2011 SPACE WEATHER ENTERPRISE FORUM SUMMARY REPORT

This document provides a summary of the 2011 Space Weather Enterprise Forum (SWEF)—an event sponsored by the National Space Weather Program Council and hosted by Mr. Samuel P. Williamson, Federal Coordinator for Meteorology, on June 21, 2011, at the National Press Club in Washington, D.C.

OVERVIEW

Purpose and Theme: The SWEF brings together the space weather community to share information and ideas among policymakers, senior government leaders, researchers, service-provider agencies, private-sector service providers, space weather information users, media, and legislators and staff from Capitol Hill to raise awareness of space weather and its effects on society. This year, we continued this outreach but sharpened the focus on critical infrastructure protection and human health and safety, with the necessary underpinnings of research, improved products and services, and applications to serve a broad and growing user community. Our ultimate goal was to improve the Nation's ability to prepare for, avoid, mitigate, respond to, and recover from the potentially devastating impacts of space weather events on our health, economy, and national security.

This year's theme was *Solar Maximum: Can We Weather the Storm?* As we approach the next peak of solar activity expected in 2013, our Nation faces multiplying uncertainties from increasing reliance on space weather-affected technologies for communications, navigation, security, and other activities, many of which underpin our national infrastructure and economy. We also face increasing exposure to space weather-driven human health risks as trans-polar flights and space activities, including space tourism and space commercialization, increase.

With strong partnerships built over the years, approximately 220 people from the Federal government and the military (47 percent), industry (32 percent), the research and academic communities (10 percent), international stakeholder agencies (3 percent), and media members (8 percent) participated in the forum. All of the presentations that were given at the 2011 SWEF and supporting material can be found at: http://www.nswp.gov/swef/swef_2011.html.

Objectives: The Opening Session and five other sessions during the one-day forum were structured to address the following objectives:

- Share information across the enterprise and raise awareness for new users, decision makers, and policymakers; areas of exchange include the following:
    - New research results
    - New transitions of research into operations
    - New products and services
    - Integrated, unified space weather operational capabilities
    - International activities and cooperation
    - Commercial space weather users and providers
    - Integration of social science into space weather services
- Identify effective approaches to build resilience across society, particularly in critical infrastructure protection and support.
- Identify effective approaches to raise awareness in the broader society.
- Improve communications within and external to the enterprise.
- Collect information to support a new National Space Weather Program Implementation Plan.

Note: Speaker and audience remarks are paraphrased and not verbatim quotes.

Forum Outcomes: The results and findings from the 2011 SWEF, summarized below, will serve as input to the new National Space Weather Program Implementation Plan.

- Extreme space weather events may overwhelm our ability to cope with impacts to our vital national infrastructure.
    - Space weather has the potential for extreme societal impacts, including the risk of widespread and long-term power disruption that could impact up to 130 million people. (National Academies of Science [NAS] Study)
    - We must develop a better, more specific, more reliable prediction and warning capability to enable government and civil leaders to make informed decisions.
- Since space weather can cause a variety of impacts, ranging from routine minor inconvenience to very rare extreme events, it is important to not overemphasize the low frequency/high impact events.
    - An extremist approach will lose emphasis and support while we wait for "the big one."
    - Significant impacts can occur any time during the solar cycle, not just at solar maximum.
- The potential impacts of space weather are not widely known or understood by the public; however, they are beginning to recognize that space systems are important to our daily lives and that potential threats exist.
    - Greater emphasis on education and public outreach is needed. Social media may prove to be the critical tool to provide timely information to the public.
    - Due to our heavy reliance on a technological and space-enabled infrastructure, there is virtually no aspect of our lives that is not potentially affected by space weather.
    - Preparedness campaigns need to focus on the risks of space weather and then recommend risk reduction strategies and identify mitigation opportunities.
- Improved prediction capabilities are needed to provide adequate warnings of potential impacts.
    - Space weather phenomena tend to be global in nature but have distinct and highly variable impacts on local scales.
    - Interagency and international collaboration is needed to significantly improve space weather observing and prediction capabilities
- We must capitalize on the synergy of interagency and international partnerships to significantly improve our capability to provide space weather services.
    - The Office of the Federal Coordinator for Meteorology (OFCM) will facilitate and coordinate the development of the Unified National Space Weather Capability, which will be an interagency collaboration.

