Space Weather as a Global Challenge
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Italian Embassy
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Welcome Remarks

Speakers

- **H.E. Armando Varricchio**, Ambassador of Italy to the United States of America
- **Prof. Roberto Battiston**, President, Italian Space Agency
- **Dr. Jonathan Margolis**, Acting Deputy Assistant Secretary for Science, Space, and Health, US Department of State
- Moderator: **Victoria Samson**, Washington Office Director, Secure World Foundation

Armando Varricchio: ...distinguished speakers, ladies and gentlemen, it's a great pleasure to welcome you here to the Italian Embassy for this workshop of Space Weather as a Global Challenge. I'd like to extend my appreciation to the Department of State, here represented by Deputy Assistant Secretary Jonathon Margolis, for co-organizing this event. Through the years, Italy and the US have a strong and wide...

[coughing]

...both as friends and allies. We share the same values and we work side by side on many subjects...

[coughing]

Space represents one of the fields where our cooperation has proved to be remarkably successful. Since the launch of San Marco satellite from Wallops Island back in 1964, our countries have forged a long-standing cooperation. Let me recall that in a few weeks' time that astronaut Tom Pesquet, will once again embark upon a long-duration mission to the International Space Station.

The main criteria for the success has always been, and I have no doubt it will continue to be, the solid partnership between NASA and Italian Space Agency, ASI. Today's presence of President and Professor of Roberto Battiston whom I work with while come here to the Embassy, perfectly analyzes the special relationship.

The secret, if I may put it that way, of our successful cooperation has always been the ability to look at the future perspectives and conjoined efforts to address our common challenges.

This event is no exception. In fact, space weather is increasingly becoming a central topic that requires a coordinated approach within the framework of international data so as to understand the particular implications of this phenomenon, and identify ways to address them. It is [inaudible] pleasure to extend, to all of you, my most sincere wishes for a productive discussion.

I'm pleased now to give the floor to President and Professor Roberto Battison. Grazi.

[applause]

Roberto Battison: Distinguished Ambassador Varricchio, distinguished representative of the Department of State Johnathon Margolis, it's a real pleasure for me here today. I extend these thanks to all the participants who [inaudible] institutions, agencies, research institutes, and industries.

We also thank the sponsors for the Secure World Foundation, and showing support for this event. I would like to take also this opportunity to thank the General [inaudible] for the continuous effort to help creating this event. I think the success of it is demonstrated by this the participants, the number of participants, and the quality of participants.

Space weather is a concept which is normally related to the conditions, either the condition of the magnetosphere, the atmosphere, or thermosphere. It's induced by the solar phenomena and the solar wind.

Those conditions are able to influence the functioning and the reliability of our space systems, and sometimes also the terrestrial one. Sometimes, even to create damages to the health to humans. This is particularly true if you consider that there are missions which are extending also the way orbit, exploring the solar system up to the latest, farthest planets.

We see how space weather in reality applies to the entire solar system, not only to the surrounding. Space is not really something which is designed for us to stay in, but we have to use space in order to grasp the opportunities that are provided by being there.

Knowing, monitoring, can I say, changing the condition of space weather is a fundamental, since satellite, aerial navigation, radio communication, in general, all the technologies from the satellite, here and on Earth, are influenced by the effect of the modification of the standard condition, which we called normal, standard weather.

In the present world, where technology and telecommunication are clearly of tremendous importance in our daily life, the knowledge of the evolution of space weather clearly is a fundamentally important, indispensable element.

There is a study which has been published about the suns, which show clearly how the instabilities of the sun will create damages also the network of radio communication and energy transmission all around the world.

Of course, radiation is a danger for the biological systems, and created damages on DNA, and our astronauts on the International Space Station knows about that and if we consider extension this stay on the stays on the Moon and eventually to Mars, the issue becomes even much more serious.

So, there is plenty of evidence of importance for aeronautics, space, telecommunication and the critical infrastructure operation which need to monitor carefully what is the space weather and the cost depending on that.

In Italy, we have quite a distinct activity in the science [indecipherable…Center for National Research…] to progress in this field the level of capabilities. The national community, which is on a different location and institution has recently created an association SWICO, Space Weather Italian Community, exactly to coordinate the various actors that work in this field.

Italian Space Agency has confirmed its own interest for the activity of space weather both at the national level, as well as at the European level, promoting another initiative to diffuse and make

available information on these type of issues related to space weather. Making also available some assets in orbit and both the data related to those assets to gather information about a space weather.

For example, Solar Orbiter is a mission [indecipherable] which launches in 2018, so it is now very close. Also recall that the Italian Space Agency participates in ESA, as one of the main contributors. Already in 2009, ESA staffed a program about space situational awareness, where Europe started working to create the first services and distribution center for data information on the forecasts of the [indecipherable] using data from various instrumentation operating on serval satellites.

And the interests in growing with the time because the assets are growing with time, and the European Union is more and more interested in the subject. The European program of critical infrastructure protection provides policy background for critical infrastructure protection while the European Union Disaster [indecipherable].

I think that really when I learned that this mission even of having this way of option organized there was for us extremely interesting to participate because we understand how important space weather policy and organization is for United States. So we're really much interested to be [indecipherable] initiative at the presidential level. We just have the new administration, and we have to make sure we continue for obvious reasons because it's about protecting the international [indecipherable] system.

And with that I wish to everybody the best possible workshop. Thank you so much.

Jonathan Margolis: Good morning everyone…

Audience: …Good morning.

[laughter]

Dr. Margolis: I appreciate that. If I'm going to put on glasses in public. I want to get at least some response.

I'm Jonathan Margolis. I work at the State Department as the deputy assistant secretary of state there for Science, Space, and Health activities.

Let me begin by saying a great thank you to Ambassador Varricchio and the entire embassy staff here. You have been tremendous supporters of a whole range of space activities. We have a long history of working together, Italy and the United States, on space issues. We're delighted to have the support, here in Washington, of that activity.

Professor Battiston, you mentioned also the great work that takes place, not only in Washington, but between our capitals. We have a long history, again, of Italy and the United States working together on a range of space activities, whether that's through NASA or through agencies in the United States. We're delighted to have such a partner as Italy, as we go forward with a whole range of space activities.

Professor Battison already mentioned the importance of space weather. I'll just say a couple of things about that. It has economic implications, safety implications, human health implications, national security implications. As we all know, as we become more and more interdependent on communication networks, navigation system, and electrical power grids, across borders, the impact of space weather can not only be a national incident. It can be an international concern.

That's one of the reasons that we think it's very important to be having these kinds of discussions. Historical records, I'm sure people in this room are well familiar with it, reveal that space weather events of great severity have occurred within the last 150 years, the largest being Carrington Event in 1859.

If you're not familiar with it, the US National Academy of Science has estimated that the economic impact from a similar event of that magnitude today could reach up to $2 trillion -- that's not billion, that's trillion. That's 20 times the cost of a Hurricane Katrina, for example. It's potentially a catastrophic type of event we're looking at here.

My country, the United States, took an important step towards strengthening our preparedness for space weather when in 2015 we released two documents, the "National Space Weather Strategy" and "The National Space Weather Action Plan." Under the Trump administration, we are using these two documents to guide activities across US agencies.

The Space Weather Operations Research and Mitigation group -- we call the SWORM -- they have sub-committees and subsidiary work that they do. It's an interagency working group that coordinates all US government activities on these issues. SWORM is a sub-committee. It's chartered under our National Science and Technology Council, which is part of the Executive Office of the President of the United States.

The Strategy and Action Plan identified a number of high-level goals that we have domestically for the United States and internationally. These include preparedness, research, operations activities, and increasingly important, international cooperation, international coordination.

The United States recognizes that in a world increasingly dependent on interconnected and interdependent infrastructure, any disruptions to that infrastructure could have regional and international consequences. The way we look at it is space weather impacts all of us.

We have four objectives for our international cooperation. The first is to build international awareness of space weather as a global challenge, the title of today's activity. The second, to increase international activities on observation, infrastructure, data sharing, numerical modeling, and scientific research.

The third, to strengthen international coordination and cooperation on space weather products and services. Then the fourth, to promote collaborative international approaches to preparedness for extreme space weather events. We recognize that, for a number of countries, the challenges of space weather are still relatively new. People are still thinking about what this means and what they need to do about it.

There is much work that needs to be done to build international understanding of the potential impacts and the types of responses needed. It's for that reason that about a year ago my department, together with Secure World Foundation, organized the first Space Weather as a Global Challenge event, about a year ago in April of 2016.

As we engage internationally on space weather, one of our goals is to explain the steps that the United States government is taking domestically, focusing on issues like research, operations, preparedness, to give a sense of how we in the United have organized ourselves across multiple agencies to have a capable response potential.

We also think it's important though to take measure of the international efforts underway. In fact, we have seen activities in the multilateral sphere, which include the World Meteorological Organization, the UN Committee on Peaceful Uses of Outer Space, and NATO as well. It's important to recognize that the other global, multi-lateral institutions are picking up the call in space weather and starting to look at this much more seriously.

Based on the discussions that we've had with other countries, as well as through these multilateral forums, including the workshop that we convened last year, there may be merits in exploring possible collaboration on advance warning of hazardous solar activities.

At our April 2016 workshop, for example, there was some discussion of the benefits of complimentary missions to the L1 and L5 Lagrange points, to increase resilience and reduce costs. In the United States, we continue to make progress towards to the actions we've identified through our strategy.

I'll give you a couple of quick examples. Under the auspices of SWORM, we released, in January, a draft space weather benchmarks and a white paper on improving space weather forecasting research operations and operations to research.

Earlier this month, for those of you following the work of our Congress, the United States Senate passed, with unanimous consent, the Space Weather Research and Forecasting Act. If approved by the House and then signed into law, this legislation is for future space weather research and planning to protect critical infrastructure from solar systems.

We've seen progress multilaterally, as well. The WMO has since approved a four-year plan, 2016 through 2019, for coordination of space weather activities. COPUOS has selected space weather as a thematic priority for Unispace+50, all good signs, all getting the word out about the importance of space weather.

Today's agenda and today's workshop is structured to provide a substantive update on both some of the domestic activities that countries are undertaking, as well as the international efforts. I look forward to the progress that we make today as we have those discussions.

Before I close, let me just thank personally my good friend Victoria Samson and her whole team at the Secure World Foundation. They've been a tremendous partner and ally in bringing space weather to the fore. We look forward to her personal involvement in the activities today. Let me turn the floor over now to Victoria. Thank you.

[applause]

[background sounds only]

Space Weather Research and Operations

Speakers

- **Mr. Steven Clarke**, Director of Heliophysics Division, NASA
- **Prof. Alberto Buzzoni**, Sr. Associate Astronomer, Italian National Institute for Astrophysics
- **Dr. Paul Shepson**, Director of the Division of Atmospheric and Geospace Sciences, NSF

Victoria Samson: Good morning, everyone. My name is Victoria Samson. I'm the Washington office director of the Secure World Foundation. You may have seen our brochure when you checked in. If not, we are a private operating foundation that focuses on the sustainable use of space.

Our goal is to promote best practices, norms of behavior, and responsible use of space that will ensure space is sustainable and available to all over the long term. Space weather, while a natural phenomenon, absolutely affects space sustainability.

Services can be disrupted or satellites can be damaged by space weather events, as well, space weather can affect the debris population, and if there is a hostile situation going on, on terra firma, and there's some space weather event that affects a satellite, it could accidentally escalate a situation.

This is the third event on space weather that Secure World has hosted. The first was a Hill Briefing on space weather in November of 2014. The second, as just referred to, we co-sponsored an event last year, April 2016, with the State Department, and so we're delighted to be a participant and sponsor of this third event.

We are very excited to be a part of the conversation today. Space weather, being global in nature, requires an international response. The collaborative approach is even more crucial, now that space is becoming more important to everyone around the world.

With that, and since we're very tight on time, I'll stop my remarks there. We have three speakers for the session, each speaker gets 10 minutes. If they stop short, then we'll have time for questions. If not, you can always hit them up during the coffee breaks.

Their biographies, I believe, will be on the State Department's website, I know they will be on Secure World's website. Our website is www.swfound.org. With that, I'd like to call up the first speaker, Mr. Steven Clarke.

