Session 5: The National Space Weather Partnership

Speakers

- Dr. Sarah Gibson, Chair, Committee for Solar and Space Physics, National Academies of Science, and University for Atmospheric Research
- Mr. Alec Engell, NextGen Federal Systems and American Commercial Space Weather Association
- Mr. Charles Chafer, Space Services Incorporated and American Commercial Space Weather Association
- Moderator: Ms. Victoria Samson, Washington Office Director, Secure World Foundation

Ms. Victoria Samson: We should probably get started since we have a clock that is ticking. It is now 3:35.

My name is Victoria Samson. I'm the Washington Office Director of the Secure World Foundation. We're part of the co-sponsors of this conference. We're so pleased to be able to be a part of this discussion.

The Secure World Foundation is an operating foundation that focuses on the sustainable use of outer space. We look at space weather as an issue area that can absolutely affect our ability to get the benefits of space over the long term.

We've done a few other events on space weather. We were co-sponsors of the event at the Italian Embassy in May that was mentioned earlier. We had a congressional briefing in November of 2014 called Beyond the Flare.

I would encourage, if anyone's interested, to look at our website www.swfound.org for more information about us. But I know you're not here to get an ad about a secure world so we'll go straight to our speakers.

This session, as Mike has said, it's a culminating session where we really hope to get down to the brass tacks. We've been planning the National Space Weather partnership, so we have three wonderful speakers.

We had a fourth speaker but you may notice, for those of you who know him, Dan Baker was unable to make it, unfortunately. His slides have been sent to the organizers of this conference and they will be included in the final event program.

We're sorry you'll be missing him, but we do have three fantastic speakers in the interim. Going down the line we have Sarah Gibson, Alec Engell, Charlie Chafer. If you have the event booklet which is available on the SWF website, they have the long bios there.

Just really quickly, Sarah is a senior scientist in the High Altitude Observatory at the National Center for Atmospheric Research and section head of its Solar Frontier section. She has a very long and glorious

biography, but more recently, she is currently the co-chair of the Space Studies Board Committee on Solar and Space Physics, and vice president of the International Astronomical Union Division E, Sun and Heliosphere.

Next we have Alec Engell. He currently joined NextGen Federal Systems, working on improving forecasting as a senior scientist for its terrestrial and space weather R&D. He helps design, develop, and deploy situational awareness capabilities. He is a member of the American Commercial Space Weather Association Executive Committee, and recently joined the AMS Space Weather Committee.

Then finally, we have Charlie Chafer. He, like all of our speakers, has a very long and glorious biography, but quickly, he's the CEO of Space Service Holdings, where he oversees a portfolio of commercial space businesses spanning market sectors from consumer to high technology, including partners from Groupon to NASA and NOAA.

I'll stop now and go straight to Sarah. Thank you.

Dr. Sarah Gibson: Hi, thanks very much. I guess I'm here to some extent representing the perspective of the research community with regards to space weather, which is a very important subject in the geospace, also known as heliophysics community. I'll talk about some of the strategic planning efforts that have been going on in the past decade or so.

I think what we'll see to some extent also is that trajectory that Thomas spoke of and how things have really changed in the last few years, and a lot of the things that keep being repeated in which I really feel like progress is being made, so I'm feeling fairly optimistic.

I'm also here representing the Space Studies Board. The Space Studies Board, for the National Academies, provides an independent, authoritative forum for information and advice on all aspects of space science and applications. It has multiple components -- astrophysics, Earth science, heliophysics -- basically anything to do with space science is in the Space Studies Board.

With regard to space weather, I'm going to highlight three related topics. First of all, one of the things the Space Studies Board does is it's responsible for oversight on the Decadal Surveys. The 2013 Solar and Space Physics Decadal Survey, I'll talk about in a moment, definitely had space weather as an important topic.

Also, it is somewhat tangential, but it is the case that the Space Studies Board is the U.S. National Committee to the Committee on Space Research, or COSPAR. I'm going to talk a little bit about an international road map that was done for space weather at the behest of COSPAR and the international Living With a Star.

The third thing is the Discipline Committee to the Space Studies Board, the Committee on Solar and Space Physics. I chair that along with Maura Hagen at Utah State, so I'll talk a little bit about that at the end.

Let me start with the Decadal Survey in 2013. It was called "Solar and Space Physics -- A Science for a Technological Society." Dan Baker, who is unfortunately not here, was the chair along with Thomas Zurbuchen who was the co-chair. I think what I want to relay here is that space weather has an important place in our community, in the heliophysics community.

People felt very strongly about it, and there's a chapter in the Decadal Survey which is dedicated to this topic. Chapter Seven shows a vision for space weather and space climate program for the nation that can provide a new integrated capability needed to serve the needs of society ever more reliant on space.

In addition to the science recommendations that were done in the Decadal Survey, there was a set of top-level applications recommendations to do with space weather. Just quickly looking at these, you'll see the first one -- and this was back in 2013 - was, "Recharter the National Space Weather Program," and there's been a tremendous amount of advance in that direction in the last half decade.

Also, "Working on Multi-Agency Partnership for Solar and Solar Wind Observations." Again, a lot of things that are mentioned here -- DSCOVR, MAVEN, and IMAP, these NOAA and NASA telescopes -- there's been a lot of progress made. The importance of looking at new observations, platforms, and locations, the importance of research to operations, all of these things were highlighted in the Decadal Survey.

We're reaching the mid-decade now, so it's awhile still until we get the next Decadal Survey, but along the way, in about 2015, COSPAR commissioned a Space Weather Roadmap. Now COSPAR is international. There was a report that came out, it included membership from all continents with the exception of Antarctica. I'm pretty sure, I could be wrong actually.