FORUM SYNOPSIS

Sessions Conducted:

1	**Welcome and Opening Addresses**
2	**Critical Infrastructure Vulnerability to Space Weather**
3	**Human Safety and Response Preparedness**
	Lunch speaker
4	**Space Weather Warnings and Prediction Services**
	Featured Speaker
5	**Strategic Communications, Education, and Outreach**
6	**Summary and Wrap-Up**

Media Coverage: Several print and internet reporters attended the 2011 SWEF, as well as video crews from National Aeronautics and Space Administration (NASA) TV and the National Public Television Network of Japan (NHK). Later this year, NHK will produce a 90-minute documentary on space weather, which will contain highlights from the 2011 SWEF. Coverage included numerous on-camera interviews with most of the key speakers and moderators, including Mr. Williamson. The press releases from the National Oceanic and Atmospheric Administration (NOAA) and NASA generated several telephone interviews. An internet search conducted one week after the SWEF returned over 54,000 inquiries/"hits" related to the phrase "Space Weather Enterprise Forum 2011."

Session 1: Forum Welcome and Introduction

Coordinator: Mr. Michael Babcock (OFCM)

Welcoming Remarks: Mr. Samuel P. Williamson, Federal Coordinator for Meteorological Services and Supporting Research

Mr. Williamson welcomed the audience and presented an overview of the agenda and goals for the 2011 SWEF. He said that. as the next solar maximum approaches in 2013, space weather and its impacts have become an emerging issue and we must work together to weather this potential storm from space. Mr. Williamson provided some examples of potential space weather impacts and stressed that we can and are, in fact, preparing for them. During his discussion of the SWEF agenda, he made particular note that a new, national initiative on space weather would be announced in Session 4.

Keynote Speaker: The Honorable Yvette D. Clarke, (D-NY), Ranking Member of the Subcommittee on Cybersecurity, Infrastructure Protection, and Security Technologies

Ms. Clarke's told the forum attendees that summits like the SWEF are important events for building collaboration and rendering greater visibility to important national issues. She noted that the topic of space weather (and protecting our most critical infrastructure – the electric grid) is gaining momentum. In 2009, we realized that we have little protection against attacks (man-made or natural) on the electric grid and from cyber attacks, and time is not on our side. Representative Clarke commended the National Electric Reliability Commission (NERC) for its work relative to looking at ways to protect against solar storms (i.e., electromagnetic phenomenon), but we must move faster. Federal agencies, the Office of Science and Technology Policy (OSTP), and Congress are involved and concerned about the impacts of space weather. In 2010, the Grid Act passed in the House but stalled in the Senate. That bill looked at our vulnerability to cyber attacks and the overall vulnerability of the electric grid. In 2011, the House introduced the Shield Act which looks at threats to the electric grid. Cyber attacks will be taken up in a separate House bill.

Ms. Clarke told the audience that, although there is not a sense of urgency throughout the entire Congress regarding on space weather and its impacts, we need to push more forcefully to move forward. In closing, she stated that a modern civil society is characterized by (1) clean water, (2) a functioning sewer and sanitation system, and (3) an electrical system. Since our electric power underpins all other components, protecting the grid must be a national priority.

Comments, Questions, and Answers

(Q): Why is there a lack of urgency in Congress regarding space weather?
(A): Congress is distracted. We're not focused on this particular threat to the U.S. That's why advocacy is necessary. The more we bring this to the House's attention, the more the House will know that we are concerned about it.

(Q): What rebuttal remarks have you gotten?
(A): Passing the Grid Act shows that there is no rebuttal. The House believes fortifying the grid is important. It's just a matter of getting focused.

(Q): What other committees are interested in solar activities?
(A): The House's Science and Technology Committee and other committees have been focused on solar activities and have held hearings on the subject. My hope is that partnering with Rep. Trent Frank (R-AZ) will lead to successful support for the House's work on space weather and the impacts of solar events.

Note: Speaker and audience remarks are paraphrased and not verbatim quotes.