Steven Clarke: Good morning. Thank you for that introduction. My name is Steve Clarke, I'm Heliophysics Division Director at NASA Headquarters. Mr. Ambassador, thank you for hosting this here at the Embassy, it's a pleasure and honor to be here. Thank you to Secure World, and the Department of State, as well, and all the sponsors for sponsoring this important event.

What I'd like to do is, I'll try to keep my comments brief here. I am in the Science Mission Directorate at NASA Headquarters. We have an integrated program of group science that we do. You see heliophysics on the left, but we have our sister/brother divisions, Earth Science, Planetary, and Astrophysics, as well.

We work very closely together to do integrated science and benefit from each other's research. What we do is, try to answer three key science themes, safeguarding and improving life on Earth, searching for life elsewhere, and expanding our knowledge.

Certainly, space weather is very key to the first and third ones. We're also starting to see some interest from the research community in searching for life elsewhere. You saw the announcement a few weeks back, about the transit one...the planets outside of our solar system.

Certainly, our research on space weather and how our star impacts our Earth, that type of research is starting to be propagated out towards the planets outside of our solar system, so we can better understand, is it viable for life.

I certainly would like to list all of the missions, but these are all the NASA research missions in conjunction with our international partners that we have flying today around the Earth, doing science research, doing planetary research, astrophysics, and heliophysics.

This next slide, you just saw a few changes were to be added to that fleet of spacecraft to increase our knowledge on all those various science teams.

In the heliophysics world, we have four missions that are in development currently. We have the Ionosphere Connection Explorer, which we fly later this year in low Earth orbit, studying the ionosphere. The spacecraft is in Gilbert, Arizona, making good progress, and that will be launched on a Pegasus launch vehicle, out of the Kwajalein Islands, later this year.

We have the GOLD instrument, which you can see at the top of that picture, that's been attached to the crane. That's the Global Observations of the Limb and Disk. This is a unique partnership here, where we have an instrument that is flying on-board an international communications satellite, the SES-14 spacecraft built by Airbus.

Indeed, the instrument's been delivered and it's been integrated onto the spacecraft in Toulouse, and testing continues. This is a very exciting, new, unique type of partnership, where we're flying science instruments on a what we call the communications commercial spacecraft.

We're beginning to see more of those type of partnerships grow. I think this is a very important step forward in combining science with some opportunities with a commercial role, as well.

Lower left, we have Solar Probe Plus. That spacecraft is coming along very well. We're looking to launch July 31st of next year. This spacecraft will be flying closest to the Sun than we ever have before. It will be taking in situ measurements and remote sensing data that we've never seen before, so we're very excited about that. We've already had two of the instruments delivered, and integration continues there, so we're on track.

You heard earlier, Solar Orbiter, which is another key ESA-NASA partnership. The United States is providing two instruments for that, Heavy Ion Sensor, which you see here in the picture, which is due to be delivered to MSSL in UK tomorrow, and SoloHI, which is the heliospheric imager, has already been delivered. It was built by the Naval Research Lab, and it's been mechanically installed onto Solar Orbiter.

We continue to progress with our partners at ESA to have this launch late next year, or early February of 2019. This is another exciting mission where we're going to be flying not as close to the Sun as Solar Probe, but it'll be in a different orbit, and the two spacecraft will be providing complementary science.

This is a picture of what we call the Heliophysics System Observatory. We have 18 missions flying today, 28 separate spacecraft. You'll see where I've circled, the international partnership missions, which are key to the research community.

SOHO is one of the large missions that we've partnered with and [indecipherable] has been a part of that. [indecipherable], we worked with our Japanese counterparts, as well, with JAXA, with Hinode and GEOTAIL, and of course, I've mentioned Solar Orbiter here. We're looking forward to future partnerships as well.

You've heard a little bit about the impacts here on Earth from severe geomagnetic storms. This is, really, just a sample from media over the last three to five years of the impacts that we have felt due to those

geomagnetic storms, and why it is so important that we advance the science of being able to better forecast and predict the severity of these type of storms so we can better prepare.

This was felt back in 1989 in Quebec City. Picture from Earth orbit, you can see where, basically, Quebec is dark. From a global standpoint, this was a more localized impact, but certainly you can understand how great of an impact it would be if it had hit and caused more damage here, not just the United States, but even Europe.

You also heard about the National Space Weather Strategy and Space Weather Action Plan, which NASA is a key participant along with several other government agencies. We continue to work through those actions, very encouraged by how the government agencies have come together to work these actions.

President Obama signed an executive order before leaving office, basically codified the Space Weather Strategy and Action Plan. I'm very pleased to know that the current administration also finds the importance of space weather research and the actions that we're working.

Again, we heard about the Space Weather Research Forecasting Act passed by the Senate. I think the key takeaway there is, not only is the administration very aware and very focused on space weather capability, and the executive branch of the United States government, but also the legislative branch. You can see we really have bipartisan support.

On partnerships, NASA has been working very closely with NOAA to develop a Memorandum of Understanding -- in fact, my colleague, Bill Lapenta and I will be signing that MoU today -- and this defined a joint modeling activities, really to bring that research to operations together work closely, so that we can start producing better models for the operational community.

I said targeted mid-May for final approval, so I think today we've hit the target, so we'll be happy to say we met that goal.

We're also working very closely with the National Science Foundation, to generate and MoU there, as well, and the final language is under review. We've been talking with the DoD, as well, about how we can incorporate those type of activities, from research to operations, and operations to research.

We have a joint grant that we'll be coming out with NSF, right now the working title is Computational Aspects of Space Weather. It's a three-year grant. This builds on top of a grant that we've already been working for the last five years, so we're going to see increased collaboration with other government agencies to do research.

Later this year, we have what we call a Heliophysics Science Center that we're going to be establishing. We have a request for information that will be coming out later this year, to better define the framework of how we can move forward. One of the primary topics that will be used in the Science Center is space weather research.

This is, basically, a flowchart of what I just described, with the Memorandum of Understanding between the agencies. You'll see in the center there, the Community-Coordinated Modeling Center, which is located at the NASA Goddard Space Flight Center, near Greenbelt, Maryland. That's a core capability that researchers have been using to validate their models and get feedback.

We see that as a core capability as we move forward with these Memorandums of Understanding, working with the operational community. Of course, you can see in the lower right, the international partnerships. The contributions are very key to this whole research to operations concept.

Ms. Samson: One minute, please.

Mr. Clarke: Thank you.

Some additional international partnerships, I just wanted to highlight. I've been talking with the Space Situational Awareness site of ESA in Darmstadt. They're looking at potentially flying a mission to L5. We're looking at collaborating in flying some science instruments on-board. Those talks continue, so we'll continue to look for new opportunities to collaborate with the operational community and the research community.

The Korea Astronomy and Space Science Institute, we developed a working group with them last year, and we now are looking at hosting one of their geospace models at the CCMC that I mentioned earlier. We're working closely with them at potentially flying a prototype compact coronagraph on a balloon flight in 2019.

JAXA, we have a next-generation solar physics mission science objectives team that we formed up with NASA, ESA, and JAXA, to look at the science objectives of what we originally called Solar-C. We want to be able to look at new concepts, new ways to do that, particularly in light of new technology that's been developed.

The Indian Space Research Organisation, we have a working group that we've set up with them. We had a very good meeting in January. They're flying their Aditya-1 mission around the 2020 time-frame, so we're looking to collaborate with them on data. Certainly, they're very interested in space weather modeling, as well.

You can see, we are expanding our international collaborations because it's, really, truly is a global effort. Of course, we want to minimize the impacts that you've heard about already this morning, not just here on Earth, but certainly in Earth orbit.

As we rely more on technology, we need to be that prepared. As we venture out beyond low-Earth orbit with humans, we have to be able to better prepare our astronauts.

With that, I'll leave with you that a long term inter-agency international public, private collaboration is really critical to successful global space weather preparedness. With that, I look forward to hear the rest of the speakers. Go ahead.

[applause]

Ms. Samson: Thank you very much. We're over on time on that one so we'll move on to our next speaker. I apologize. I've been given strict instructions to keep us on schedule. With that, we have Professor Alberto Buzzoni. If you could please address...

Alberto Buzzoni: Hello everybody. Let me start with warm greetings from Professor Nicolo D'Amico the president of INAF in Italy. Professor D'Amico cannot be here at this so important and he has have been so kind to tell me to prepare a little, a very brief overview of the INAF activity regarding space

[inaudible/indecipherable awareness, the different facets. We're involved with SST activity and space weather activity. I have, I think, eight minutes. There is no hope...

[laughter]

Prof. Buzzoni: ...these kind of problems but they were the subject of the second part of our meeting. I have the pleasure to be here in Washington, Professor [indecipherable], who is one of the reference persons for space weather in Italy. I'm sure [indecipherable] that we are active with a small team but very important, of experimental researchers.

But on the side of SST, the big problem, physical characterization of the payloads and on the other side, the space weather. On the side of SST, INAF activity is coordinated within a national facility, you could say, a national level.

It is [indecipherable] together with the National Air Force and with the National Space Agency, which is actually our national framework with ESA and the European Commission. Within this group, we are carrying on our activity, especially on the side of SST.

A very brief sketch of the different scenes in Italy where INAF is carrying on its activity on SSA. You see that, as far as space weather is concerned, you see that we have a main backbone from north to south, crossing what we have in Rome, in many cases in Italy, but we have two referenced posts, one in [indecipherable] concerning the regular monitoring of the sun.

From the optical side, in Sicily, in Observatory Di Catania. Two more nodes will probably join. One is Napoli, the solar physics from the optical point of view, and the other is Torino, which is especially focused on data [indecipherable] and theory.

On the side of SST, the central focus is in Bologna. It's my institute. I come from Bologna. We work on space debris and physical characterization of orbiting bodies. Artificial and natural ones.

But from the radar point of view and the optical point of view, in Bologna, we have the largest and oldest radio telescope in Italy, which is close to Bologna in a small town called Medicina -- It's a big telescope. 600 meter -- which is currently, in part, dedicated to space debris.

From the optical point of view, we have, in Loiano, which is another small town south of Bologna, we have a big facility. Actually, for the astronomers, this is a small telescope, if you want to look at the universe. But it's a very big telescope for our business.

Actually this is the Cassini Telescope. 1.52 meters. With this telescope, we can detect...space debris in geo-orbit. Just to give you an idea, we are able to catch the spacecraft GAIA at the Lagrangian point, L2, for instance, and on the other side we can track orbiting objects down to about near-orbit, about 3,000 km.

Refurbishment of this telescope has been carried out in recent years so we can move the telescope outside the sidereal track. So we can track different bodies. The further refurbishment is in progress to equip the telescope with a wide-view camera, which would allow the telescope to enter the business of LEO orbit. So tracking much lower orbits.

Just let me spend two words about two possible, current projects, which to some extent are merging.

The SST activity with the space weather activity. One deals with the physical characterization of the constellation Russian satellites, Molniya.

It's a big constellation of 50 satellites. They are not operational but they are especially relevant for this kind of science because of their orbit, Molniya orbit actually, which led them to cross four times a day and due to this kind of orbit, below the Van Allen belt. Due to this kind of orbit, Molniya in fact can be used as probes to test the magnetosphere of Earth.

This is because, as they are a big payload, they are spinning, [indecipherable] and the spinning is dissipating, it dissipates according to interaction with the magnetosphere. We are tracking -- it's a long-term project -- to see how, not the orbit but the spinning properties of this constellation evolve.

Another project, which has much to do with space weather, take the move from this simple table. It's a compilation of the detected reentries in the last year by [indecipherable]. You see that along the year 2016, about eight events have been recording.

In eight cases, we have seen satellites or their payloads or space debris reentering the atmosphere. If you see, no detection is present for month of September.

According to the NORAD statistics, In September, just to pick an example, along the month of September, 41 dead payloads have entered Earth's atmosphere, which means that [indecipherable] and this is due to the fact that we have evident limits in the prediction of when and where these bodies will reenter.

The possible way out, that we say, [indecipherable] I think between academic science and citizen science. Let me mention this network, this project, which is starting now in Italy and it is led by INAF. It is called PRISMA. The PRISMA network is a network of fish eye cameras -- very small fish eye cameras. $2,000 per equipment -- which is spread across the country.