This roadmap, the charter was to review current space weather capabilities and identify research and development priorities in the near-, mid-, and long-term, which will provide demonstrable improvements to current information provision to space weather service users. Most of the people involved were in the research community, but there's was an attempt to really reach out to the user community.

I encourage you to look this up. It was a paper written for "Advances in Space Research," which is COSPAR's publication, and it's very comprehensive. For example, it takes three pathways, one which looks at the question of how to do better in terms of GIC prediction and understanding, another which looks at how to do better in terms of radiation belt understanding and prediction.

Another has to do with how to predict in advance solar flares and be able to get the instantaneous impact events, to be able to have some prediction capability for them. I'm not going to go into those.

There's very detailed pathways with roadblocks along the way and things that could be done and observations. Instead, I want to talk a little bit about some top-level recommendations that this road mapping exercise -- again COSPAR/ILWS-commissioned -- came up with, and they had three groups.

The first one was research. I think what you're going to see here is that you're now getting things from the research communities' idea, and a lot of the same bells are going to be rung that you've heard in the SWAP activity, for example.

In terms of research observational, computational, and theoretical needs, the recommendation was to advance the international Sun-Earth System Observatory -- we heard about the System Observatory earlier -- along with models to improve forecast based on understanding real-world events. This I think is an important component that came across in this road-mapping exercise, which was through the development of innovative approaches to data incorporation.

We work on these models, we bring together these observations. How can we take it to the next step? How can we model the magnetosphere as opposed a magnetosphere?

There's data assimilation methodologies from the point of view of Earth science, but when you start moving out to the solar wind and to the Sun, things get more complicated. What's the next step there?

The second recommendation then takes it back to the Sun and says you have to understand the origins of the Sun. In terms of a long-term goal, clearly we want to be able to predict flares before they happen. But even before we do that, we need to be able to see something happen in the Sun and get a good prediction on the Earth.

If you think about it, if we're ever going to have any useful prediction for GICs if we can predict the flare before it happened, you still have to do that step. So first get that step done, initially prioritizing post-event, solar eruption modeling to develop multi-day forecasts of geomagnetic disturbance, times, and strengths after propagation through the heliosphere.

Then when it gets to the Earth's space environment, it's a complicated, coupled system. Trying to understand, again, the GICs and the radiation in geospace, coupling the solar wind disturbances to the internal magnetospheric processes and to the ionosphere below.

The final research goal that was highlighted was the idea of looking at space climatology, developing a comprehensive space environment specification. I think this clearly connects to the benchmarking exercises that are ongoing, and helps if you are ever going to harden your resources. You need to understand the environment is likely to be.

The second set of recommendations that came out of that road map had to do with teaming, which I think is quite relevant to this group today. How do you coordinate and get a collaborative research environment?

The first thing, of course, being partnering with the user groups, and to be able to do research and science which is informed by and motivated by what is most useful and impactful to the user community.

The idea of building test beds in order to have coordinated observation-supporting model development, the idea which we've heard about today, about having some sort of standardization of data and product metrics, and getting some sort of harmonized access to data and model archives.

Then being able to optimize the observational coverage of the sun-society system. How can we determine which observations are the most important, the most essential, and how can make sure they're well-covered?

The third set of recommendations has to do with the collaboration between agencies and communities, again very relevant to this group. Implement open space weather data and information policy. This is something that, from the research point of view, is critical.

Provide access to quality education and information materials. Again, we heard about this today, about how there's a whole new audience out there for space weather. How do we reach them, and how do we get good information out, and work with new startups, with news agencies, etc.?

Execute an international inter-agency assessment of the state of the field on a five-year basis to adjust priorities and to guide international coordination. Here, a key word is international, because again, this was an international effort.

Develop settings to transition research models to operations. This is something we keep hearing about, and I think we'll hear more about. Finally, partnering with the weather and the solid earth communities to share lessons learned.

There's a lot out there in terms of predictive science that the geospace, the heliophysics community can learn from. That was the COSPAR road mapping exercise.

I've moved from 2013, the Decadal Survey, through 2015, that road map that came out. I'm going to bring you essentially up to the future, into the future, through the present with the Committee on Solar and Space Physics, the CSSP.

The overarching purpose of our committee is to provide advice on the implementation of Decadal Surveys, and oversee the activities of any ad hoc committees established by the academies to author reports on issues related to solar and space physics or heliophysics.

The committee interacts with sponsors, and serves as a venue for dialogue between the government and the scientific community. The CSSP -- and I'll come back to this -- really wants to be a bridge between the broader community, and in this case, the broader space weather community and the research community.

One of the things that the CSSP can do now is to write short reports. Here we go. In addition to the very long Decadal Surveys, which take a lot of people and a lot of time, the short reports are done, for example, as part of our biannual meetings.

We can have a very targeted and specific goal, and write something on the order of a dozen, 10, 20 pages. This report was on heliophysics science centers, and it's just very recently been published. You can find it online on the National Academy's site.

The charter was to talk about heliophysics science centers, which in turn, were a recommendation of the Decadal Survey to tackle the key science problems of solar and space physics that require multidisciplinary teams of theorists, observers, modelers, and computer scientists.

There's a real realization that there are some problems in heliophysics that are just too complicated to be done by an individual, or even a very small group, and that are multidisciplinary in the sense also of that you have to bring together different methodologies.

You have to bring the theorists, the observers, and the data scientists together. Our charge was to clarify how to make the HSCs unique, and to provide options for implementation.