(Q): Do commercial utilities recognize they have a responsibility for infrastructure protection?
(A): Yes. They understand, but Congress needs to incentivize efforts to protect infrastructure. That's why government is so important. When the House raises this to a level of policy, the utilities know that we are serious about electric grid protection. The Grid Act and the Shield Act demonstrate that this issue is on the House's policy radar screen.

Invited Speaker: Dr. Margaret Cavanaugh, Deputy Assistant Director, Geosciences (GEO) Directorate, National Science Foundation (NSF)

To provide a "big picture" context, Dr. Cavanaugh began her remarks by quoting from President Obama's State of the Union address that as Americans, *We need to out-innovate, out-educate, and out-build the rest of the world*. She cited OSTP statements that of all the challenges we face as a Nation and as a planet, none is as pressing as the three-prong challenge of climate change, sustainable development, and the need to foster new and cleaner sources of energy. She said she thought OSTP and the Office of Management and Budget (OMB) Fiscal Year (FY) 2012 priorities indicate a focus on space weather.

She told the forum that the trend at NSF is to identify and foster the link between fundamental research and actions that society can take. The emphasis on global climate change research is a good example of this. Major GEO investments in 2012 include building a world class research infrastructure and a cyber infrastructure framework for the 21st century. She emphasized that we must continue infrastructure investment even in tough economic times.

Two important initiatives with the GEO directorate are the "Creating a More Disaster Resilient America (CaMRA) initiative and the Science, Engineering and Education for Sustainability (SEES). The objective of CaMRA is to catalyze basic research efforts in hazard-related science to improve forecasting and prediction of natural and man-made hazardous events, while the SEES initiative aims to generate discoveries and build capacity to achieve an environmentally and economically sustainable future.

Dr. Cavanaugh pointed out that several Federal agencies are following the NSF example in space weather model development and stated that NSF funded development of the first large-scale, physics-based space weather model that has transitioned into operations.

Comments, Questions, and Answers

(Q): Dr. Devrie Intriligator (Carmel Research Center (CRC), Inc.): Where does the private sector come in with respect to the partnerships?
(A): Dr. Cavanaugh: In the university grants which NSF issues. The NSF Director is thinking about how NSF (as an entity) can make these partnerships directly with the private sector. Stay tuned for more novel ideas from the Director.

Luncheon and Featured Speakers

Coordinator: Mr. Michael Babcock (OFCM)

Luncheon Speaker: Dr. Kathryn Sullivan, Assistant Secretary of Commerce for Environmental Observation and Prediction, NOAA

Dr. Sullivan focused on 2 points: (1) the threat from space weather is indeed real and (2) NOAA recognizes this threat and is committed to offering the best observations and prediction services possible.

She said she believed the attitude toward recognizing the importance of space weather and the immediate impacts of space weather events is still developing in the world and that most people have an "out of sight and out of mind" attitude. However, critical infrastructure including GPS, energy generation grids, etc., are susceptible to the adverse impact of space weather. Dr. Sullivan echoed the position of Dr. Jane Lubchenco, the NOAA Administrator, that space weather is everybody's business and the occurrence of an extreme solar storm capable of societal devastation is a matter of "when" not "if."

Dr. Sullivan stated that NASA also takes space weather very seriously. To that end, astronauts are officially classified as radiation workers outfitted with dosimeters for space travel. From her first hand experience on the Hubble Space Telescope deployment mission, she could attest just how valid the concerns about space weather are to astronaut safety. They depend on the NOAA solar activity forecasts to limit radiation exposure from solar energetic particles.

She pointed out that, as new space-based and wireless technologies emerge, our vulnerability to space weather events increases. Challenging the audience, she asked, "How do we build resistance and resiliency into our society? How much risk is acceptable? How much risk can we buy down?" Then she described efforts to replace the Advanced Composition Explorer (ACE) spacecraft to provide critical space weather observations and inputs for advanced warning. The Obama Administration has proposed funding to replace ACE with the Deep Space Climate Observatory (DSCOVR) mission as soon as 2014.

Dr. Sullivan concluded by emphasizing the importance of continuing development and the advancement of space weather capabilities to lessen potential societal impacts. She lauded the Unified National Space Weather Capability Initiative sponsored by the National Weather Service and OFCM as an important effort to help build our resiliency.

