks at the correlated occurrences of these extreme phenomena.

In addition to that, in addition to simply doing a long term forecast of what might happen, there's significant opportunity for doing analysis of specific events, what I would call scenario analysis and developing real-time products.

Of course, I'm going to close with this cliché. There's plenty of opportunity here for other researchers as well.

With that, thank you.

[applause]

William: Thank you, Jeff.

The all six international strategies focused on increased International Cooperation. We all know space-weather is very much a global impact, requiring a global response.

It was appropriated that the State Department on that goal, goal six. We've got tremendous work from Chris Catanzaro and our Principal, Ken Hodgkins. Ken is our next speaker. He gives an update on goal six international activities.

Kenneth Hodgkins: Thank you, Bill.

I'm going to give you a different perspective.

[background conversations]

Kenneth: OK. That's good.

[laughter]

Kenneth: I'm going to give you a different perspective. I joined the Federal Government in 1980, when I was about 10-years-old, because I'm really not that old.

I have to say that this interagency process, and for those of you who aren't part of it, or those of you who are part of it, this was really an incredible thing because Bill deserves all the credit for getting us to the point that we are on the space-weather.

The reason I say it's incredible is because we brought together, or they brought together a hugely diverse interests in agencies, and they all had a shared vision. It wasn't fighting over, "Well, I'm not going to pay for this. I'm not going to pay for that." It was, "OK, we have this issue."

Space-weather, which has not only national but international implications, we have to understand it and we depend so heavily on space systems and ground base systems that we can't afford to have some severe space-weather event that could knock those out.

I'm not a scientist. The closest I got to science is political science but I do know that when we have some challenge, in my sphere, deals with space, we have to look at it and we have to look at what we can do.

The space weather issue is low hanging fruit from my standpoint, which is we have research, we have events, we have people that know what they're doing, and we can translate that, for me, into space diplomacy and diplomacy for space.

The point that we made when Bill first start organizing this whole interagency review was, we want other countries to cooperate with us, help us in expanding our observation and forecasting capabilities. We don't want our friends' and allies' systems to go down because of a severe space-weather event.

That's why we wanted to see all these domestic agencies step up and say, "OK. This is what we can do internationally. This is what we can do to increase the awareness among policy makers in other countries." That space-weather is not an abstraction, but it has practical consequences.

You've seen these presentations that...again, I'm not a scientist but I take them at their word of the things that we need to do. What we wanted to do in this overall strategy is have a really, really, really thick comprehensive section on International Cooperation that would take the expertise of the various agencies.

They can use it through their various mechanisms that already exist to underscore the importance of the work that we're doing domestically, but also what they could do domestically.

The second thing is that we wanted to use this whole process to go to a little bit higher level and not necessarily make these scientific cases but to say through various mechanisms, like the United Nations or through our bilateral activities, say the whole issue of space-weather is emerging because we have so many different agencies looking at it from a different point of view.

We want your particular governments to look at that as well, for our purposes, in terms of our bilateral relations, but we also want to make sure that our friends and allies maintain their infrastructures as we maintain ours.

The one thing that struck me when we first started talking about space-weather, and the whole interagency process, and what was going on is that if you look at it...and this a way I look at it because I don't deal necessarily with ground infrastructure but I deal with the space systems.

If you have a satellite going down, you have to figure out whether somebody's interfered with it intentionally or whether it's happened naturally. If you don't get the right decision, then you're going to

make the wrong decision, which is if you think somebody intentionally interfered with your satellite, then you have one matrix that you're going to follow.

If it happens naturally, I, from space-weather, which we know as reality, then you take a different course of action. The work that we've been doing, particularly on the GPS side, is working with other countries on resiliency, and making sure and ensuring interoperability and compatibility.

We have another international activity where the US, Russia, China, Europe, India, and Japan, and the United States have a committee on global navigation satellite systems. We've agreed on common signals. We've agreed on common principles, on transparency, interoperability on the civilian side.

One of the other things that we've looked at is the GNSS signal is a weak signal. It's vulnerable to space-weather. It's vulnerable in various orbits around the world. We want to make sure that there is some ability to decide, is what's happening to our signal naturally occurring or it's being interfered with?