We came up with a set of conclusions, which I will briefly summarize as that we emphasized the importance of having cross-cutting teams, of critical mass, and that there needed to be open competition to make sure that the sciences really were the grand challenges in our field.

CSSP and space weather -- space weather is a recurring subject in the CSSP. It's one which we, before I was the chair, but about a year ago, in October 2016, there was a mini symposium on the topic at the CSSP meeting.

This was then discussed in a panel discussion at Space Studies Board meeting the following month in November. To finish up today, I just wanted to show you some of the topics that came up in this mini symposium discussion.

What this discussion highlighted was six impediments to progress in space weather, and they took a very broad view of it. First of all, the impediment with regard to vision. What are the horizon goals? Can we identify very specific science long-term goals that we really would like to achieve with regards to research objectives for space weather?

Then with those in mind, with those horizon goals in mind, how does that drive our strategic and tactical programs? Another impediment was to science. This is, I think, something which we've talked about, and various groups have talked about, which is, "What are the gaps in terms of measurement, in terms of modeling, in terms of forecasting tools?"

The key there, I think, is that we need to be able to identify what the low-hanging fruits are. Which of those gaps can we approach right now with resources we have, and make some substantial progress with?

The third one is policy. Again, we hear this over and over again. How do we support research to operations, and also operations to research? The fourth one is implementation. We've talked about the CCMC, the Community Modeling Center.

How do we move towards a national model, for example, some sort of consistency? How do we develop, maintain, and improve? We need an international view of what the benchmark models are in space weather.

Then awareness. How do we decide what are the most important requirements, and who's responsible for them? Again, this is something which I think is very much in the mind of SWORM. It's still an awareness gap.

Finally, and I think it'll transition to our next speaker well, the question of culture. How do we overcome the persistent apparent conflict between pure and applied science? We cannot work in a vacuum for issues such as space weather. There are fundamental, basic science questions that have to be solved, but they need to be applied in order to have impact, and then to feed back to the basic science.

I want to conclude by saying that Space Studies Board and the CSSP, I think many of you have gone to the biannual meetings. They welcome interaction with the full range of stakeholders.

There can be informal discussion out of the biannual meetings, fall and spring. In spring, the DC Space Science Week in March 2018, for example. The next October meeting we're still scheduling.

We can have, if people are interested in discussing or getting us involved in discussing having a panel discussion, mini-symposia, as you saw is something that can be done, or indeed short reports for very specific topics. These are possible modes of engagement.

Abby, would you wave your hand back there. That's Abby Schaffer. She is the CSSP Study Director. If you want more information, please talk to myself, but also definitely talk and contact Abby.

Thank you.

Mr. Alec Engell: Good afternoon. I'm Alec Engell. I'll be piggybacking a little bit off of Conrad Lautenbacher, Admiral Lautenbacher's speech, talk on the American Commercial Space Weather Association. Let's jump right into it.

Here's a snapshot of the National Space Weather Enterprise with the companies directly underneath that blue timeline. Then you see agencies in academia in purple and red.

Forgive me, I'm sorry, if you're color blind. You can recognize the symbols down there.

ACSWA is geographically diverse. If you look at the Senate subcommittee and the Congress subcommittees in space we can do quite a good job in communicating to representatives what is going on and what should be going on in space weather. We don't only do that for ourselves individually or collectively as ACSWA but we are able to do it on behalf of other agencies and other efforts that are going on in space weather.

ACSWA has been heavily involved. We are thankful for being involved and being asked to be involved on several different policies, such as the American Space Commerce Free Enterprise Act that was just recent, the National Space Weather Enterprise and Forecasting bill. SWAP, in particular, the R2O-O2R document that came out earlier this year and had public comment, as well as the NOAA Commercial Space Data Policy from last year.

ACSWA is quite unique in how we can position ourselves in-between the different activities, namely SWAP, all the goals or actions that are to come from it, as well as the communities themselves. So for activities, understanding and forecasting, impacts, protection, mitigation, response, and recovery.

Forgive me, I've mixed the six goals into four bubbles here and I've left out international because we are focusing on the national partnership here. Then, communities. Federal agencies, government labs, the universities, as well as the customers.

What are some of the ACSWA advantages? We have corporate memory, expertise in specific technical areas, regional expertise, customer-oriented priority setting, cost effective, and Agile partnering, whether Agile partnering is business to business, agency, or a combination.

I'll let your eyes scan here of ACSWA's capabilities but they are pretty in depth and cover quite a wide range, from Enterprise IT to bringing fundamental research all the way to technology readiness levels, or TRLs, or applied readiness levels, all the way up into operations. One to nine is the scale there, and so there are a lot of capabilities within these 18, 19 different companies.

SWAP, if there is funding or indirect funding that is going to come from...eventually, what would ACSWA do? We can mobilize this collective model of capabilities that was on the previous slide. we can convene a high level board of directors, and then once the mechanisms for recognizing these supports, whether it's a combination coming from SWAP or other agencies, depending on...

The program ideally will be self-propelling because we will be bringing in...if you remember Conrad's picture, we will identify other mechanisms of funding in the commercial sector and bring that back into the Space Weather Enterprise. We heard $9 billion as a figure earlier mentioned that goes on in the terrestrial weather section. We would very much like to build up to some number like that. Wouldn't that be great?

When ACSWA is continued here, it could begin as a test bed. Simply, for instance, SWAP focuses on GIC, end of the world. We could focus on a topic like that to prove our capabilities by, again, doing Agile partnering and such. Then we could expand from there once proven successful.