We are extending to the south. We have still some problems to the south. The project is expanding very quickly. Each red dot is the operational camera. Each orange dot is a camera, which is there, it is in position and will be operational within weeks. We hope, before the end of this year, we're covering at least the northern half of Italy with the green of the other 100 km.

These cameras are able to look at measures but not [/indecipherable]. In fact, with a little trick, it is possible to look at a number of other interesting events. By chance, during the calibration experiments in Bologna, we have got an Iridium flare for instance...

Ms. Samson: One minute, please.

Prof. Buzzoni: Yes. This is the last slide. You see that these cameras are automatic, of course. Looking at the sky 24 hours a day, and they are recording what they are seeing. We can detect meteors but we can detect, for instance, possible reentry for a number of...different application for civil protection inside our country.

With little refurbishment, it is possible to enter with these cameras also, the other business, which is not only the entry but also to track the orbits of the biggest payloads, of the other [indecipherable]. This is more or less what we are doing now in Italy. Thank you so much.

[applause]

Ms. Samson: Thank you. We're right on time so if anyone has questions, they could approach during the coffee break. Thank you professor. Next we, for the last speaker for the panel on space weather research and observation, we have Dr. Paul Shepson.

Paul Shepson: Thanks very much for having me here at the podium. I want to thank the ambassador and the organizers of today's event. I'm here representing the National Science Foundation. I'm directors of the Atmospheric and Geospace Sciences division. NSF contains within it, a geospace science program.

Our role is funding, mostly the university community that studies the fundamentals of geospace science processes. I'm going to just tell you a little bit about NSF's role and a little bit about the international context.

As Dr. Margolis commented, space weather is not a national challenge, it's obviously a global challenge. Part of this results from our global interconnectedness from a continental scale to international communications and business systems and satellites that we rely on for information and aviation guidance.

A variety of things that make the plan and go. It's clear that space weather and space weather readiness, having, developing effective space weather readiness is an international challenge. In terms of understanding the fundamentals and having the appropriate observational systems that would enable effective predictability, we're not there.

In a way, that's a scary challenge. It's also an exciting challenge for those of us who are in the scientific community. As various speakers so far have mentioned, Steve among them, in 2015, space weather was elevated to a position of national scale and prominence and intense focus in the United States with the development of the inter-agency space weather action plan.

As also discussed, we have coming legislation that connects to and points to the charges that are delineated in the space weather action plan. For NSF, we participate in many of the six goals. What are the six goals? One of them is increasing international collaboration.

NSF's primary role is supporting the space weather enterprise by funding basic research. We do that through multiple directorates across NSF. There are a number of international collaborations that we support through supporting travel and international scientific efforts of the PIs. We fund, we support international workshops like this years' Chaplin Conference.

We're also part of the International Space Weather Initiative that I think I understand has representatives from all six continents. All six continents that fund science. We also support ground-based observations through a variety of distributed networks that cross continents and involve multiple partnering countries.

NSF also supports space weather observations. They tend to be, for the most part, ground-based.

I'm professor in my off hours and can't really speak without a pointer so I'll use a pointer.

They include solar observations, the model solar observatory, the Big Bear Solar Observatory, the developing Daniel K. Inouye Solar Telescope that is on track for operation late '19, perhaps 22.

We have observations of the magnetosphere based observation...Magnetometer chains are an international component of our surface-based observations, the ones in blue here, have an international

component. The SuperDARN radar and that work that I think includes 35 radar installations in multiple countries.

The Advanced Modular Incoherent Scatter Radar facilities and other ISRs that we have in multiple countries, but mostly in partnership with Canada and Greenland. We are not entirely ground-based. One of the ways that we're doing satellite observations, the NSF has played a large role in stimulating and helping develop that technology is CubeSats.

The CubeSat program started in terms of NSF funding, again, mostly of the university community but we've had great partnerships, in particular NASA and others.

The geospace section has pioneered the development of CubeSats for space weather research and it is clearly a technology in terms of geospace observations and a variety of Earth observations, clearly a disruptive technology in terms of what it is enabling and who it is enabling, that is, every country in the world, in principle, has the ability to have a space science program.

Although it started in geospace, we're currently reevaluating our program to engage other scientific disciplines like the Earth observations disciplines or surface observations to take advantage of this technology.

This is from the National Academy report, achieving science with CubeSats, that shows the explosive...Explosive is probably not the best word to use.

[laughter]

Dr. Shepson: Fantastic rate of acceleration of the utilization of CubeSats. Here it's broken out according to the scientific focus and an important thing to see here is the light blue part of the bar in communications that just took off in the last several years, that is, the commercial component of CubeSat development.

Here, in terms of who is supporting the launch, universities have played a big role, in part through NSF. I'm not sure what the different between the blue and the yellow. Universities support a lot but there are probably others supporting universities like NASA.

But the commercial world has positively taken off. This is an opportunity for us to share technology with other nations and to have continuing collaborative science through this capability.

NSF geospace supports modeling of all of the components of the geospace system from solar eruptions to study of impact on the magnetosphere and then connections to an impact on the ionosphere and the Earth.

We also are excited about it and working on a development of models that are oriented towards geospace systems sciences.

We're well aware of the growing need for research to operations and the feedback from the operational community to the university community, the fundamental science community in terms of understanding from operational models where there are needs in our understanding that will turn back into new developments that enable us to approve those operational models.

Ms. Samson: One minute.

Dr. Shepson: A minute. No problem. Some of the models that are operational at this point have been developed with NSF support and I think Steve mentioned the CCMC that no one in NSF co-fund -- that provides a mechanism for transitioning research-based models into operation.

I'll just conclude again that understanding space weather and having the Space Weather running this, is a global challenge.

The partnership that we're here to talk about today is really quite important. I already said this about R2O2R, that it's quite important, and that I think it's important globally in sharing technological developments and having the ability to share observational data and models. It's going to be important in developing this international capability. NSF will be a partner in this process in supporting the basic research side of our progress. That's it.

Ms. Samson: Thank you.

[applause]

Ms. Samson: I think we're actually at time, so maybe if you want to approach him at the break. Thank you very much.

Space Weather Services

Speakers

- **Dr. Mamoru Ishii**, Director, Space Weather and Environment Informatics Laboratory, National Institute of Information and Communications Technology
- **Dr. William Lapenta**, Director, National Centers for Environmental Prediction, NOAA
- **Dr. Leonardo Sagnotti**, Director, National Institute of Geophysics and Volcanology
- **Dr. Juergen Drescher**, Head DLR Washington Office, German Aerospace Center
- **Gen. Luigi Del Bene**, Italian Air Force
- **Mr. Ralph Stoffler**, Director of Weather, Deputy Chief of Staff for Operations, USAF

Ms. Samson: We'll go on to our next panel, Space Weather Services. Our first speaker is Dr Mamoru Ishii.

[pause]

Mamoru Ishii: Good morning, ladies and gentlemen. My name is Mamoru Ishii from National Institute of Information and Communications Technology, Japan. Today I would like to introduce Japanese activity for space weather. As a member of ISES, International Space Environment Service, we provide operational space weather forecast every day. Including the weekend and the holidays.

We have a briefing meeting every 2:30 PM. We provide information, about 3:00 PM, by our website and emailing. Web access is about 160 thousand and number of email addresses is about 10 thousand. Many user information is subject to operate additional recent companies apart from companies [indecipherable] and many for academic re-use.

This is the number of our observation [indecipherable]. So, we have all domestic observatories here: Hokkaido, Tokyo, Kyushu, and Okinawa. And we have routine observations in Antarctica, at a research base with cooperative observation with other Southeast Asian countries.

Here I would like to introduce some of our research activities for space weather forecast. In our laboratory, we develop many kinds of space weather forecast models from the Sun to the Earth.

Recently we succeeded to develop [indecipherable] system [indecipherable] to reach 0.9 [indecipherable].

This is an example of 3D [indecipherable] observation with high [indecipherable] in Japan. We have a GPS network in Japan with 1,140 points [indecipherable] available for deducing atmospheric conditions. So here I would like to show you [indecipherable] just off of East Japan [indecipherable].

[indecipherable]

We established [indecipherable] Alliance in 2010 for information exchange among space-based organizations in Asia and Oceania. The number of invites 27 organizations from 17 countries, not only Asia and Oceania region, but also the US and Europe. We have face-to-face meetings every one-and-a-half year, and the last one was hosted by Korea last October.

And the reason we succeeded to get the budget from the grant in 8 [indecipherable]. The name of the project is Project for Solar Terrestrial Environment Prediction. The acronym is PSTEP. One of the [indecipherable] of PSTEP is to provide usable information for users. Also we establish Japanese policeman hazard map for preparedness against an extreme space weather.

I would like to show you a very brand-new result based on these PSTEP activities. This is provided from [indecipherable] of Kyoto University. She developed a model of [indecipherable] Geomatically Induced Current in Japan. For long years, many people, even scientists, believed that [indecipherable] event is not so important in Japan because Japan is [indecipherable] companies.

But Japan has two characteristics for [indecipherable]. One it Japan has a very complicated structure of ground composition. Another is that Japan is an island surrounded by the ocean which is highly conductive.

So she proved these characteristics in her model and [indecipherable] has happened. This result shows that [indecipherable] depends on the direction of the magnetic field very drastically, but it every case there are very serious [indecipherable] around the coast.

This is not too good of a result because millions of Japanese plant, especially nuclear plant, are located on the coast.

This is a comparison with how results are uniform model of [indecipherable]. Up above shows the higher results. In this case, for example the direction of the electric field is east to west. Our model shows a very small about of DC in powerplant.

The direction of the electric field is southward in some case, some of the part in the nuclear plant has big DC. So from that on we start to discuss the results with the power companies in Japan.

Thank you very much.

[applause]

Ms. Samson: Thank you. We do have time for one quick question if anyone has one for Dr. Ishii. Please wait for the mic, and when you get it if you could please identify yourself. Thank you.

Audience Participant: Hi. Dr. Ishii. I'm the [indecipherable] President of Asia America Initiative, and we do a lot with disaster response and also the preempting, trying to do some predictions. Before the Fukushima earthquake and then the tsunami, was there intensified space weather activity that you were able to track or monitor?

Dr. Ishii: No, but I'm going to show that [indecipherable] extreme event, extreme…aspect event to space weather with the experience [indecipherable]. So it's not an obvious relation, but it's an example [indecipherable] of a phenomenon to space weather.

Ms. Samson: Thank you very much. Thank you again.

[applause]

Ms. Samson: Our next speaker is Dr. William Lapenta.

William Lapenta: While we each sit up here, I want to first of all thank the Ambassador for hosting this very important event. I want to thank all the sponsors for pulling together and making this happen because I know these things aren't easy. Good morning. My name is Bill Lapenta.

I'm the director of the National Center for Environmental Prediction which is part of the National Weather Service under NOAA. What I'm going to talk about today is the Space Prediction Center and how it fits into this global role of space weather predictions.

You heard a lot already this morning about the Space Weather Strategy and the associated action plan that's been developed in the last couple of years.

The only think I want to add to it is because of this action plan and the commitment of the agencies and the countries involved to work together it's really maintained a high level of energy through this transition period in administration which is really important because without this perhaps we wouldn't be as engaged as we need to be.

This is a really good sign. There are six working groups that meet on a monthly basis, and we're really focused on actually completing the action that will put forth this action plan, and this is something that's been continually updated in time.

This is a very important part of in the line infrastructure within this country, and I expect there is international components of this as well over time. This is a really important thing to keep in mind moving forward. The Space Weather Prediction Center is one of the ten national centers in the National Weather Service.

What you see here on the left-hand side is a picture of the operations floor. A big part of the forecast process is monitoring current conditions, looking at the sun, looking at the observations, and being prepared to make predictions based on solar activity. Then those predictions you have forecasts, conditions for tomorrow.

You have watches, conditions are favorable for impacts or storms of events and you have warnings meaning something is eminent and it stays in place, and then from that information alerts are provided to our customers. It's no different than what we do for hurricanes, what we do for tornadoes, convection, and what we do for winter weather.

It's really the same forecast process that is applied to space weather. The challenge with space weather is that you don't get immediate verification that an event took place other than through some monitoring and observation.