For me, this whole exercise on the space-weather strategy and then the implementation plan has huge, huge foreign policy implications because -- on the part of GNSS -- we're developing a system of systems.

We want to make sure that these signals operate in an open way, but also operate in a way that we can determine what's going on. That's why the international section of this strategy was so important to us, because we wanted to form a basis on which, at a national level in the US, we can make the case that these are the things that we're doing domestically and we want to translate those into international action.

Steve already mentioned the workshop in Boston in August, which I think is an important one. Within the UN, we also have an event next year called "UNISPACE+50."

It's the 50th anniversary of the first international conference on the Peaceful Uses of Outer Space, which took place in 1968. We've had three of them -- one on 1982, one in 1999.

The next year, we're going to commemorate the first one. We have seven thematic priorities, but of them is space-weather. This is important because the UN has its weaknesses. The Committee on the Peaceful Uses of Outer Space, that I'm the representative to, has done really a good work over the past 50 years.

It's not easy, but we've been able to accomplish something. Having space-weather as one the thematic priorities really, really important because what that means is that going forward, within the UN system, we can use that to raise political awareness about space-weather, its impact on space systems, as well as on the infrastructure on earth, and to encourage greater research and forecasting capabilities.

Final point is we have civil space dialogues with Japan, with China, with Vietnam, with the Europeans, with Russia.

We can use those dialogues as well to raise potential cooperation in space-weather because this is the other thing that we were looking at when we put together the international action plan, which is how we're going to increase our observational capabilities. I think we have one satellite up there now, the DSCOVR?

An ACE.

What we want to do is look at the possibility of getting other countries to launch satellites that can give us the observational capabilities that will give us the possibility of having better forecasting in terms of severe space-weather events.

This is all part of that, the package that we put together for this action plan. I apologize for not having slides. Like I said, I'm a product of the '50s.

[laughter]

Kenneth: The fax machine was a big revelation for me. If you look at the action plan on the International Cooperation, it really is comprehensive and it really gives us a firm foundation on looking at what can be done at the research level, what can be done at the political level, what can be done at the space agency level.

For those of you who are interested in that, you should really take a look at it. I'll conclude and leave time for the rest of the panel by just saying one more time that this process was really fascinating for me because it brought together a whole lot of agencies that I'd never dealt with before.

It was fascinating over the fact that they were all speaking the same language, which at one point or another, I might have understood or might not have. You can't underestimate the accomplishment that's been done here in terms of the overall strategy, but for me, particularly, on the international side.

I think it's to Bill's credit and to the co-chair's credit that they were able to bring everyone together. I don't expect that we're going to make any major changes now in what we want to do.

I'll leave it at that. Thank you.

William: Thank you, Ken. Steve mentioned earlier the space-weather, the sworm.gov website that should be released soon. The idea behind that, as he mentioned, was we want to make sure the process and activities within the SWORM was transparent as possible, get that information out and make it publicly available to everyone.

That will happen. The other way, of course, we tried to communicate the activities progress the SWORM as true venues such as this. We'll take advantage of the next 15 minutes to open up to the floor to ask questions of our panel on anything that you may be interested on regards to the implementation of the SWORM.

As you're thinking about your questions, I want to put this to the panel, said you finished on it, but I'm interested in Ken's perspective as well, and that is this issue of the benchmarks is so critical to process. It was the first goal in the whole action plan.

If we're going to reach out to industries and say, "You have to protect against this natural phenomenon, the space-weather," the question is, what level do we have to protect against?

We wanted to find these benchmarks. As we put the benchmarks out for public comment, it was interesting that we did get some public comment from the International Community interested in engaging.

If it indeed is a global threat and requiring a coordinated global response, perhaps we should be working together on the international front, on the development of these benchmarks, and just to explore Steve's last comment as a possible option as we move forward. I'd like to get Ken's thoughts on that.

Kenneth: Again, I know I sound like a broken record. I'm not an expert. Here's the thing that was striking for me, and it has nothing to do with space-weather.

We were talking with the major operators of geostationary satellites, Intelsat, SCS, Eutelsat, a whole number of others. We're developing a set of international guidelines on the space operations. One of them includes space-weather and the exchange of information.

When we're talking with these operators, they said, "We use maybe four different models to determine where our satellites are in the geostationary orbit." All four different models come up with a different conclusion. You might think you're here, but your other guy thinks you're there.