Featured Speaker: Mr. David Jones, President, StormCenter Communications, Inc.

Mr. Jones discussed the challenges in broadcast meteorology, particularly when TV meteorologists have to cover unfamiliar topics such as climate change, space weather, and other natural environmental issues. A George Mason University survey of TV news broadcasters showed that nearly all of the respondents rely on their TV meteorologist to cover science or environmental stories since they generally have the highest level of scientific knowledge on the entire TV station staff.

He said that, due to severe and continuous time pressure, TV meteorologists don't have time to research and learn new things, since they are either performing, preparing for, or advertising their broadcasts.

Why do TV meteorologists need to be trained in communicating space weather? Mr. Jones said the TV meteorologist is the one person that gives public their "daily dose of science. About 64 million households can be reached through their TV weather cast—108 million people. The need to train TV meteorologists is clear. He estimated that fewer than 1 percent of the TV meteorologists know about space weather warnings and what they mean, yet news directors turn to the TV meteorologist to explain what is going on. Since they have not been trained to understand space weather impacts, and they are not

aware of space weather services and the multitude of data available, they often fail to correctly communicate the message and the public suffers as a result.

Mr. Jones explained the role that StormCenter Communications, Inc., has played in helping to alleviate the problem. It provides a pipeline of information from agencies and scientists, gives scientists an outlet to discuss issues, and provides training workshops for broadcast meteorologists. StormCenter has developed the ability to create real-time visualizations using Google Earth for real science collaboration, which should spur investment, foster partnerships throughout government, and improve communication, collaboration, and comprehension across the industry.

Comments, Questions, and Answers

(Q): Dr. Ernie Hildner (retired from NOAA): What role do you see for the American Meteorological Society (AMS) in helping convert or educate broadcast meteorologists in becoming more expert on space weather? Is the AMS certification program a possible solution for space weather?

(A): Mr. David Jones: I think so; we have a proposal to put together workshops—the AMS and StormCenter are partners in putting together short courses and full-day workshops on many weather subjects. The AMS role is through its certification process. TV meteorologists have to get a certain number of continuing education credits. TV stations usually pay meteorologists with an AMS seal more because the station promotes that credential.

(Q): Mr. Allen Roth (Advanced Fusion Systems): How do we deal with misinformation and overly sensationalized reporting on space weather events? Even the SWEF is focused on Solar Maximum when, in fact, space weather events are occurring now. An extreme solar event can occur any time in the solar cycle. TV broadcasters show the latest spectacular imagery of solar flares and when no impacts occur, there is a loss of credibility.

(A): Mr. David Jones: The strategy to deal with that issue is when a TV station dedicates itself to science education. The problem is that the resources at the station are diminishing. We have to find ways to help the broadcast community without sensationalizing potential impacts.

(Q): Dr. John Allen (NASA HQ): In the absence of broadcast meteorologists having the expertise in space weather, have there been deliberate efforts by them to go out and get the information?

(A): Mr. David Jones: The education and outreach provided by the NASA/NOAA workshops are very important, but it takes more than that to keep it going after that workshop is over. You need to start delivering real products so they can then build on that short course, launch an application, etc., to see if there's something they can talk about today. That requires money.

Session 2 Critical Infrastructure Vulnerability to Space Weather
Moderator: Mr. John McClelland
Director, Office of Electric Reliability,
Federal Energy Regulatory Commission (FERC)
Coordinator: Ms. Patricia Mulligan

Panelists:

- **Mr. John Kappenman**, Storm Analysis Consultants
- **Mr. Eric Rollison,** Engineer of Reliability Assessments, North American Electric Reliability Corporation (NERC)
- **Mr. Mitch Narins,** Chief Systems Engineer for Navigation Services, Federal Aviation Administration (FAA)
- **Mr. Tim Deaver,** Vice President, Hosted Payload Development, SES World Skies U.S. Government Solutions

- The Session Moderator, Mr. John McClelland, set the stage for the session by stating that the issue of geomagnetic storm (GMS) impacts is getting more traction. Recent publications in the *Washington Post*, *Scientific American*, and *BBC Knowledge* claim that a "cosmic Katrina could wipe out society." He cited a recent study which concluded that a storm similar to the 1921 solar and geomagnetic storms could damage hundreds of transformers and knock out power for 130 million people and then posed the question, "Are we prepared to meet that inevitability?"