From the public perspective they may never know that a space weather event took place which is a good think because it means that the community has taken the appropriate mitigation steps to limit the impacts to the public at large.

Then what's unique about the Space Weather Prediction Center is that it's a small group, it's maybe about 60 people in total, and they are responsible for the operational forecasting, technique development and model development and its limitations. It's a very small concentrated group within the agency.

It's nothing like we have with terrestrial weather. It’s much smaller which is why it's so critical that we interact with and partner with other agencies, academia and the private sector to transition advancements in techniques into our operations.

Customer demand for space weather information continues to rise, and this is what this graph shows, the area under the blue curve shows the number of customers that come to [inaudible/indecipherable on a daily basis since 2006. The upswing continues as the demand for these products and services grow. Our customer bases are very diverse.

It goes from emergency responders, the electric power grid operators, drilling and oil exploration, the satellite industry which is becoming more and more important as they can be more commercialized at a time, and of course airlines and the Department of Transportation. Space Weather within the National Weather Service may seem like an oddity, but it's really not.

Within the National Weather Service we have a strategic imperative called the Weather Ready Nation which is really about getting the nation ready, responsive and resilient to high impact events, high impact weather so tornado, winter weather, hurricane, space weather. It's all the same thing. Ready, responsive, and resilient.

This is where the National Weather Service is really emphasizing their relationship with public safety and protection of life and property and how we work closely with those that are responsible for making decisions to mitigate the impacts of high impact events such as space weather.

We don't' make those decisions for our stakeholders, but we provide them with the information they need to make informed decisions for their stakeholders. As we move forward the Space Weather Action Plan I talked about earlier the executive board of that has been signed by the president. We're really working to develop what we're calling a space weather ready nation.

This really is a global problem which is why we're all here today to talk about this important agenda. In terms of what the priorities are right now within the National Weather Service and space weather, observations are of course a very core component of what we do.

I'm a terrestrial meteorologist, and I used to complain about the lack of observations and the atmosphere and over the ocean, but now that I'm responsible for space weather activities I have nothing to say about terrestrial shortcomings. What we have in space weather is an extremely difficult problem with limited observations, and yet the stakes are very high.

DSCOVER went operational in July 2016. GOES 16 was successfully launched less than a year ago and those products becoming operationally in the not too distant future, we rely heavily on ground based solar networks to support our operations, and looking forward working with the satellite service and NOAA and also NASA the Space Weather Forward Observatory which will be a follow-on to [indecipherable].

The critical component of prediction is having a modeling capability, providing some sort of guidance for forecasters to use to make decisions about, and really the first operational model that we put in was the WSA-Enlil, which was about 2011. The production suite, as we call it, or the suite of models available for operational forecasting within space weather is still in its infancy compared to what we have in terrestrial weather.

It continues to grow. Systematically, with time, we've gone from the WSA-Enlil, which is basically a solar flare model. We now have a geospace model that looks more holistically and broadly about the effects of geomagnetic forcing on the earth's magnetic field. We continue to develop the suite of operation space weather prediction capabilities that are required from an operational forecasting perspective.

Lastly, what I'm going to talk about is the SWORM SWAP and its influence and our commitment, from a space weather prediction center perspective, to make sure that that is truly a successful endeavor. Again, we, within NOAA, can't do it alone. We have to rely heavily on our partnerships with other agencies and the academic and the commercial centers, as well.

In closing, within the Space Weather Action Plan, the working goal six is focused on increased international cooperation. What we heard this morning, you can't underemphasize the fact that this really is a global problem. I have to say that even severe weather forecasting a global problem. Our tools and techniques have gotten a lot better. Now we're capable of deriving outlooks for the potential of severe weather a week in advance.

It may just be a broad area, but the situational awareness that our observations, our understanding, that our numerical guidance systems provides us with far exceeds what I thought would be possible even 30 years ago. While space weather's in its infancy in terms of prediction capability, I expect that it too will grow in its ability to deliver information that our stakeholders need going forward.

Working Group Six and the SWAP is going to be an integral part of what we're talking about here later today and this afternoon in terms of getting together, working across international boundaries to address the challenges and mitigating the impacts through the space weather prediction perspective.

That's all I have. Thank you.

[applause]

Victoria Samson: We have about one minute if anyone has any questions for Dr. Lapenta…

…All right. You're off the hook. Thank you very much.

Dr. Lapenta: I'll be here all day.

Ms. Samson: [laughs] Next we have Dr. Leonardo Sagnotti.

Leonardo Sagnotti: Ladies and gentlemen, good morning. First of all, let me thank our organizers for inviting me back into his workshop and letting me present here the activities of INGV, in general, in this sector. I understand your readings, and I also brought a lot of material today, so [inaudible/indecipherable who really important and supportive of this solution.

I'm the director of one of the departments in which the institute is subdivided, which is the Environment Department. The INGV was founded in 2000 through the process of merging different research institutes with activities revolving around the assessment and mitigation of seismic and volcanic risk.

We are mostly interested with dealing earthquakes and volcanoes, but also with the investigation of geophysical phenomena all over the earth, and understanding the mechanisms that control evolution of our planet.

The mission of the Institute is to observe and monitor geophysical processes in both solid and fluid components of planet Earth, study and modeling not only geophysical and volcanalogical processes, but we are also in charge of surveillance of seismicity and volcanic activity for the entire country through state-of-the-art instrumental networks.

We are to try to develop original methods to evaluate a variety of natural risks, not only earthquakes, volcanoes, and tsunami, but also climatic changes, as well as space weather, of course, but equally important for focus on the Italian region, and to develop innovative research in earth sciences, focused on global issues -- national security, sustainable development.

In charge of seismic and volcanic surveillance. That's a priority agreement with our Civic Protection Department in Italy for the surveillance of seismic and volcanic activity, with the operational rules, which are in charge around the globe 24 hours a day, each day of the year. We already have this unique basic surveillance about geophysical processes in our country.

The institute is organized in several divisions. Mainly the divisions are those shown in the red dots, and also local offices, which are distributed all over the country. The main headquarter is the Rome. The personnel I would answer for now is about 1,000 persons in units, including scientists, technicians, and administratives.

Scientifically, the institute is subdivided in three departments, which are earthquakes, volcanoes, and environment. Environment includes everything which is not strictly related to earthquakes or volcanoes, and has a very different activities that I will show briefly and shortly.

Our scientific organization is based on infrastructures, infrastructure about national and institutional infrastructures, but also European infrastructures. In the bottom of this slide you see two drawings, which refer to European Research Infrastructure Consortium, for which INGV is about the observational of the European Plate, and also seafloor and [indecipherable] community of [indecipherable].

Concerning our infrastructure, we have a lot of monitoring networks, not only concerned with the seismic activity and volcanic, but also about the geomagnetic field, the ionosphere and also GPS measurement for the information in the Italian region.

We have several observatories. One is the ancientest volcanic observatory in the world, which is the Osservatorio Vesuviano -- featuring upper left in the slide -- which was founded 175 years ago, in 1841.

Some of them are, instead, very modern. The two bottom photos show the observatories which INGV is running in Antarctica. It's a French-Italian base in Dome C, and also a modern seafloor, multidisciplinary observatories, which are placed on the bottom of the sea.

We have a variety of laboratories in geochemistry, petrology, experiments on high pressure and high temperature, and paleomagnetism and rock magnetism. Then we have, of course, the data products and software, which are available. It includes also sharing real-time data about different geophysical phenomenon. Also, high-performance computing facilities, which can help to analyze these data.

With regards to the environment department, I will give you a very short talk, an overview. Then the details about the space weather we just introduced, that will be the subject of much more detailed and specific presentation this afternoon that will be given by my colleague, Vincenzo Romano.

We include several activities and research span a very large variety of disciplines, not only magnetism, including geomagnetism and paleomagnetism, but also upper atmosphere physics. These parts are all relevant for space weather. We have also activity of operational oceanography, the study of present-day climatic changes, climatic changes of past, polar research, fluid geochemistry, and exploration geophysics.

This research is then translated into a variety of services. We publish bulletins and maps, real-time data, database models. We make some activity for environmental monitoring, consulting for different institutional stakeholders, and outreach activities.

With regard to space weather, we have different groups working on the geomagnetic field as one of [indecipherable] present-day [inaudible/indecipherable geomagnetic field, but also the behavior of the geomagnetic field during the past at least studied, and we will start [indecipherable].

We have a group working on atmospheric physics and space weather, sun-earth interactions, with the of [indecipherable] the magnetic field in the ionosphere and [indecipherable] model is in the [indecipherable] region, as well as in both polar regions and South America.

And space weather, I will complete with this, summarizing this computing slide. It includes monitoring ionosphere and geomagnetic parameters at mid, low, and high latitudes. Investigation new models and indices, developing of forecasting and alert tools, contribution to international initiatives, and participation to international projects.

We are ready to support the National Space Weather Centre. Thank you for your time.

[applause]

Ms. Samson: Thank you, Dr. Sagnotti. Any questions? [Silence]. All right. Thank you again.

Next, I'd like to call Dr. Juergen Drescher.

Juergen Drescher: Good morning, again it is better to speak to you today. A year ago, we had also a meeting here in Washington about space weather, the importance of space weather, in the framework of space situational awareness.

I want to reflect a little bit what DLR is doing in this area. While we are speaking, I have here on my iPad the original data. You can see how does it change. It talks about, we have seen it in the previous TEC, total electronic content in the upper atmosphere. This is the so-called ionospheric monitoring.

We have this station near by Berlin. You see the green ring [indecipherable] It's a multi-point station that exists since 1913. For more than 100 years, we are investigating the influence of changes in the ionosphere. They are very important for radio wave propagation to forecast and monitor to support the services for navigation, communication, and remote-sensing systems.

Here, this shows you a little bit, for those of you who are not familiar, what does it mean, ionosphere and interference with radio waves coming from satellites. The electron intensity in the ionosphere changes in a day-and-night rhythm.

You see the propagation of radio wave is influenced in the dependence on the concentration of these ions. The higher the concentration is, then the signal maybe delayed, even for information that we're getting on the ground. Maybe we get a feeling that the satellite is more far away from the earth or there is a runtime error.

For time-critical systems, for instance to improve landing systems for aircraft, we have to do a correction. These measurements with the electron intensity allow us different correction to the systems.

Even in the worst case, if the signal gets lost, that we see in the blue course, we can then give a correction to the ground systems. This has a very important influence. It's a very important service for the Ground-Based Augmentation System for aircraft landing procedures and for aircraft, which have a GNSS guided landing procedure.

You can see here, in this figure, that if the electron density is really worse, it changes the amplitude of the GPS signal as well as you can have effects of total signal loss and if we don't have a correction of the signal then maybe the aircraft lands 100 meters nearby the runway then it's not correct.

If you want to read about the effect there is, on the lower part there is an article where you can see with an experimental aircraft, the technical how the space radar, the ionospheric monitoring service improved landing procedure, having a higher resolution for the spatial and temporal characteristics of the signal.

Here, what you see in our Ionospheric Monitoring and Prediction Center, this is the service that you can real-time see on the Internet and it's provided to the European Space Agency to have always the information on the current state of the ionosphere for the forecast and for the warnings.

That means the IMPC, the Ionospheric Monitoring and Prediction Center in Neustrelitz provides services for scientists, for governmental decision makers, for commercial applications operating in low-earth orbit and also for teaching education, public outreach, public interest.

The IMPC facility works tightly together with the Space Weather Prediction Center in Boulder, Colorado, analyzing data from this cover. Formerly, we analyzed a satellite. We investigate the influence of solar storms on the ionosphere and using this information, we have a better prediction for forecasting of trouble in the ionosphere.

This service, IMPC is, on the Internet here, you can see the different products we have, from modeling to electron density maps. It's like a weather forecast map but it focuses not on the weather that we

have in the lower atmosphere. It's the weather in the ionosphere. This service is embedded in so-called European Space Agency Expert Service Center, the Ionospheric Weather Center of ESA.

In the lower part, you can see there's this one component with other stations in New York, providing capabilities to coordinate the ionospheric weather services. We run this service for planning and the other procedures in this Expert Service Center is...The service center has the task to provide a timely product for pre-operational services and it serves for the observation, the monitoring, the interpretation and the modeling and forecasting of the weather in the upper atmosphere.