Here's a five-point proposal. Kent Tobiska actually showed this in the Space Weather Week down in Broomfield, now, Colorado. And so, I'll go through this briefly.

An active tax incentive for expanding space weather capabilities. Expand agency opportunity programs. This obviously could be a number of things but, for instance. NASA flight modeling, data analysis, DoD can do the same for agency flight and modeling, as well.

You can create FAA, NOAA, and other application opportunities with investment of matching funds. Exploit SBIRs and STTRs. These are great programs. In particular, STTR, that does a great job of connecting that three-legged stool of agency, academia, and commercial in order to bring about a good business model and, again, find that commercial money that can bring it back into the Space Weather Enterprise.

In particular, you can do phase two enhancement fundings and matching funds, and then phase three sole sourcing. A lot of agencies that come out with these SBIR and STRR topics, they understand that they'll likely be one of the customers in the commercialization process that happens towards the end of phase two and phase three.

That's the idea there, and so that should be focused upon in the agencies, especially if it's working for them so far in the phase two efforts.

Incentivize, open sourcing while upholding IP. This is difficult and this is something that we're going to have to chip away continually in this field. It's been discussed several times. We're going to have to have that conversation, I think, and identify opportunities as they come along.

B2B cooperation for space weather expansion to new industries. Formalize R2O-O2R paradigm. Again, this has been talked a little bit about.

Again I wish Dan Baker was here because this would be the focus of his talk. I present to you here a general idea of what an R2O-O2R type of facility could be, whether it is physical, or virtual, or a combination of both.

You could have a board of directors from DHS, DoC. Basically the leaders of SWAP, FEMA and Navy could be there, too. I'm putting those names down there as an example. Fundamentally, this facility must be flexible, Agile, innovative, and include all of the community because there really are abilities throughout all of the community, as we've heard extensively today.

For instance, you could have nine rotating R2O workstations. You have the TR levels two to five. You want to bring those, especially if they're effective, up to that operational capability level nine. Then you have the test beds that enable that sort of capability.

These test beds could be run by SWPC, CCMC. Even NASA has their operations that they do run for internal purposes, and then, also, DoD. There's no reason to leave out commercial, so, for instance, AGI has their ComSpOC.

That is a commercial test bed, to some degree, for space situational awareness. It doesn't have to be agency test beds, either.

Low-hanging fruit, in terms of capabilities. Some company efforts have led to GPS scintillation products, SEP and flare forecasting capabilities, and aviation radiation monitoring.

A little bit of NextGen's perspective, my company's perspective in terms of engineering all of the community. Are there products out there that we could start developing today relatively easily that could enhance all of the community efforts and improve our understanding of space weather and forecasting capabilities?

Many interacting systems. It's one complex system. We have pushed limits based on our funding and our understanding of physics observation theory and computation.

Data science is sort of a new statistic. Statistics, it's been said that you can play in everybody else's backyard. Data science could be one of those areas that could be exploited, I feel, a little bit more in space weather given all of these interacting systems.

Open source and crowdsourcing has been mentioned today. That is obviously important. Can you create technologies around those sort of capabilities that can be exploited?

Just a couple of examples of this. Here's crowdsourcing. You have detection events here. You have your flares on the top, your solar energetic particles on a second plot, your coronal mass ejections on the third, and on the bottom you have your magnetic fields measured at GOES.

Here, this relates to the metrics and benchmarking of SWAP potentially. You have 40 years of this data, roughly. You could identify these catalogs. You could have users go in and help identify whether they are academic researchers or even from the general public.

This could be a Wikipedia type of capability where you could say, "Hey, I didn't agree with Alec that that event started here. It actually started here."

Furthermore, we talk about these connected events -- a flare, to a SEP, to a CME. Now you're talking about a connected event catalog, not just a singular catalog. That becomes an important capability. Of course, this leads to the benchmarking, forecasting, and understanding, helping that type of capability.

Lastly, we have, also, new technologies that can bring those physics-based models, the magnetosphere, what is the right model, into an environment that can be validated. The GPS satellite data, for instance, the proton and electron data. There's 16 assets over almost 20 years that can be leveraged. Their cross-calibration, of course, to do a lot of this effectively and quickly.

You can throw, once you have the conversion files for these models that are, for instance, run at the CCMC. They can be inputted into this type of system.

You have your in situ measurements from all your different orbital regimes, from LEO, MEO, and GEO. Then you are talking about validating these models effectively, seeing where some fail, seeing where some succeed, and then identifying where the physics is lacking, the understanding is lacking, or perhaps if the model is being fed an observation where the observation is lacking and where we need more instruments.

I'll leave you with some conclusions. ACSWA lives and breathes the National Space Weather Partnership. We are very much involved in all areas. The mixed-model approach delivers cost-effective solutions, very important for our customers that we work with.

Customer-oriented Agile partnering across all types of areas. Revenue generating -- we want to bring that money into the Space Weather Enterprise.

And then, cutting-edge technologies are coming about from data science and also web based platforms and that sort of technologies are really here. I think they're here to help the space weather community.

With that, thanks for your time.

[applause]

Mr. Charles Chafer: Thank you very much and howdy from Texas. I've given presentations at SWEF and the Space Weather Workshop over the years. I almost always begin with the "Monty Python" observation, "Now for something completely different."

It's not as much the case anymore, thanks to a lot of developments, such as Alec talking about, and such as the new efforts in radio occultation and others.

I was asked to present the results of...I think we've done five competitively-awarded studies by NOAA, a data purchase by NOAA, and a Space Act agreement from NASA over the years, attempting to make the case for a commercial solar wind program. I'll talk a little bit about that today.