That struck me when we first started talking about the space-weather because my understanding is that there are different matrices that countries say, for example, the UK used to say, "This is a major event but our conclusion comes at a different level." In and of itself, that might not be a bad thing.

It struck me that this is another example of where we need the experts in the various agencies to come up with a process to conclude on what matrices we're going to use to look at what a major weather event is, and then the reaction that we take to it.

Now, on the satellite side, the geostationary satellite operators have created their own association, the satellite data association. Obviously, there are propriety issues that are involved in this. They all want to make money. They don't want to share stuff that might cut into their profit margin. They also realize that there is an advantage of coming up with some interoperability.

For me, the question is for the experts here. The deal with space-weather is, is there a process that we can take advantage of or do we create a new process where we come up with these matrices that have as all at the same position and conclusion in terms of an event, what it means, and what we should be doing to respond to it.

I'm not suggesting I can solve that problem. I'm just saying that there's enough information here and there's enough dialogue within the US government that we should, at least, be thinking about that and then look at what the various mechanisms are, that the domestic agencies have, that they're involving internationally.

Jeffrey: Ken, I don't know if this is quite following on from your points. I just like to emphasize that when we're looking at benchmarks for extreme events, one thing that has been difficult for us to come to grips with is defining what it is to be extreme.

Sometimes, a space-weather event is extreme in some ways and not in other ways, or in some places and not in other places. That's the complex spatiotemporal reality of space-weather. That's one point.

Another point I would just like advertise is that, in terms of International Cooperation and opportunities, there's a lot of data being collected out there on the ground, ground-based, magnetometer data, or ionosondes, or other types of space-weather data.

They're collected in different countries according to different standards, sometimes for different purposes, and the United States could benefit from receiving some of these data from other countries.

To get it into the form that the United States and the American user might want, though, it might need to be changed in formats, or the data adjusted in some way, or report it in real-time, or something else that meets the requirements for a US user of the data. That's part of the challenge.

Rather than the United States going out and distributing sensors and asking other people and other countries to operate them, if we would be more proactively engaging in foreign scientific communities and helping them sometimes to collect the data that we might want, and in some cases, giving some money for it, we could get some data from other countries, I think, at a good rate.

That is, I think, an opportunity that needs to be further developed.

This is small amounts of money, used in intelligent ways around the world, could help American scientists and American space-weather community get more of the data that it needs.

Steve?

Jeffrey: If we're going to continue on that line of thinking, I think I'd like to bring up modeling.

We, on the research side, I have seen a definite increase in interest with our European and Korean partners in hosting some of their space-weather forecasting models at the CCMC, that you heard mentioned earlier this morning.

We're now starting to work with them to validate their models and start sharing data between our models, their models. Now we're getting a whole different set of data coming in.

I think we're going to see some great benefit coming out of that collaboration with ESA, with CASI, and the Indian Space Research Organization has also expressed interest in the modeling field. That is an area that is rich with potential benefit as well from a global aspect.

William: Ken?

Kenneth: I'm going to speak one more time, and then I'll shut up. When I worked at NOAA back in the '80s, we created an organization called The Committee on Earth Observation Satellites.

The whole idea was to have the current and future operators of remote sensing satellites come together and look at common formats, common data processing, make sure that we keep the level of duplication to a minimum, and this we created 1984.

Today, Steve Volz will tell you. He spends a huge amount of time with this group and it's an informal coordination group.

The whole idea was that we were, maybe, competitors but in the end, we didn't want to be competitors because we wanted our civil and commercial Earth Observation Systems to be compatible to the extent that users could receive the same data, using the same receiving stations and didn't have to buy stuff in order to take advantage of one system or another.

Bill and I had talked about this right in the beginning of this policy review, it's something worthwhile to look at, which is how do we standardize...that goes to my earlier point.

How do we standardize what we're forecasting, what we're receiving, how we're processing it, and looking at how we can increase the possibilities of other countries producing the observational capabilities that we need beyond L1 and wherever else?

That was the point that we are driving at in the international section of the strategy and overall limitation.

William: Perhaps there's no other sector that best illustrates the importance of coordinating on the international front as it is with aviation. Fortunately, important things are happening on that front within the United Nations ICAO, the International Civil Aviation Organization.