Here you have some nice pictures how the ionosphere electron density influences the Wide Area Augmentation System that we have in America and also the European Geostationary Navigation Satellite Overlay System.

Looking at the work, we are today in an international meeting here, we have heard about Japan. We see all these space weather services, which are world-wide distributed and using this data, this is a very good backbone to support the space weather forecast activities.

Last but not least, because in our meetings, we always talk about next-generation workforce development. It's very important also to get future engineers in the team, we provide services for young engineers running summer schools, doing space weather workshops, working together with the very best team of Huntsville, Alabama.

For my side, I only can invite you if you make a trip to Berlin. It's only 90 kilometers north from Berlin, Neustrelitz. Please come and visit us and make connection to our scientists.

We are really looking forward to this cooperation. In addition to all these facts and figures that we have seen about space debris, space weather and especially the space weather, the ionospheric monitoring is a very important component for cooperation as well. Thank you very much for your attention.

[applause]

Ms. Samson: Thank you Juergen. We have about two minutes if anyone has any questions for him.

Audience Participant: I have a question for you, speaker. The model of providing the information, it is for free or there is certain services, which are requested...

Dr. Drescher: This is really totally for free. Unfortunately my iPad stopped working but this SWACI. It's called SWACI. Space Weather Acquisition Center of Information and I can tell you that some of the universities, they take this data, make maps out of it and then they make money.

If somebody's here who makes the application for the iPhone, you can download the data from Neustrelitz, make your application and provide this to anybody who wants to have space weather information. It's very interesting. I'm probably been at Neustrelitz since 2009.

It was very, very difficult in the field of, let's say, governmental decision makers, to convince them that this is an important service.

Because we have really emphasis in Neustrelitz, they work, they provide antennae, we will see the satellites, the information that only low-earth orbit has and we provide it for free like a common good. Science that everybody can read it and everybody can use it.

Audience Participant: While modeling the ionospheric weather, how do you take into account some kind of interdisciplinary approach for example, by making feedback from the [indecipherable]?

Dr. Drescher: What do you mean by interdisciplinary?

Audience Participant: I mean, for example, extreme space weather events that have increased the radiation in the atmosphere and [indecipherable] for example, the navigation sector, that not only have they implemented models on the radiation inside the atmosphere...

My question was, in your models, have you tried to implement possible things about other...disciplines?

Dr. Drescher: My second slide where I showed this background thing here. I pointed at this, electron density influences the navigation signal...It influences communication signals. It changes amplitude. We also, in the field of earth remote-sensing satellites, they twist the polarization area of the remote-sensing signal. By the models of the [indecipherable], we can correct it. We know how much the polarization area is twisted.

We know the runtime error for the navigation system and via this so-called ionospheric correction, we give this information to the GBAS, the Ground-Based Augmentation System...

Ms. Samson: We're running close on time here.

Dr. Drescher: This gives the information via a high frequency link to the aircraft and then communication system for the landing procedure will be improved. Is this the [inaudible/indecipherable you are asking for?

Ms. Samson: Actually, we're close on time. I'm sorry. Maybe you guys could pick this up at the coffee break.

Dr. Drescher: At the coffee break.

Ms. Samson: Thank you very much.

Dr. Drescher: Thank you.

[applause]

Ms. Samson: Our next speaker is General Luigi Del Bene.

Luigi Del Bene: Distinguished guest, good morning. I'm Brigadier General Luigi Del Bene and I work in the Air Staff and I'm the chief of the Department of Plans and Policy. Let me quickly thank you, Mr. Ambassador and the embassy staff for organizing this high value workshop today. Roberto in particular.

Also let me bring here the readings of General Vecciarelli who is the chief of Air Staff. My big presentation will cover how the Air Force fits into the space business and therefore into our core business and how that specifically relates to space weather.

I'll give you a quick overview of our duties and responsibilities, which are no different from any other armed force in the world. Our mission priorities and what are space implications and the space weather approach, which is building up in recent years and the conclusions.

The armed force, basically, our main task is to defend our national interests and the air space and the air force. Obviously, safeguard NATO and EU interests and then contribute to international stability and crisis management wherever that occurs.

Then obviously, contributing to Homeland Security and disaster relief when they happen. Mission priorities. This is just according to the latest Chief of Air Staff mission. I'll go by order of importance. First of all, we need to make sure grant ISR and situational awareness to the warfighters and also inter-agency community.

We do this on efficient air mobility as a major expeditionary and operational neighbor. We do have by trade, to grant integrated air and missile defense within the NATO area and missile defense internationally, then go through naval procedural engagement.

That is obviously head up by command and control capabilities. But we also have some other standing missions like, for example, search and rescue, both nationally and when we do combat search and rescue. Air traffic control for both military and civilian traffic. Weather service, and that bleeds into our purpose into space weather, and then [indecipherable].

We decide on why we fit into the space business. Obviously, for us, it's a domain but it's also for operation and then we'll get into details for that. We obviously see that as an intelligence enabler and service providers. We're mainly focused on these three capabilities and fields. Sat coms, obviously. PNT, including ISR, observation with different sensors.

There are some bottlenecks in all of this. Maybe you know them all. We're talking about regulatory frameworks, technology and knowledge that are advancing and we as the Air Force, we're also facing a challenge in decreasing human resources in the next few years according to the governmental finance.

Now, the Air Force is a bi-fold approach. We are definitely a user but also service provider to space. We are a major stakeholder in the MOD. Obviously, the defense is the interface for the outside world. We're part of an international space endeavor with many public and private partners, academia and other industry.

Obviously, we recognize the National Aerospace Agency as the particular reference for space and we do have a lot of cooperation going on. Also, space governance culminates, has already been said by the president into our head office, basically.

In terms of our vision on that, we also need to support and protect the current and future enabling capabilities as observation as already mentioned, sat com and PNTs because that will grant access to space.

But we do have some special focus areas these days and we're looking specifically into suborbital and space managing…and space situation and also space weather as part of the SSA as already mentioned before.

Space weather. What's space weather? For much smarter people to talk about. Many smarter people that talked about it before so I won't repeat that.

Obviously, we are very worried in the effects of that space weather to bring both to space access but also to air access and they can hinder our ability to operate in their domain. We see that as a natural threat and challenge and threat is basically a recurring [indecipherable] already heard.

We do have a space planners experience already that we experienced in ISAT through the years. We started applying some space weather products linked into military customers right now like the joint operational HQ and our Air Operational Center.

We do have some references. First of all, the four-year plan for government activities. We'll look at that very closely. There is a CONOPS for space weather information support to international navigation, and then there is an upcoming amendment to the ICAO that will link the normal weather services that we provide regularly, to space weather.

We're looking, how can we fit into this new construct. What we have done so far. Basically, we're just linked into the different networks where information is stored. We're starting to build up some capability basket in terms of engineers, physicians and specialists.

Now we're building this basket of forecasters and space planners in order to establish a cadre of experts and then be able to operate in a much wider network environment, as has already been said. In conclusion, most of the works have recently [indecipherable] challenge in partnership.

The Air Force itself, within its own core missions, is a node of a very complex stakeholder's architecture. It's important for us to maintain this wide array of links and being twofold, both as a user and, of course, provider. It's important for us to stay in this business and have a good understanding of what's going on.

With this, I just concluded my [indecipherable] and I'm standing by for any answers.

[applause]

Ms. Samson: Thank you General. We have time for one quick question, if anyone has anything. No? Right. Thank you very much.

[applause]

Ms. Samson: Our last speaker for this panel session on space weather services is Mr. Ralph Stoffler.

Ralph Stoffler: The idea's coming up. Mr. Ambassador, I really appreciate the opportunity to come to this great event and for DOD to be here is obviously a very important thing to because we live in this business each and every day. Operations is where we're at.

A quick overview of what I'm going to talk about. Obviously, we provide DOD weather services. We'll talk about applications. That's what we're all about. What we're doing from an observing point of view across the continents and how we interact with the community and the real reason of why we're doing this is we support the war-fighting mission and space weather impacts the war-fighting.

That's why we're doing this stuff. We have an entire organization that does this. The Air Staff on the Air Force side has been anointed by the chief of staff and by the chairman of the Joint Staffs to provide space weather services to the entire DOD.

My primary job is to develop policy and work the inter-agency matters. At Offutt Air Force Base, we have a space forecast center that's embedded in the 557th Weather Wing. They operate 24/7.

Their job is to conduct operations. At Langley Air Force Base, we've got another organization whose job is to develop research requirements and needs and then they work with our labs and our program

offices in Los Angeles at an enhanced Air Force Base to actually develop programs and models that we can then utilize.

You can see that the R2O challenge is not as challenging for DOD because we have a complete streamlined process to make all that happen. Applications is where it's happening. We operate 24/7 at the SpaceWOC, at the 557th Weather Wing.

We collect data. We run models and we provide assessments on space weather issues to the operational community. Our operator's set at the Joint Space Operations Center out of Vandenberg Air Force Base and also at Peterson Air Force Base.

They're the ones that execute the command and control of our entire space-based capability, in particular the satellites. This is very important. I think all of you realize that DOD has a global focus and we have become very, very dependent on space-based capability, whether it's communication, surveillance, navigation, space drives a lot.

Whether you're on a ship in the middle of the ocean or whether you're in a small two-man special operations team somewhere in Africa, you need space-based services. Understanding that and tracking it is important.

That's exactly what the folks at the JSpOC do. We advise them of potential space weather issues and if something occurs, we also evaluate if that was a natural event or potentially something else. It's a very close operation and the key is to be there 24/7 integrated into that.

Along with that point, you can see on this map, the existing capabilities that the DOD has and the planned capabilities. We operate a global network. The importance of that global network, which will be an important thing as we talk about observing capabilities later on, the data has to be available with low latency, which means you can't wait. You have to have it for your operation to use it.

The other thing which a lot of us don't talk about enough is the issue of cyber security. All of our systems are integrated and are cyber secure so we can bring it into the networks so they're available, when we need them most.

The other thing I'm going to point out, the blue box in the bottom. Not only we are really expanding our terrestrial-based observing capabilities through space weather, but the last Secretary of the Airforce in the future, every air force satellite will have a space weather capability in the form of a dosimeter installed on it.

The end result is we'll be collecting increased information both from surface and space-based observation points.

Interaction with everybody is key. Unity is a global entity. We work with NATO, we've worked with a variety of nations across the globe to make this happen. You've already heard that we provide training and we run a training course and people from several different countries have attended that would include Italy, France, the Netherlands, and Germany, so working those issues are very, very good.

We learn from the other nations as well. For example, we run a solar observatory in Italy and then we deployed forward in particular NATO operations. We can exchange information, both on the atmospheric and on the space-based side.

Cooperation with our civil partners is important as well. I have a liaison officer with NOAA SWPC. We put out joint bulletins both over the military and civilian side. We also support the classified side and we recently stoop up a presidential weather support unit which would advise the new president on space weather issues.

We're working with other nations, in particular, the UK and South Korea, helping them scale up their new ops centers. Of course, data sharing via secure web is a way of cutting up costs if we're trying to make that happen.

Increased cooperation between the various sectors needs to happen. There's a lot of work being done in the commercial sector, a lot of work done in academia. Of course, the government does a lot of its work within DOD as well. I really have to advocate here. We need to push for more of an app-type culture where we build a plug-and-play.

We need to be able to take new ideas and use them operationally very quickly. If I have to spend a lot of time and money recoding and redoing, it makes it that much harder to bring developments from the commercial and the academic sector on board. Why do we do it?

Everything which we do is related to an operational mission. We build centers because they collect information that allows us to enhance the lethality of our combat capability.

Whether you're operating a satellite, whether you're in the middle of the ocean, you're dependent upon HF comm, or whether you're running an RPA and you're worried about scintillation of your communication backbone, these centers are there.

We collect data, we process it, and then we advise the operator recording them. We go beyond that because we try to mitigate. For example, if we know that an event is going to take place, we try to relay that so the operation actually gets changed because you don't want to run on these problems in the middle of a firefight.

That's kind of the summary of what we do. You can see all of our missions down there. I think the bottom line is we're here to work together. We want to cooperate with you but the important things for us are we gotta be operational, we need the data in a real-time fashion. We need to be cyber secure and we have to apply it and I think that's where it's about. Thank you very much.