I'd like to make essentially four points. The first is that a commercial satellite platform at L1 or up to Sun-Earth line which combines multiple users can meet NOAA's requirements at the lowest cost while, and I think this is important, maintaining the inherently governmental function of solar monitoring and warning.

This is not a speech about, "Hey, I know a solar wind event is about to happen. If you just subscribe to my company I'll tell you all about it."

That's clearly not a model that, although it would make a lot of money, probably is not acceptable anywhere in the community. And so, we are looking and we've built our models around the existing policy and approaches of NOAA.

Secondly, cost sharing of space assets, launch, and certain operations means a cost savings, which I think you'll see, versus the dedicated system. There are some tools that are available in the private sector that the government either opts not to engage in or cannot engage in -- such as use of insurance, private capital, and commercial procurement construction techniques -- that can result in benefits both for the commercial enterprise and for the government.

Finally, the structure of data purchase relationship means that you get paid when you perform. That creates incentives and requirements for things like data continuity, which in the solar wind realm we were on the ragged edge of for the last few years.

For any of you that have ever pitched in Silicon Valley, then pitched to by Silicon Valley people or talked investments this is a hockey stick. It's an older NOAA chart. I think it only goes to 2012, but it shows

what you all know and what a very few people out in the commercial world know, which is that there's this incredible growth in demand for products and services in the commercial space weather realm.

That can lead to some interesting architectures. This is one that we did for NOAA back in 2006. It makes use of solar sail technology, which, although still nascent, is very exciting. What it attempts to show is a system architecture that delivers better than NOAA's current requirements for solar wind data but, at the same time, is able to simultaneously capture other markets and therefore provide a lower net cost to the user, in this case NOAA and the federal government.

Brief commercial -- who are we and why am I here talking to you all? We've been around forever. We did the first commercial launch into space back in 1982 under astronaut Deke Slayton's leadership.

We have about $20 million of investments across a variety of space arenas. Some of them are working great. Some of them, like my space weather investments, not so much yet but we're hopeful. We're headquartered in Houston.

The models that I'm talking to you about that we have built -- and we've done a fairly extensive amount of financial work -- were worked very closely with an investment bank in Stamford called Near Earth LLC. I think many of you are aware of Hoyt Davidson and the groundbreaking work he's done for some of the companies that you see there, ranging from major satellite entities to NanoRacks and many new space businesses which are now capturing people's attention.

I asked Coyt if he was OK if I mentioned it today. He was thrilled. He said, "Maybe we can finally get something going in the space weather arena."

A couple of things I wanted to emphasize. What I'm telling you or what I'm suggesting as a buyable model isn't just Charlie and a bunch of his friends who got together and looked at this. We've done a lot of work and I think, over time, we've changed some minds throughout Washington and the other areas.

As a result of our '05 run agency announcement work for NOAA, a presentation was made at the Space Weather Workshop where NOAA concluded a profitable business case exists for the government/private partnership and a clear benefit exists for the government from this approach.

Fast-forward a little, eight years later, still working. NOAA presented additional work as a result of the five efforts that we put out, and others worked, as well. And we were third-partied by NOAA.

I think, again, what you want to conclude is bullet number two there, that there's substantial evidence that commercial providers could take on the risk of building, launching, and operating a mission to meet NOAA's requirements.

These are NOAA conclusions based on the work that we've done for them or they were NOAA conclusions at the time. I won't represent them as current agency conclusions.

I'm going to blast through a couple of the benefits that I see in commercial approaches to this system. The first is that a business model that gets paid upon delivery of data demands redundancy and demands the use of insurance. Two examples.

It wasn't all that long ago that ACE was out there all by itself. No DSCOVR. Trinana was in a garage somewhere at Goddard subject to a lot of political discussions and continuing expenses to whether it

was fine. There was genuine concern that ACE would fail and that we, as a nation and as a world, would have no, what I call "tsunami buoy" at the L1 point.

There are other observations of the sun, obviously, but on the Sun-Earth line with the proper polarization and warnings ACE was it. It was it for a number of years.

We lucked out and we had DSCOVR in the tank. We were able to launch it, but I don't think it was a result of policy that said, "This is too important of a service to put at risk."

A commercial company, any commercial company, as I say, that only gets paid when the data is delivered is going to build redundancy into this system from the get-go. In fact, the models that we built always have at least two satellites available so that in the event that one goes away we have a capability to continue making money and providing data for the government.

The other element is insurance. It wasn't too long ago that DSCOVR was launched on a Falcon 9. Falcon 9, at that point, didn't have the record that it's had the last few months of enormous success.

It's a simple fact, and I've blown up enough of them, that rockets fail. Had DSCOVR gone into the ocean we would have had to wait for another appropriations process before we could start building the follow-up. Again, a commercial company would never do that.

A second benefit of commercial approaches, and this is a chart I stole from Kathy Sullivan about Sunjammer, which was a neat idea that didn't make it. That doesn't mean that solar sails still aren't useful.

Of course, I believe everybody in this room knows that if you can free yourself from L1 and you can go up the Sun-Earth line by using a sail you can double the warning time. Believe me, if you're a nuclear power plant operator or a grid operator or an airline that's caught over the poles having twice the warning time is a good thing, particularly if you can package it in a smaller system that uses a sail to cross that line.

That's, of course, what Dr. Sullivan said in that last point -- game changer, add hours of warning lead time to geomagnetic storms. We, as a commercial company, have and continue to invest in sail technology. We would look to adopt that and provide those advantages.

I can also mention that in the models that we've built we've gone to some miniaturized sensors, a magnetometer that's about the size of a quarter. As we all know, mass in space equals cost. If we're able to deploy lighter-weight systems that meet or exceed data requirements that's an innovation that shouldn't be ignored.