Efforts are very much underway now to standardize, Ken, as you know, the space-weather processes. I know my experts, Mike and Mike Stills in the audiences here. Mike is the lead dispatcher for United Airlines.

Mike and I I've talked about this and Mike says, "Bill, what we do not want to see happening is our United flights departing from the Northeast heading over to London and Europe, getting the briefings from the Space Weather Prediction Center in Boulder and then returning and getting briefings from the space-weather service providers in Europe saying something totally different than the United States."

That would obviously have some significant consequences and we have to obviously work closely together to try to avoid that, but we are certainly doing that.

The FAA very much in taking the lead in working on the international front to ensure consistency and standard products across the local aviation sector. That is all.

Steven: This is me speaking of somebody who doesn't do work with complicated models, but I guess I just want to express a concern. Space-weather models can be visually beautiful and teaches lessons, qualitative lessons about fundamental physics and still not do a very good job of predicting things.

Sometimes, I look at models of the magnetosphere and I think, "That's a good model of a magnetosphere not necessarily the Earth's."

If we're getting inconsistent predictions from Boulder or their European counterparts, I just would like to encourage the modeling community to scrutinize the results and maybe not so much focus on the successful parts of the model that they have identified and learned about but scrutinize them and also focus on the parts that are really problematic.

That sounds obvious, but I review a lot of papers and that's often at times a problem with the way the modeling community approach is. I think we need to collectively recognize that that's a challenge and work on it.

William: Any questions?

Audience Member: Now can you hear me?

William: Yes, it's on.

Audience Member: At ITU World Radio Conference, it happens about every three years. The next one's 2019 and the next one is 2023. There is a proposal that have been put up by the United States that there will be a special assignment for space-weather sensors.

The World Radio Conference is really a set of the radio regulations and it's not a scientific and so this problem about international satellites, do you feel that the world radio regulations is the best forum to get into national standards set?

At the present moment, there is these proposal six years from now which is saying that there should be a radio frequency set aside for space-weather because space-weather is going to be so important, they must have protected radio frequencies.

William: Ken, are you familiar with that?

Kenneth: I'm not familiar with that particular proposal but I think there are two aspects the way that I look at it, one is the ITU pretty much does what it wants to do and it's driven by a lot of factors, not the least being, the companies that pay a whole lot of money for telecommunication satellites.

The question of a frequency being allocated for space-weather is one thing.

What I've been talking about is the notion of looking at what countries can do to monitor the space-weather to cooperate in the forecasting and to cooperate in potentially building new satellites that can give us more information.

The frequency part of that I'm not all that familiar with. I did not realize that there was something that was going to be dedicated totally to space-weather. I don't know, Steve, if are aware of that or not.

To be honest with you, there are a lot of things going on in the ITU is a star chamber as far as I'm concerned. I apologize that I can't really answer the question definitively.

William: One last quick question we go to break.

Audience Member: I'm not sure it's well formatted but I've heard this panel and some others comment on recovery from an event and the possibility of someone using EMP as a weapon or the Carrington type of that are seem to me to be ones where recovery starts being question.

The lady from FEMA this morning talked about sort of parceling out scarce resources and focusing on how to direct them to the right place but general recovery for the United States or some other major country, you have to think about where would the protected assets be that could be that would start the recovery and how would you deal with a geopolitical problem that results.

For example, you have deployed armies that you might like to contain.

William: Anyone has got any comment on that.

I will say just one thing on that. There're a lot of focus especially from the science community on the operational response to space-weather alerts and warnings, but there are also actions on the way both in directed founded executive order and within the action plan to understand -- to fork as well -- how best to engineer around these issues.

It's just an important point to make that, for example, the executive order, who work with the department of energy on a volunteer basis to have electric power grid owners and operators, introduce some blocking devices or other engineering solutions to help protect the critical infrastructure.

As much as we can, we want to work with industry in their understanding and their assessments of vulnerability too to find ways to harden against the trail of space-weather.

It's just a piece that I'll take the opportunity to share that too, that hasn't been mentioned much.

Mike, I know we are running a little bit late, so we should wrap up now. Another round of applause for our panel.

[applause]

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