- Mr. John Kappenman reviewed the vulnerabilities of power grids and showed video, illustrating how 20 minutes of bad space weather caused blackouts in Quebec, Canada, during a 1989 GMS. He pointed out that GMSs have been known to be on the order of 10 times more severe than what was observed in the 1989 storm. Simulations of severe scenarios give projections of transformer exposure and conservative estimations show power blackouts all along the east coast of North America. Mr. Kappenman said the March 1989 storm taught us that GMSs have the unique ability to, within a few minutes, cause damage to large transformers that could take on the order of a year to replace. During severe GMSs, power grids act as space weather antennae. Since power grids are getting bigger and using higher voltages, they are becoming even more susceptible. He asserted that we have been unknowingly engineering a power grid that can couple into overwhelming GMS-induced currents without a design code for mitigation. Given sufficient time, a major storm is a certainty. We must adapt the national power grid to mitigate these potentially devastating impacts.

- Mr. Eric Rollison described NERC's mission to develop and enforce reliability standards, assess current reliability, and identify key issues. He stated that NERC is an "open" organization and aims to keep industry abreast of potential threats. GMSs are a critical risk to bulk power systems and have been identified as a top priority, since disturbances can introduce ground-induced currents (GIC) over large geographical areas. He said NERC is currently evaluating 19 proposals for action to prepare for GICs and adopted a critical infrastructure action plan in late 2010 to cope with the GIC threat. NERC's information dissemination process starts when the NOAA's Space Weather Prediction Center (SWPC) issues a warning of a major GMS. This information is then sent to power grid operators and power generation stations. NERC also leads a task force of more than 80 organizations to conduct advanced planning efforts for strong GMSs, including determination of the current state of the grid, planning models, validating vulnerability, and creating/maintaining a Spare Equipment Database.

- Mr. Mitch Narins gave an overview of the National Airspace System (NAS), emphasizing the vital role that extremely reliable, precision navigation plays to ensuring safety of our Nation's air traffic. He described the new L5 civil signal on GPS satellites to largely mitigate adverse impacts from the

- Mr. Tim Deaver described a variety of effects if we were to lose satellite communications capabilities. These include routine impacts such as spacecraft anomalies, attitude disturbances, and transponder shutoffs, which require satellite operators to be more vigilant and proactive. Satellite anomaly trends can also drive manufacturing changes and higher production costs to add more communication redundancy, extra power, and/or fuel capacity. More significant anomalies have caused serious mission impacts. In 1994, attitude failures on two spacecraft took several months to fully recover. The Galaxy 15 satellite temporarily failed during a GMS, adversely affecting the WAAS system. Mr. Deaver described compact space weather sensors on SES spacecraft that detect environmental conditions on the spacecraft for anomaly resolution. Data from these sensors can be shared with the space weather community. He urged that more should be done to sustain space weather programs that provide critical information to space operators.

Comments, Questions and Answers

(Q): Dr. Thomas Mehlhorn (Naval Research Laboratory (NRL)): What is the basis for the variability of the vulnerability of power transformers, and why are those at nuclear plants more susceptible to GICs?

(A): Mr. John Kappenman: In a typical GMS, there are numerous sub-storm events and transformers could be hit multiple times. Transformers at nuclear plants are particularly vulnerable since these transformers have large capacity with a lower electrical resistance. The lower resistance means that more GIC can flow through the transformer. A statistical analysis shows that transformers at nuclear plants are about twice as vulnerable as other transformers.

(Q): Dr. Ernie Hildner (retired from NOAA): Is LightSquared (an organization which operates a mobile satellite system) a threat to GPS?

(A): Mr. Mitch Narins stated the the FAA and the Department of Defense (DOD) tested the ability of the proposed LightSquared signal to interfere with the GPS-supported aviation navigation system. They found that the proposed LightSquared signals could interfere with the air navigation systems.