[applause]

Ms. Samson: Thank you, Mr. Stoffler. Any questions? All right. Seeing that, I think we're ready to go into our coffee break.

Developments within the United Nations system related to Space Weather

Speakers

- **Mr. Ken Hodgkins**, Director, Office of Space and Advanced technology, US Department of State

Ms. Samson: Thank you all for coming back after the coffee break. I would like to ease into our keynote speaker of Mr. Ken Hodgkins. Ken you have 10 minutes?

Ken Hodgkins: It's a real pleasure to be here. I want to thank colleagues from Italy for organizing this conference along with our colleagues from the Secure World Foundation. This is a really important issue not only from scientific but also from, because you all know, security and policy aspects as well.

I was the state department representative to the SWORM. We develop the national strategy on space weather and the subsequent action plan. I don't know if anybody has shared with you earlier this morning about how we ended up where we are.

It's a very simple but interesting narrative, that is President Obama met with the prime minister of the UK, David Cameron before the London Olympics. Cameron was very concerned about things interfering with their ability to broadcast the Summer Olympics and brought up this issue of space weather.

Of course, the president, not…no criticism but really didn't know too much about it so he asked his science advisor, John Holdren, "What is this space weather thing?" He did a review and a briefing for the president, concluded that the US was ill-equipped to deal with a major space weather event that could impact not only our space-based systems but also our ground systems.

That's why the OSTP was given the mandate to put together a national strategy for dealing with severe space weather phenomena. In the course of doing that review, we, the State Department, made the case that this should be portrayed as a global challenge.

That is, not only will space weather affect our infrastructure in the United States but it will affect the infrastructures of other countries, particularly our friends and allies and the last thing we need is to see one of our close allies, their infrastructures go down because of a space weather event.

Part of the strategy, part of the action plan was emphasizing the need to raise awareness of space weather as a global challenge among international policy-makers. It was really something that I consider to be low-hanging fruit.

That is, engaging in international cooperation on the research, monitoring and mitigation really was not a complicated thing because we have the best and brightest people here in the United States in the civil, commercial, and security sectors that understand space weather and want to make this a signature kind of activity.

When we look at what we can do to protect our space systems and the space systems of our allies and friends as well as the ground structure...You've heard a lot early today about some of the things that we're doing on the international level and what I want to do is just take a brief part of this morning to talk to you about what we're doing in the United Nations.

In the United Nations, we have a Committee on the Peaceful Uses of Outer Space. The committee was created back in the '50s. It was an initiative of the United States as well as about 19 other countries. The committee is set up to promote international cooperation and peaceful uses of outer space.

We have a variety of mechanisms within the community where we build capacity and we promote cooperation. We develop the international treaties and principles on space cooperation and what we succeeded in doing is raising the issue of space weather within the committee and to get buy-in from the member states that this is something that's worthwhile to do.

We started back in 2007 with the international heliophysical year, then we established the International Space Weather Initiative. This was done as a result of the IHY and we had the first discussions on space weather in February 2010 in the scientific and technical sub-committee of the outer space committee.

The committee has a program called a Space Applications Program, which is designed to build capacity in developing countries of utilization of space systems and technologies as well as data. We've been doing capacity building workshops pursuant for the ISWI over the intervening years since 2010.

We've had workshops in Egypt, Nigeria, Ecuador, Austria and Japan. The International Space Weather Initiative has placed space weather monitoring instruments at 112 countries on all seven continents as you can see here, the map of where they're located. This all feeds into the ISWI secretariat.

Within the committee we're working on guidelines in the long term sustainability of space activities. This is not centered around space weather per se, but the whole idea is that we have a growing number of countries and non-governmental entities in space. The number of objects up in space will be increasing in a significant way, as they already have, particularly in lower Earth orbit, and the idea was to come up with a set of guidelines that kind of represented the best practices of commercial as well as government and national security space activities.

Looking at things like orbital debris mitigation, greater SSA data exchange, where we have two guidelines dealing with space weather, sharing operational space weather data and forecasting, and develop space weather models and tools to collect established practices on the mitigation of space weather.

Then finally, we have a guideline on promoting and supporting and passing the bill.

The idea is to take some of the more operational things that the operators are doing and combine them with other practices, or best practices, of research and data exchange, in this case, space weather, to maintain the space environment for future generations, but also to recognize how dependent we are on space systems today, whether it's for national security or commercial or research activities. That, in and of itself, I think is fairly important.

In the area of global navigation satellite systems, I'm not an expert. I know that the experts here understand that the GPS signal and the signals from GLONASS, BeiDou, Galileo, are very, very weak. They're susceptible to space weather events.

This just underscores the other point about space weather and the need to understand this because it will have, and can have, a fairly critical impact, negative impact, on our space systems. I will just use the example of GNSS as being one of those things we really have to focus on to ensure that our space systems remain robust and resilient.

In June of 2018 we're going to celebrate the 50th anniversary of the first UN conference on the peaceful uses of outer space. It was held in 1968. A second conference was then held in 1982, and the third one in 1999.

We thought we would take the opportunity of 2018 to celebrate the 50th anniversary, so next year the committee will have a special event commemorating what we've done in the past and what we want to do in the future.

There are seven thematic priorities, one on global partnership and exploration. There's other thematic priorities, legal regime...

Ms. Samson: Sorry, Ken. One minute.

Mr. Hodgkins: ...of outer space and outer space government, enhancing information exchange on space objects, and an international framework of space weather services. Then you can see the remaining thematic priorities.

These were endorsed by the members of the Outer Space Committee as well as by the UN General Assembly. So between now and 2018 we'll be doing considerable work on raising the visibility of space weather in the international framework that we need so that when administers arrive in 2018 we'll have a whole set of recommendations and information on all these thematic priorities. Space weather is going to be one of the top seven.

The objectives for this framework on space weather is to strengthen the reliability of space systems, develop a space weather roadmap for international coordination, recognize that space weather is a global challenge, and increase the awareness through communications and capacity building, and help each other on space weather services.

Ms. Samson: Ken, I'm sorry. We're moving close on runtime.

Mr. Hodgkins: All right.

Ms. Samson: Ten.

Mr. Hodgkins: Oh. It's ten?

Ms. Samson: Yeah.

Mr. Hodgkins: OK.

Ms. Samson: I'm sorry.

Mr. Hodgkins: Then we'll have a special report on UNISPACE+50 that we'll be preparing with the various organizations there. Then Pat will talk more about it, but there will be a workshop on space weather in July at Boston College. There are the objectives. OK. Thank you very much.

[applause]

Industry Perspectives

Speakers

- **Mr. Bob Jackson**, Navigation Systems, Lockheed Martin Space Systems
- **Mr. Frank Koza**, Executive Director, PJM Interconnection
- **Mr. Vincenzo Giorgio**, Chief Executive Office, ALTEC
- **Mr. Ignazio Droghini**, Managing Director, Loccini USA

- **Mr. Marco Brancati**, Head of Innovation and Technological Governance, Telespazio
- **Mr. Stefano Cesare**, Product Line Manager for Scientific Spacecraft and Payloads Thales Alenia Space

Ms. Samson: Thank you very much, Ken. OK. We'll be at work time so we'll move on to our next panel on industry perspectives. The first speaker is Mr. Bob Jackson.

Bob Jackson: Good morning. I'd like to give a little presentation on what we are doing to address the challenge of the ionosphere to aviation safety. Since the introduction of all-weather flight in commercial aircraft, there's been a known risk in the final phase of the flight, which is landing phase, and a recognition that the ability to deliver a precision approach for every landing significantly increases safety.

What you see there is a picture of the aftermath of the Korean air crash in Guam when the landing system, which is typically used to provide three-dimensional navigation for the landing aircraft, went out of service. They were trying to execute a non-precision approach.

Lateral navigation was spot on. They almost hit the VOR station, which is just a circle off to the lower right. But their vertical guidance was off.

It's a well-known phenomenon. In fact, 20 years ago the Flight Safety Foundation concluded from a lot of analysis that commercial aircraft is five times as likely to have an accident on a non-precision approach as a precision approach.

That was noticed by the FAA, by European authorities, about the same time that widespread use of GPS began to come into circulation. The FAA, and then later Europe, embarked upon an implementation of satellite based augmentation system. The goal was to provide that three-dimensional approach.

Very quickly, set up reference stations, monitors and satellites, they collect data on errors and error sources. That's passed to a master station to uplink to the geo satellite with a navigation payload and then back down to the user receiver. The user receiver then combines the implementation message with the underlying messages, comes up with a very precise, very accurate, high integrity message that is then used to construct the precision approach guidance.

It works quite well in the US, and in European Union with EGNOS system. In fact, the International Civil Aviation Organization adopted a resolution in 2016, saying, "We wanna do this everyplace, but we wanna do this everyplace by 2016.”.

Unfortunately, they discovered that may not be realistic with the current state of the technology, and so they said, "Well, we'd still like to to do it if we can, but if we can't get precision approach, at least we want a straight-in approach, which is a less demanding application, both in terms of the technology, but also, it doesn't give you that full level of confidence.

What happened? The sum total was, we discovered that the ionosphere is more dynamic than was originally thought. This is what it looks like, as the sun rises, excites the ionosphere, the electron count increases, and density variations occur, which are the GPS signal.

The morning, where you start to see that increase, is really not a problem. It's the evening, when the total electron count collapses, and tends to collapse rather chaotically, and that's very difficult for a SBAS system to model.

Just very quickly, the first-generation SBAS, WAAS, and EGNOS in the European Union, they basically have a fairly dense network of reference stations that collect data on the ionosphere.

Effectively, this SBAS system creates a map of the ionosphere, transmits that up through the GEO to the end-user receiver, and then the end-user receiver says, "Well, if I'm more or less here, I'm looking at GPS satellites that are broadcasting through this section of the ionosphere, so I then apply this correction to that signal."

It works fairly well in the mid-latitudes, where the ionosphere is relatively stable, it doesn't have a chaotic collapse, especially in the evening, does not work in the equatorial region. You can see there the effect of...that's the availability of the Wide Area Augmentation System in North America, pretty good.

If you look at it from a global perspective, you'll realize that what was expected to be a global adoption of a capability, significantly improved flight safety, is not really expanded much beyond North America and Western Europe.

Not depicted there is the GAGAN system in India, which uses little more sophisticated modeling. It's better than the WAAS and EGNOS models, but still has problems modeling that chaotic collapse of the ionosphere, especially in the evening.

We are proposing...exploring the introduction of a second frequency on the GPS and Galileo satellites, by the introduction of the L1 with E1 on Galileo, and the E5-L5 combination.

The end-user receiver is now able to make its own ionosphere corrections, so instead of having to extrapolate its ionospheric corrections from a map constructed by the SBAS, the end-user receiver compares the effect of the ionosphere on the L1 and the L5 signal and then make it's own calculations for each satellite it is looking at.

We'll also be using multiple constellations, so it's not just GPS, we'll also be using Galileo, which the European Union is rapidly bringing into full service.

We have embarked upon a test-bed with Geoscience Australia, and Land Information New Zealand. The equipment is actually being installed beginning next week, at a site in New South Wales, Australia. We will, as I said, be monitoring both the Galileo and the GPS signals.

Our Spanish partner, GMV, will be providing some of the core processing capability, and the control consoles, we will be providing use of the uplink station and the signal conveyor.

INMARSAT already has a navigation payload on a GEO satellite orbiting over the region, and as I said, Geoscience Australia and Land Information New Zealand will be providing the raw data from their CORS networks into the processing.

Our goal is to use as many existing assets as we can, but at the same time, anticipate what an operational system would look like, using the topology of the test-bed.

Ultimately, we envision being able to expand this to a global integrated network that will bring safety of flight, and satisfy that original ICAO objective of precision approach to, essentially, every qualified airport and runway on Earth.

We have done some simulation in labs, and concluded that we have a basis for going forward. The simulation result's there at the bottom. The deep red is good, a little bit of a reverse, but we're showing very good availability of a precision approach globally, with a fairly minimal set of ground infrastructure assets.

We've demonstrated it in the lab, now the goal is to demonstrate it with a signal in space.

Ms. Samson: One minute.