Another benefit is that multiuser platforms reduce cost to the government. There's a lot of words here, but basically if you can do polar communications, if you can do SA of asteroid materials, if you can fly a host of payloads, if you can attract General Electric as a corporate sponsor because they want to save the planet and green is good, and bring all of those diverse revenue streams to bear on your system -- it makes sense that you would be able to save money to the user.

The final point in commercial's favor is, oh, by the way, this is national policy. It goes back to at least President Reagan, probably before that.

I've got a few select ones here. You can pick a bunch of them. Using commercial systems to meet governmental needs is something that is a national policy. Fulfilling national policy, generally speaking, is a desirable goal.

What are the barriers? The first one is a nice way of saying, "Not invented here."

Another way, we were asked by a very senior person, "Why are your zeros and ones better than my zeros and ones?" when we were making the case. One answer is they're not. They're zeros and ones. [laughs] They're data that comes to you per your specifications.

A second answer is that you get all of the above benefits that I talked about. Lower cost, technological innovation, more customer awareness, attempting to solve problems earlier versus traditional procurement. It's not that you can't do it that way but I'll give you two war stories since I'm an old guy.

In 1982 we were invited into James Bigg's office at NASA. We had just launched Conestoga One. My job out of Georgetown was to get 11 separate federal agency approvals, including a gun dealers license to launch that. There was no Commercial Space Launch Act of 1984 then.

We were given a very extensive briefing about how we were a threat to the Space Shuttle. We, a little eight-person office in Houston attempting to do commercial launches, threatened that national asset.

Second war story has to do with Landsat. We, in '84, proposed the first commercial remote sensing system. In walks some representatives saying, "It can't ever be a commercial business because Landsat cost $500 million, has a three-year lifetime, and there are only 12 ground stations around the country that the government gets $20,000 a year in revenue for. That math doesn't add up."

Well, of course, today we have -- thank you Elon and others -- a viable, growing, expansive commercial launch system and we have a commercial remote sensing system. We have eliminated government's role. We haven't eliminated government systems but we've created jobs and fulfilled policy and done good things just because we weren't traditional procurement.

The second barrier was mentioned earlier, which is how you're going to radiate all this information. Are you going to be able to use NASA's NOAA assets such as tracking and frequency? It's a thorny problem but it's able to be resolved should there be the will to so do.

So I'm through doing studies. I've done enough. I'm convinced that we can build a multi-satellite system, offer it to the government for substantially less than any follow-on system that we're looking at for DSCOVR. I tip my hat to the folks that figured out, "Hey, a pilot program in RO is a way to put the nose under the tent and begin to allow the commercial guys to go prove that all of these lofty statements about why commerce is good in the US."

As I look at the act that President Trump signed, there's plenty of realm in there to do pilot programs for space weather data purposes and should anyone get the religion that says, "Hey, this might be a good to look at while we're considering how we follow on the DSCOVR program," the tool is there.

It wasn't there a few years ago but the tool is there to do that. We might all be surprised with the results.

With that, I'll say thank you very much.

[applause]

Victoria: If you have any questions please come up and approach the mic. I'll use the power of the chair to ask a general question of the group.

Given, if you were king or queen for the day, what would you do to ensure proper implementation of the Space Weather Partnership? What are we not doing that we could be doing? What could we be doing better?

Feel free to jump in, anyone.

[pause]

Charlie: I think I just said what I think we should be doing. I think we ought to look to the commercial sector to begin implementing it at the observation level, not just at the ground or solid earth level.

Alec: I guess I would say putting out opportunities that ensure you are soliciting for projects that can involve multiple groups. For instance, again, STTR program, ensuring programs like that could be acted on more effectively or expanded upon in other areas.

I think that is important. We need to start to connect the academic agency, commercial sector, and the customers under one opportunity. That could be very effective in bringing the partnership as well fruition of products into space weather.

Sarah: I'll add I think we've made a lot of progress but we have to continue to make sure that there's sufficient communication across research to operations, users, basic research, and vice versa.

Victoria: That does lead me to a question I have coming at it from an outsider to the scientific community. How do you handle communication with the general public when the general public tends to be not as scientifically literate as, perhaps, [inaudible 50:29] benefits. Particularly for an issue like space weather where I think it's easy to misunderstand what's being actually stated by the scientists. How do you handle that sort of communication challenge?

Sarah: It's a challenge. Speaking from the research community, a lot of us have connections through NASA, through NSF, NOAA and other agencies will have outreach programs and they will get the scientists involved in participating in various "NOVA" or media interactions, and so on.

That's one way to do it. I think it's something which we have to continue to do our best at because it's very easy to get misinformation.

Charlie: Of course you have to be a little bit careful, because it's really easy to scare everybody to death. I'm certainly as guilty as anyone, in my public speeches, of quoting the end of the world scenarios from an un-forecast Carrington Event, so the first thing to do is to be a little bit careful.

Our business model is to use both earned and purchased media. We've done 15 launches. We average about a billion media impressions per launch, and we use that to drive traffic to our website.

Why is that an important communication for space weather? We've never really used it for space weather, but it's a perfect example of what I mentioned, what I call non-traditional revenue streams.

There are multiple opportunities for companies, and I mentioned several that are interested in portraying themselves as saving the planet.

There's not a better "save the planet" space program that I'm aware of than solar wind or others, being able to use non-traditional actors to communicate on your behalf to the general public who, in general, are totally unaware. Everybody's kind of getting that fact that asteroids could end it all now, but people are just unaware in general, and particularly of potential for major events.