(Q): Dr. Steve Tracton (Capital Weather Gang (CWG)): What satellites have been launched that are protected against space weather activity?

(A): Mr. Tim Deaver: Satellites are only protected to a certain level. Manufacturers have a choice of what's prudent and reasonable versus the cost of catastrophic loss. You have to choose protection and redundancy. We create a system with redundancies to backup critical operations. The March 1989 type of storm is used as a benchmark for planning and response.

Comments, Questions and Answers

(Q): Dr. Madhulika Guhathakurta (NASA HQ): Do you have any ideas for hardening and response to the electric power grid's vulnerability?

(A): Mr. John Kappenman: Improve situational awareness (maintaining space weather forecasts and observational assets that can give advanced warning of space weather events) and try to look at operational procedures that could help reduce vulnerability. The alert NERC issued in the spring should put more power providers on notice and help bring them up to the same level of knowledge and understanding.

(A): Mr. Eric Rollison: NERC released an advisory to industry that covered immediate operational planning and operating and long-term planning recommendations. The NERC alert brings everyone up to speed with certain operators having more defined response plans than others. Currently, agile operations are the only way to mitigate this threat.

(Q): Mr. Steve Tracton (CWG): Some companies have response plans. Can they put them into effect immediately? How much protection do they offer?

(A): Mr. John Kappenman: We don't know; it may be somewhat limited and superficial. Most response plans are a reaction to the March 1989 event. I'm not aware of response plans for the more severe storm events that we have simulated.

(A): Mr. Eric Rollison: NERC's multiple response plan is designed to be implemented in a short time, but we are not certain what that will buy us in terms of protection.

(Q): Dr. Jim Spann (NASA/Marshall Space Flight Center): Which geographic areas will receive warnings about solar activity, one of the coverage maps presented seems to show that part of the U.S. is not covered. Is that the case?

(A): Mr. Eric Rollison: The Midwest region has a large operating footprint; they notify other operators in that area, which disseminates information to operators at lower levels.

Session 3: Human Safety and Response Preparedness
Moderator: Mr. Jon Malay
Director, Civil Space and Environment Programs, Lockheed Martin;
President, American Meteorological Society (AMS)
Coordinator: Dr. Madhulika Guhathakurta, NASA HQ

Panelists:

- **Mr. Michael Stills,** Manager, International Operations, United Flight Dispatch
- **Mr. Leviticus (L.A.) Lewis,** Federal Emergency Management Agency (FEMA) Representative, Department of Homeland Security (DHS) Space Team
- **Dr. John Allen,** Program Executive for Crew Health and Safety, NASA Headquarters Space Operations Mission Directorate
- **Dr. Brenda Phillips,** Professor, Center for the Study of Disasters and Extreme Events, Fire and Emergency Management Program, Department of Political Science, Oklahoma State University

- Mr. Jon Malay opened the session by stating he was honored to represent both the private sector and the AMS. He believes that the space weather enterprise needs to be a team effort between the public, private, and academic sectors. He was proud that the AMS has been a strong supporter of the SWEF since its inception five years ago. Mr. Malay told the forum that space weather has become more important within the AMS as evidenced by the new AMS Science Technical Committee for Space Weather and declared that "AMS is your space weather society!" He concluded by saying that space weather vulnerabilities were presented well in the previous two sessions and that this panel takes on protection of life and limb and health and human safety issues related to hazardous events (radiation exposure or infrastructure breakdown effects).

- Mr. Michael Stills began his remarks with a review of the pertinent Federal Aviation Regulations (FARs) that drive airlines to seek and use space weather information for flight and crew safety. The main area of concern is operations on polar routes that limit communications between the aircraft and controllers and entail increased radiation exposure. United Airlines (UA) relies on space weather information from NOAA to plan aircraft routing to avoid hazards or alter flight plans in reaction to sudden space weather events. Alternate routing results in suboptimal performance and may make the cost of the flight not economically feasible. Over the past 10 years of operational experience, UA has learned many lessons and has had to take actions to ensure safety of flight on several occasions.