Mr. Jackson: Thank you very much.

[applause]

Ms. Samson: We have one minute to ask any questions to Mr. Jackson, if anyone has anything.

Yes, right here. Can you please wait for the mic?

Audience Member: [indecipherable]

Mr. Jackson: Scintillation still remains an issue. The effect of scintillation, it is a loss of [indecipherable], and so you potentially have a drop in availability of a position solution.

However, the use of both GPS and Galileo means that you're looking at, effectively, twice as many satellites as you would earlier, with just a GPS-only system. You could afford to lose quite a few, frankly, satellites in view and still maintain a viable position solution.

Ms. Samson: Great, thank you very much. We're out of time, thank you again.

[applause]

I'd like to welcome our next speaker to the podium, Mr. Frank Koza.

Frank Koza: Thank you, and good morning. It's still morning, by the way, we're about to cross over to the afternoon. I would like to thank the sponsors for organizing this event. I appreciate the opportunity to speak to you. I'm Frank Koza, Executive Director, Infrastructure Planning, at PJM Interconnection.

PJM, if you're unfamiliar with us, we are a transmission system operator in about 13 to 14 state regions in the United States, basically, in the mid-Atlantic states and the Midwest, and including the District of Columbia.

What I'd like to do very briefly here is, talk to you about the impacts of space weather on the power system, and then more specifically, what is PJM and what is the industry doing to address the threat.

The threat to the power system is a coronal mass ejection. We're showing that, basically, on the left side of the slide here. When the CME strikes the Earth, it interacts with the magnetic field of the Earth, will generate high amounts of electric current in the ionosphere, that's what is shown by the

[indecipherable] on the right. We're talking about serious amounts of electric current here, in the millions of amperes range.

Now, this is a representation of how it gets impacted. The electric jet there is that very bold, black line in the upper left, where that multi-million ampere electric current is. The transmission line is represented by those three parallel lines, close there to the plane of the Earth.

What happens here is, because you've got that high electric current in the ionosphere, it induces an electric current in the transmission lines. What happens here is, the current flows in the ground, or it can flow in a transmission line. It can go up through the transformer, or down from the transformer into the ground.

It's that concern of the ground-induced current that we're concerned about in the power system.

The reason we're concerned is, what happens is a phenomenon called half-cycle saturation. We're not getting into what all that means, except to say that it messes up, if you will, the magnetics of the transformer, and injects a DC current into what is, really, an AC current environment.

What that does is, it causes increased reactive power consumption, and what that means is, we start to go in a negative path toward reducing voltage across the system. If that continues to happen, we'll go into voltage collapse. That's the number one primary concern that I've circled at the bottom of the slide.

If you're in the Northeast, you'll remember the blackout that occurred in 2003, that was a voltage collapse situation. That's the kind of concern that we're worried about, relative to space weather causing that underpower system from the CME.

Secondarily, I bring your attention to the box on the right. The box on the right talks about transformer heating. As I mentioned, the magnetics of the transformer get messed up in a CME event, that causes heating within the core of the transformer and also the structural parts.

If that occurs to a very, very great degree, the transformer can catastrophically fail, so that's the other threat to the power system that comes from space weather. We've got this issue of decreasing voltage and voltage collapse, and then secondarily a concern about transformer heating and the potential failure of transformers.

What does PJM do? We recognize the threat...The good news about CMEs is, we do get some warning. It takes a day or two for the CME to traverse through space, from the Sun to the Earth, so we're very much dependent upon the information we get from the Space Weather Prediction Center. We'll pay serious amount of attention to all those alerts and warnings.

If we see that kind of a situation developing, where we're going to get struck with a CME, we'll start doing sensitivity studies, we'll analyze the power system, and make sure we're positioning the power system as best as we can to take the hit from the CME.

We also have GIC detector stations, in PJM we have probably 50 stations now, that are providing telemetered GIC real-time data back to the control center. We'll try to operate very conservatively in that mode, and make sure that the power system is protected.

I have to mention here that, what the industry is doing in more general terms is, creating standards to deal with the GMD threat. The standard that's now being put in place is a standard that will require all

the transmission system planners in North America to mandatorily do an analysis of the power system, to make sure that their power system can withstand a benchmark GMD event, and that benchmark is defined within the standard.

It will also require the owners of the high-voltage transformers to do a thermal assessment of those transformers, as I mentioned, the heating threat, to make sure the heating is such that it won't cause damage to the transformers.

That's what's being done on an industry basis and that standard's now in place and the industry is working to make sure it gets accomplished. Dr. Ishii showed, I guess, GIC calculations but we've done some GIC calculations on the PJM system..Those yellow spots and particularly the red one are the areas of our power system where we expect the GIC intensity to be the greatest. There are a number of factors involved here, system topology, basically how the transmission system is located. The magnetic field strength and orientation was also presented earlier.

The ground model as well and approximately the water. All those things enter into this but I didn't want anybody to walk away thinking that the impacts are constant across the whole power system. They're very specific in very specific locations.

So where is PJM and where is the industry? We have had operating procedures in place since 1989. We were directly impacted by the Quebec event in 1989 and since that time, we've had operator procedures in place that our operators are prepared to execute in the event of a CME event.

As I mentioned, we've installed a number of GIC detectors across the system and we're now working with NASA on a pilot program to install magnetometers and get more accurate ground measurement devices in place to validate electric field models.

Now the industry in general, the awareness has been really raised for the industry. Obviously the mandatory model, the mandatory requirements are out there in the standards so the industry will be required to do all of this work in the future and make sure we assess the power system.

The other thing that's going out is American Transmission Company, an outfit in Wisconsin. They've installed a GIC blocking device. If you're unfamiliar with that, it's a technology that will basically block the GIC current from propagating other power systems.

It's new technology that's being tested. ATC has the first device in place and they're checking how that works right now. In general, I think the industry is starting to -- the power industry, that is -- is starting to get its arms around the threats due to space weather.

We're taking some positive steps to increase our ability to not only monitor and to respond to it but also to do that kind of forward-looking analysis to make sure that we engineer the threat out of the system as much as we possibly can. That concludes my presentation. Victoria will know if we have time or not.

Ms. Samson: You do.

[applause]

Ms. Samson: Thank you. We have about two minutes, if anyone has any questions. Yes, can you please pick up a mic?

[audience member asks question]

Mr. Koza: Good question. Thank you. The question, if you didn't hear was what kind of adjustments did we make ahead of the CME strike investment? The answer is, for the most part, we will put more generation on to make sure that we have additional generation in case we lose generation in the course of these events.

We'll also try to boost voltage wherever we can. We'll bring back facilities if we can from outages if that will help us position the system to take the hit. Then we're general, at PJM, we will try to reduce our reliance on outside transfers, if you will, so that we're localizing the load of the generation to make sure we...

In case we lose some transmission line from outside our system, we're prepared to respond to that and keep the system alive.

Ms. Samson: We have one minute. Did you have one quick question?

[audience member asks question]

Mr. Koza: Our operating procedure is based on the real-time information that we get from the GIC detectors. The GIC detectors are measuring above a certain level -- in our case its 10 amps -- if we're seeing continuing measurements above 10 amps we will then automatically invoke our operating procedure. We'll put in place the steps that I just identified for the previous question.

Ms. Samson: Thank you very much.

Mr. Koza: Thank you.

[applause]

Ms. Samson: I'd like to welcome our next speaker, Mr. Vincenzo Giorgio.

Male Participant: Good morning and thanks to organizer for allowing me and also the group who prepared this presentation to be here this morning. My name is Vincenzo Giorgio, I'm the CEO of ALTEC and vice president of Thales Alenia Space. ALTEC company owns the Thales Alenia Space and the Italian Space Agency.

As you can see, the work that is being performed as well as the presentation that has been prepared by ALTEC as an engineering and service company, the Italian [indecipherable] and the Turin Observatory.

Why did we decide to work together on that thing? We have an excellent, ongoing cooperation, which has been established between industry on one side, ALTEC and INAF on the other side, for several things.

The most applicable to what we've talking with is GAIA, the Italian Data Processing Center, which is based on ALTEC with the operation of ALTEC and the Astrophysics Institute and the activity we are doing on an instrument led by Italian Space Agency, which is from the corona static insulator.

What do we aim? What are we doing? First, metrics, which have been described this morning, we are actually producing [indecipherable] on the outer solar corona and. The identification or rejection of magnetic loads reaching the earth...

What objective we are aiming to? First, we want to consolidate the existing Endostatic Data Center, which we have established together with the Chilean Observatory and this is based today on the ESA approved long-term archive. And we want to... [indecipherable] space weather center for the impact of solar disturbances. Of course, I won't go into the details but the basics of this is that we start with database existing, extremely different one from each other from NASA and other data and then they're a lot bigger.

This input to what we call a space weather mission, which we then interface later on, all the entities and public and private space operators. What we start from is scientific capability and technical capability and the idea is to establish a front-end to this space weather mission. I'll get later on into the capabilities.

Today, what we are working with is a number of databases, which are coming from solar [indecipherable] institute and one data coming from a NASA mission DSCOVR and we do it with other data centers, which we're working with.

In particular, when talking of about current graphic data, we have not much information today as the...C1 and C3, which is space craft for the L1 now and the SETI core 1 and core 2, which are two spacecraft today orbiting around the sun.

We will soon, as it was announced also this morning by Professor Battison, a solar orbital mission, which will let specific instruments, which deals with the solar corona.

What do we bring into as competencies? First one, competencies of the observatory of Turin, which is the National Institute of Astrophysics, which is a mean research field on the physical solar corona...

The competencies of combined ultraviolet and visible light, which means having information on both energy as well as velocity and dynamic of these effects starting from the solar corona, and then the allotment of two applicable specific to space weather.

On the other side, what we bring as company, as engineering company into the system is the capability of big data, data mining. We believe to observe quite a lot of phenomena just extracting data from satellite, which are meaning for completely different application.

The current activity and it was in the previous speech, it was very much interesting to see how the CME is one of the effects we want clearly to go into it. Actually, what we are today developing is a prediction pipeline for the CME.

What we start with is modules that we already have, which is the CME alert module, the flare alert module and the CME kinematic modules that we have today. We are integrating all of them together to get a real single module that can give the CME prediction at the end, as an end result.

What do we want to do? What we have today is, we're working and we're almost there with the first two modules, which have to do to solar module and the endostatic module.

What we still need to do is the third part, which in fact gets up to the end, which means that we will lack capability also to send alert and to send information about the phenomena of CME as well as all the impact on the aerospace part and we will send them back to what we call the National Space Weather Center.

Of course, what we are trying to do is to get some additional information, some additional databases coming from a mission, an actual mission or future mission. I just talked about the [indecipherable] chronography of the solar orbiter mission.

Why I think that it's worth to investigate, what can we get from satellite or from assets, which are not designed to look at the sun, which are not designed to look at the corona? That's an interesting part, which we still want to investigate.

One example is being that working on GAIA, we've been able to establish how phenomena that have been detected and generating L1, they propagate in L2 and what's the dynamic to propagate in L2?

By simply studying the effect on the CCD of GAIA, which is a satellite designed for astrometrical missions, completely different part, we were able to established correlation by means of algorithms specifically designed for that.

At the end, what we're trying to do is to make databases and information, which are channeling by different systems which have been designed for different systems to put them together to have the capability to study, in particular, the CME phenomenon, which we consider is the starting point in and the driving point. Thank you for your attention.

[applause]

Ms. Samson: We do have time for one brief question if anyone has anything.

[pause]

Ms. Samson: Thank you very much.

[applause]

Ms. Samson: Our next speaker is Mr. Ignazio Droghini.

Ignazio Droghini: Good morning everybody. My name is Ignazio Droghini with Loccioni USA. We're located in the DC area. We are a subsidiary of an Italian engineering company. It's an honor for me to be here and be able to support this event. Especially because we're quite new to the aerospace industry.

Since many of you maybe are not familiar with our name, I spend a few words about our company. We are an engineering company, privately owned. Started in 1968. We focus on customized testing and automation solution support for industries.

Our goal is to help industry leaders providing support for their products and their processes. We range from R&D type of testing rates to complex processes.