That's why I started out by saying you have to be careful, but you also have to let people know that these are important programs that really are out to protect you.

Victoria: Some of the earlier speakers touched on the international efforts that are being done on this. I'd like to extend that question to this particular panel. Obviously, this is the National Space Weather Partnership, but there are significant interests across the globe in this.

I wanted to hear how that impacts your organization, what you're working on, if you think there is anything that really needs to be tackled at the global level, in particular, from your point of view.

Sarah: Yes, definitely. There's no question that space weather is a global phenomena. I think, traditionally, the scientific community has been very international in the way people interact and collaborate. Space weather has been very much something which international collaborations are formed around.

I think it continues to be encouraged. There's questions of data, as well, and observations in the different space agencies, for instance, which have different satellites, which can be used together. Data can be shared, and so on.

Both from the point of view of international observations, international modeling and research programs, there's no question that it's win-win. I think that's understood.

Victoria: To jump on that, one of the issues that [inaudible 54:52] work internationally is data sharing is difficult just in terms of making sure it's in a format that everyone can read and understand. Do you guys run into that a lot when you're doing work, particularly with groups like COSPAR?

Alec: Certainly many different data outputs, inputs, yes, we run into that problem all of the time. Really, there are libraries out there that have been enabling streamlined capabilities for dealing with that, to a degree. I would, again, say look at existing technologies that had been developed over the past five years.

There are abilities, but I think there will always be a struggle to get that coalescence pure and simple. There are tools out there that are being explored and certainly developed at an accelerated rate in the past five years.

Sarah: A lot of the missions that I know personally have used data from solar missions, for example. There's often people from different countries involved in the mission, from the ground up. This really helps in keeping some level of uniformity, in terms of the observations and how people can use them.

Dr. Jeffrey Love: Hi, Jeff Love, USGS. I just wanted to jump on this issue about the international aspect of commercial, government, academic collaborations. I'm all in favor of that. I'm all in favor of data being collected and data exchange, and all of it being done in real time. I also do see it as challenging.

When I look to some of my corresponding agencies in other countries, for example in Britain, government agencies in Britain can often enter into very tidy relationships with companies in Britain. That affects the dissemination of data that they collect. It's oftentimes not reported in real time, because there's a commercial interest in maintaining that data and using it in real time.

I see that there's some challenges there, and it comes about from the fact that, in different countries, different countries have different government policies, and that can affect the landscape of this collaboration that we're trying to promote. I don't know what the answer is, but I can see that there's some significant challenges there.

[laughter]

Victoria: Everyone agrees with you. Well done. Was there another question from the crowd?

Mr. Mike Bonadonna: Yes. In Alec's presentation, there was a list of capabilities in the commercial sector that may be applicable to the 99 actions in the Space Weather Action Plan, but I have not seen the mapping of those capabilities to the particular action. Has that work been done? If so, how could you communicate that to us?

Alec: Thanks for that question, Mike. We did put together an actual capabilities structure, especially for the general goals, one through five, excluding international for now. We did not put together a matrix of them. We do have that document. It's just now something that we submitted formally or put out there for the community to digest.

That is something that perhaps the commercial sector can do a little bit better in producing that and putting out there for the community to take a snapshot look of how we would create a matrix capability for all these different action plans that are ongoing, including metrics, benchmarks, and things like that.

Yes, initial work has been done. It has just been not finalized. I think your question brings it to the forefront of my mind, and that's something that I think I'll take back home and work on for you.

[pause]

Victoria: Any last thoughts from our speakers? Your final remark, if you had one statement you'd like people to take away from what you said today, what would that be?

Sarah: I'm not sure if it's a take-away message, but I just want to say that it's been a very interesting meeting for me. I haven't been to one of these before and I've learned a lot. It speaks to the point of opening that communication between the broad space weather community.

Alec: Personally, this field has been very welcoming to me, from an undergrad to a researcher to a graduate student to working in the commercial sector. I'm very thankful for all the relationships that I've had. The walk-away of what I've had recently is that the commercial sector is here to help, and mores that data science is here.

There are lot of capabilities that can be done with it, and it's really exciting stuff, especially when you talk about all the different data systems and physical systems that space weather has. There's a lot to explore in it.

That's what I would have as a take-away is data science, machine learning, computer vision, it has a lot to offer to this field.

Charlie: No analogy is perfect, but I look at the development of the earth observation world -- be it governmental or commercial -- and as humanity continues to expand its presence in space, I think it's of great interest that we'll have value-added firms in space weather. We'll have new firms offering innovative space weather solutions.

You can't listen to these conferences, as I have for years and years, where we talk about our increasing reliance upon systems that are subject to space weather, and be a commercial guy like me, and not see the beginnings of a robust economic sector that can and is being led by the US, but also it's a global challenge, which means there are global opportunities.

I'd encourage us all to be thinking a few more years out and a little bit more innovatively in how we address what is clearly a key challenge for humans.

Victoria: Please join me in thanking our panel for a fantastic final session.

[applause]

Mike: Thank you very much panelists. Right now we have a special announcement. Mr. Bill Murtagh has some news for us.

Mr. William Murtagh: In the category of good timing, the Senate Bill 141 passed unanimously in the Senate in May. We wondered what would happen in the House. We just found out 30 minutes ago. I'm trying to read this without glasses.

Congressman Ed Permutter introduced Space Weather Research Forecasting Act. This bipartisan legislation is signed by Jim Bridenstine, Republican from Oklahoma and Democrat Eddie Bernice Johnson from Texas. It's the House companion bill to the Senate 141, introduced by Senator Gary Peters, Cory Gardner, Cory Booker, and Roger Wicker, which passed the Senate earlier this year.