As I said, we started our history specializing in measuring and testing instruments and then realized with the evolution of the many different industries from automatics to the energy sector to biomedical, that

this [indecipherable], this quality control process is along the production process, analyzing multi-sensor data are the challenges for the future.

So industry 4.0 is what we're looking at. For this reason, a couple of years ago we decided to start an aerospace industry...because we believe that industry 4.0 topics are also of great importance to the aerospace industry.

I listed a bunch of topics that are very important as far as quality control and verification for the aerospace industry normal conditions. But we are experiencing a phase where the industry opened up to the private sector.

The number of missions in aerospace systems produce are increasing. Time line and cost reduction are more tight, and militarization of satellites are now a reality. So, to remind ourselves that testing and verification during design implementation phase in a mission is a critical and challenging topic.

Just, a couple examples of some applications that in the aerospace industry where some challenges were collected recently linked to this evolution of the industry...So for example solar panel producer for space applications are seeing their numbers increasing rapidly.

Their production processes are mostly pointing them to a processor, are not adequate for these new numbers. Or the application of collaborative robots in riveting and assembly procedures for satellites and non-contact measurements to verify those operations are required now.

For another challenging process we are undergoing is using a network of fiber optic stress sensors to monitor the integrity of the body of a satellite during production. Mostly during transportation between the plane and the launcher.

Getting to the space weather topic today, as I said we're quite new to the aerospace industry but we have decided to join it first with our research group led by Professor Curry, University of Maryland. Professor Curry was supposed to be here today and present the research but his flight got delayed so now I'm professor Curry.

[laughter]

Mr. Droghini: I'm 30 years younger so I'm sure he wouldn't mind but I do lack his physics so bear with me as I introduce the general topic with our point. The main object is to perform a topography of the ionosphere to try to understand external effects of space weather on earth, particularly for structure where they are about power, telecommunication and...Having worked a long time in the automotive industry, with the automotive industry going towards autonomous driving, we have collected also these worries from their side, as a potential threat.

The basic concept is to use satellites, beacons installed in satellites, that emit radio emissions at two different frequencies and having a very simple network of ground stations, receiving stations and correlate the differential between these two frequencies.

Our role would be to support a local network in Italy. We're defining a couple of locations and mostly, the goal will be -- since the preliminary data of this research has been collected from beacons, very old beacons installed in Russian satellites -- ideally would be to install new technology, these beacons in [indecipherable] satellites and adding out network of ground stations in Italy.

I have been very brief. Again, it's a real pleasure for us to be here and thank you very much.

[applause]

Ms. Samson: Do we have any questions? No? Thank you again. All right, I'd like to welcome Mr. Marco Brancati up to the podium please.

Marco Brancati: Thank you. Thank you for organizing and inviting myself to this event, especially to the organizers. I'm Marco Brancati, CTO of the Telespazio. I'll try to wrap up and summarize some of the items that have already been defined in this forum and to try to complement...

The [indecipherable] PJM, already this the impacts of the space weather events over the navigation services. Let's say that if we look at the space infrastructure, we understood that concerning in particular, the LEO satellite, we can say that, with respect to such a phenomenon, they have a minor exposure. If we consider that they are consider they are shielded from a geomagnetic standpoint

While if we consider the impact of such events on the target the atmospheric target, we understand that for this kind of infrastructure, there is [indecipherable] position. Of course, if we talk about the MEO and the GEO satellite, it's clear that this position is more intense.

We talked about the impacts on navigation but let me say that if we look at the telecommunication services, we understand that the space weather phenomena can be even more and more impacting. In particular, already if we look at a minor event we understand that these can already have a degredation of the service.

If could see the severe and the extreme events, definitely we can phase a telecommunication breakout loss of [indecipherable]. If that's a reality, can have a duration which goes from six seconds to two hours.

We also already talked about the impact of space weather events over civil aviation, especially if we talk about what occurs at the high latitude and so concerning the flight, of course, the polar routes.

We heard several dates concerning when these space weather phenomena started to impact our daily life. We can say that actually the very first event was the so-called Carrington Event. We are talking about 1859. Actually, there was a scientist, Richard Carrington, that observed a large flare that caused a coronal mass ejection which moved from the Sun to the Earth.

Nowadays, this phenomena has been replicated and simulated. We understood that it took probably almost 18 hours to move from the Sun to the Earth.

Should such an event -- we are talking about more than 150 years ago -- occur today, we would have, more or less, an equivalent of about 80 satellites in different orbital position which could be disabled in terms of service provisioning. Of course, the possible failure of the navigation satellites.

But If we look at the LEO satellites that are planned to de-orbit in the next years we could also understand that the they would be accelerated due to the changes of this phenomena to the ionospheric portion of the atmosphere.

If we only look to the potential economic loss of such an event, just looking at the space-based services, we can count about 70 billion of loss, which becomes higher figures, as we learned this morning, if we

consider all that impact. Just looking at lost revenues in terms of services, as well as the necessity to replace the geo-stationary satellites.

What is something that probably all of us understood today, but is important to be underlined, is that the impact of such phenomena on critical infrastructure is today even stronger than in the past; because critical infrastructure, which were originally designed to be separated, and that most of them mainly interconnected by the national telecommunication networks.

This implies that a domino effect at the very end can be definitely caused by this kind of phenomenon. Therefore, why company as Telespazio is interested in such a phenomenon?

Telespazio is a service company, and in doing that, manages the services which are based on satellite. More often telecommunication and television and that aspects, geo-information, and operations over infrastructures.

The real point is that in delivering our services, we manage large communication networks integrating both satellite and terrestrial solutions. We provide geo-spatial services to our land business, including e-GEOS Company, that is controlled together with the Italian Space Agency.

We perform LEO for any orbit control for third parties customers. At the very end we understood that a company which delivers services in the field of satellite embarkment is a real stakeholder of such a phenomenon, because it owns asset and forms operations for its own.

At the same time we have the possibility to provide the same solution to the other stakeholders. Especially to the ones that are not completely aware about the risks that the space weather phenomenon are going to cause. For this reason we cooperate very much with the scientific community in Italy.

The [indecipherable] Community was established in 2014. It's a community that combines about 110 different members belonging to 15 different institutions, many of them are represented here today.

Are [indecipherable] and other industries, like for instance [indecipherable]. The first work that was performed together within such community was to evaluate which are the assets that can be utilized to provide wider services to phase the space weather effects.

There were two main approaches handled during the last years to better understand and address this topic.

One of them called Spark, actually was dealing with the understanding of the impacts of the space situational awareness in general, more specifically about space weather on the critical infrastructure.

To define which could have been the guidelines to have a better understanding and better behavior in this respect. Also to make aware to establish and enlarge a community of experts to phase these impacts.

The second project...

Ms. Samson: One minute.

Mr. Brancati: Yes. The Space Prediction Service actually was more focused on development of specific platform. [indecipherable] on a platform able to deliver services to phase the space weather phenomenon.

They say, which is the strategy? The strategy is at the very end.

For understanding that in order to enlarge the knowledge of the community concerning space situation awareness, we need to combine all the different assets that can allow wider platform to be made available for developing space weather and services, and to implement a service center dedicated to this project.

At the very end there are two major items that we are going to address on what side to develop a national service platform which is composed by some elements which are already available on the other side to focalize on the specific space weather services.

Which could address both field and military needs. For instance...

Ms. Samson: Sorry, we're at time.

Mr. Brancati: ...developing some specific qualities of data collected for the focuses. This is the conclusion of my presentation.

Ms. Samson: Thank you very much.

[applause]

We have our last speaker for the industry's perspective panel. Mr. Stefano Cesare.

Stefano Cesare: Thank you to the organizer. I'm Stefano Cesare from Thales Alenia Space. I'm going to talk about the conclusion that my company can provide to space mission for space weather forecast.

Let's start with a few words on space weather that it's mainly driven by the solar wind, which is originated by the solar corona when massive solar wind is flowing from the solar corona toward the Earth during a coronal mass ejection or in general.

When the solar wind peaks, the magnetosphere and ionosphere these [indecipherable] during the storm.

So, space weather coronagraphs are these instruments for monitoring the sun’s corona and for detecting the appearance of these eruptions, the coronal mass ejections, and to provide the early warnings of the geomagnetic storms.

Thales Alenia Space has a certain tradition in the implementation of space weather coronagraphs dating back from the 90s when in cooperation with [indecipherable] we implemented a spectrograph of the UV corona spectrometer of the UV [indecipherable] which is one of the [indecipherable] of the space weather monitoring network. It’s an ESA/NASA mission which has been already talked about this morning.

You can see here the spectrometer of the [indecipherable] being calibrated at Turin. And this instrument has observed the sun’s corona for nearly two eleven-year solar cycles in the UV band, [indecipherable]

meters. I don't think [indecipherable] for the measuring of the solar wind with a spectrograph. [indecipherable]

A couple of pictures taken by UCS the UV. And much more recently we've implemented a cooperation with another Italian company the [indecipherable] coronagraph for the [indecipherable] mission. This is a very normative instrument which has been proposed by the Italian scientific community which has been led by professor [indecipherable] of the INAF observatory at Turin. And this will allow for the first time to provide images of the full-sun corona in both visible light and UV light. And this will allow…

[indecipherable crosstalk near microphone]

…Two images of the sun corona one in the UV, and the other in the visible light. And this unique instrument will be carried by a unique spacecraft [indecipherable] an ESA/NASA mission that will for the first time bring 10 instruments. Six weather science instruments [indecipherable] and four [indecipherable] instruments very close to the sun down to [indecipherable] astronomical units. Even outside of the [indecipherable] we'll be able to look at the pole of the sun.

In this mission one of the main challenges is was related to the coronal instruments because at the closest distance from the sun the [indecipherable] will experience a temperature up to 400 degrees. At the detectors which are at one, one-and-a-half meters from the [indecipherable] we'll operate at minus 20 degrees so you can see the challenge.

Another challenge is related to the need of docking the live cam from the sun disk and [indecipherable] this light to one part in one billion in order to the detection of the very tiny corona in visible light.

This is something that is also very highly autonomous and is able to identify onboard the occurrence of a solar coronal mass ejection and to adapt its operation accordingly.

And we also develop a very new facility for the performance verification of the instrument because it is implemented in outer space with [indecipherable] and with this facility we're able to characterize the performance of the instrument and to calibrate in both the visible light and the UV light.

For this mission, the solar orbiter, we implemented another key element which is a heat shield because, as I said, at the [indecipherable] astronomical unit that this spacecraft will be such as 270 kilowatts per square meter and the outer face of the heat shield will be heated up to 500 degrees. These conditions, the heat shield, which I think is only 46 meters, has to maintain the temperature of the spacecraft and the onboard instruments at a temperature not exceeding 50 degrees [indecipherable]. Here you can see the flight model of the heat shield which is ready to be integrated on the spacecraft.

At this point I would like to summarize what kind of proposals our company can offer to the future of missions for space weather monitoring forecast.

First of all, a whole set of platforms space specifically designed for mission operating at the sun-earth Lagrangian point. You know this optimal location for missions that are monitoring the solar activity because the Lagrangian points have a constant position with respect to the Earth and the Sun.

And this spacecraft has been implemented and [indecipherable] by Thales Alenia Space specifically designed to operate at the Lagrangian points.

And they're also implemented the space-based detector for high-energy physics, and studying gamma rays, [indecipherable] for the study of extragalactic or non-solar sources of space weather.

Then we're [indecipherable] systems for spacecraft such as very high solar location [indecipherable]. Like solar orbiter [indecipherable] and other spacecraft which will be implemented [indecipherable] like Bepicolumbo which will be launched around [indecipherable] time.

And finally, we can provide instruments for solar activity and ionosphere monitoring like coronagraphs like [indecipherable].

I thank you very much for your attention.

[applause]

Ms. Samson: Thank you, are there any questions for the speaker?

Audience Participant: [Asks question]

Mr. Cesare: Yes, indeed. Not only but as well to bring a combination of science and instruments measure also with the hemisphere the location of the space capsule [indecipherable] taken by coronagraphs for all of us or so, a lot of data to the hemisphere [indecipherable] to understand that better modeling that was so useful on Earth and that adaptation of the space weather.

Ms. Samson: Thank you very much.

[applause]

Ms. Samson: I'd like to thank all the speakers this morning for sharing your expertise and time. Very much appreciated.

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