It's looks like it's a bill that it was just introduced on the House. The best I can tell, it's almost identical to the Senate bill. It's going to get the support we need, and I think we'll see this passed as law here pretty soon.

Good way to finish.

[applause]

Mike: That's just great news. I appreciate that. Now we're going to shift gears here. We're going to turn to the federal coordinator for meteorology, Dr. Bill Schulz, who will give you the summary of SWEF and tell you where we're going from here.

Thank you, panel.

Dr. William Schulz: Good afternoon. As Mike said, I'm Bill Schulz. I'm the director of the Office of the Federal Coordinator for Meteorology.

Just to put a point on the end of SWEF here, my major take-away from this gathering today is that the Space Weather Enterprise is a good news story. It's a good new story in the face of a pretty hard problem. I saw three good things happening as we went through the discussions here this morning and this afternoon.

The first one, this is the SWEF since SWORM became an official sub-committee and we had Executive Order 13744 signed into effect. That means that we have a strong policy foundation for the Space Weather Enterprise

That's a good thing. It was no small trick, and that was largely due to the leadership of the previous staff at OSTP. Thank you, Tammy.

The second thing I've seen, as I listened today, is that there is an increasing awareness among decision-makers in the civil world, the military world, the commercial world, about the effects of space weather. We're not talking just about the high-impact, low-probability events, but the everyday effects on communications and positioning, and effects on aircraft.

It's good to see increasing awareness like this. I think the hockey stick diagram that showed up in a couple of the presentations here underscored that. It shows not only just an increasing awareness by decision-makers, but also an increasing consumer demand for information on space weather.

The third thing that kept coming up again is the impressive amount of inter-agency and international coordination that's going on within the Space Weather Enterprise. It's really a model for some other areas in federal weather coordination, as well.

Inside SWEF, I think it was mentioned several times, about 80 percent of the 99 tasks of the Action Plan are either on-track on completed, and that's just in the last 20 months since that was signed in. We've had several examples of tangible international support brought up.

State Department hosting a couple of "Space Weather as a Global Challenge" events is one example. There were several examples of activities within the WMO, ICAO, and other UN frameworks. That's the three phases of a really good news story here.

Of course we did hear several instances where we have room to grown, room to improve. But the good message there is there seems to be a real enthusiasm and a real willingness to engage on these challenges and keep moving forward.

The ones that keep coming up today, first off was developing the R20 O2R loop. This is really the only way that we can get from the 5 to 20 percent operational posture, depending on which of the panelists you believe, but they were both fairly small numbers.

The best way we can get from that 5 to 20 percent towards 100 percent operational capability is perfecting that R20 O2R circle. That's going to be the best use of dollars to get us to move forward in a good speed there.

The second one is to increase engagement with the commercial sector, through industry associations, through SBIRs, through STTRs. There are many opportunities there to engage the efficiencies of the commercial sector to move us forward in data observations and collections.

A corollary to that was brought up in the last panel. There's room to engage in a multi-disciplinary environment, getting disciplines that we normally don't associate with space weather into the fold here to address some of these challenges.

The third one that several of the State Department folks brought up, a little bit of investment, wisely deployed around the world, may yield great benefits in terms of data sources that we have not yet tapped into. I think those are the three big challenges that we heard. There's enthusiasm for addressing those, and I think they would be beneficial to the enterprise.

The bottom line is we need to keep the press on in space weather, but we have good momentum right now. I think the Space Weather Enterprise is moving in a great direction. There's lots of enthusiasm for it, and I think we're well-positioned for the immediate future here.

The next steps. Of course the SWORM will continue to shepherd the actions outlined by the Space Weather Action Plan. As far as this conference goes, the materials that you saw today will be available online within the next few weeks. There'll be an updated conference book. Presentations will be on there, and there will be a written transcript available soon. Look for that in the coming weeks.

I think the last thing to do is say a few thank-yous here. I do want to thank all the speakers, the moderators, the rapporteurs, the panelists, the poster authors that put their posters up in the back session there. Thank you for doing that it made it a very comprehensive forum today. Lots of topics covered, kind of seamlessly worked together. It was a very good mix of topics here.

Big thank you to the Air Force Director of Weather for providing the funding to make this happen. The Secure World Foundation, not just for providing the catering in the back for all the work they do in keeping the awareness of these issues up outside the government.

I'd like to thank the National Space Weather Partnership members for keeping things moving forward as well and the National Transportation Safety Board conference staff. I don't know if Rochelle is still in the room back there, if she can hear me, but she leads the staff here and they do a fantastic job getting this open for us so that we could inspect it, we could get set up.

I don't know if you've noticed but they've had a nearly invisible but highly effective cleaning crew going in and out while we've been back here. Hats off to those guys for keeping this going.

Finally, I'd like to thank both my staff for putting this together -- not so much me, my only job was to get a congressman here and I didn't, I had one job -- but the rest of the staff did a great job putting this together. The SWEF organizing committee, that's 23 people from 17 organizations, government, industry, academia, so it's a little microcosm of SWEF itself putting this together, and they did a fantastic job of selecting speakers and topics and putting this all together I want to leave it with a personal shout out to Mike Bonadonna who chaired that committee and got all the cats herding in the right direction.

Great job, Mike. Thanks for doing all that. With that, I don't think there's anything else to say.

By the power invested in me by the Federal Coordinator Chair, I now close SWEF 2017 and we commence planning for SWEF 2018. Thank you.

[applause]

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