- Mr. L.A. Lewis told the audience that FEMA's basic mission is to support citizens and first responders during disasters. This includes extreme space weather impacts, which he characterized as just one more phenomenon under the "all hazards" management umbrella. FEMA response procedures follow the same general course of actions for all disasters. He stated that FEMA is paying close attention to space weather and is not going to get caught by surprise. Mr. Lewis also pointed out that space weather can directly or indirectly interfere with FEMA responses to other emergencies due to its impact on power distribution, satellite services, communications, and navigation. FEMA Region 8 has been designated as the "Center of Excellence" for space weather events and exercises regularly with NOAA's SWPC. Finally, Mr. Lewis emphasized that the key to successful disaster response depends on diverse communications methods, advanced planning, access to power, and strong advocacy with the public.

- Dr. John Allen described two types of radiation risks to astronauts: short-term risks characterized by relatively high levels of radiation caused by Solar Proton Events, in which exposure leads to cell depletion of sensitive tissues, and long-term risks related to cosmic rays, which increase the probability of cancer and possible damage to the brain and reproductive organs. The basis for the

- Dr. Brenda Phillips told the audience that the basis for effective public response to disasters includes three steps: hazards identification, risk analysis, and preparedness. Space weather is still not on the public radar. She pointed out that some “at-risk” populations are truly dependent on power grid and communications systems for their lives. We must develop preparedness campaigns that communicate effectively to the public. She stated that disasters are low priority, even in organizations and agencies; even businesses are focused on protecting computers and not people. Dr. Phillips explained the “Preparedness Cycle,” which begins with planning and organization and then moves through training, conducting exercises, evaluation, and finally, improvement. Whether people will respond depends on many factors including social or geographic isolation, language, whether they understand or know someone who understands space weather, recognition that the threat affects them personally, and the cost of preparedness and response. She emphasized that it is important to communicate to people through their social networks.

Comments, Questions, and Answers

(Q): Mr. Jon Malay asked each panelist the following question: "If you could have one wish come true, what would it be?"
(A): Dr. Brenda Phillips: User-friendly material and integrating that material into schools.
(A): Mr. L. A. Lewis: Make sure we have adequate warnings. So we need to get a new spacecraft up. We also need to get Congress involved so they understand.
(A): Mr. Michael Stills: We need forecasts. Advanced notice is paramount.
(A): Dr. John Allen concurred with the other panelists.

(Q): Dr. Steve Tracton (CWG): Why did United Airlines not monitor solar activity 10 years ago?
(A): Mr. Michael Stills: United Airlines did not fly polar routes 10 years ago.

(Q): Dr. Steve Tracton (CWG): What is the time frame for getting to the point of an action plan to respond and recover during a disaster?
(A): Mr. L. A. Lewis: FEMA is developing a Federal operations plan with the express purpose of figuring out what resources should be brought to bear on all disasters. FEMA is planning to be prepared for "multiple Katrinas." FEMA is trying to get Americans to switch their current thinking so that the thinking embraces the fact that individuals are the first responders who must take responsibility for themselves.

(Q): Dr. Gerald Dittberner (Harris Corporation): What's the average dollar value of a 180-minute delay or a stop in Anchorage?
(A): Mr. Michael Stills: I am not privy to a dollar amount, but it's fairly expensive. Making the decision to delay or reroute a flight is a procedural response and done without question to cost. It's a matter of safety.

(Q): The questioner was reacting to what seems to be the American character with respect to disasters. He believed that the Japanese culture is very much attuned to disasters and makes the appropriate response, especially a response that involves helping others. A Japanese academic said that, from a very early age, they are trained with a collective way of thinking, calmness, value of the group. Is there something we should be doing about American character? Should we be doing something on a national level?
(A): Dr. Brenda Phillips: Anti-social behavior is not the norm. Pro-social behavior is the norm. So there is a lot of cooperation during a disaster in America. The people who help you most are your family and neighbors.

(Q): Dr. Leslie Beil (LAB Creation): If we have the capability to shield aircraft, why don't we use it?
(A): Dr. John Allen: As far as aircraft capability, I would have to defer to the engineers. NASA procedures are for protecting people.

Session 4: Space Weather Warnings and Prediction Services
Moderator: Ms. Maria Pirone, Harris Corporation
Coordinator: Dr. Genene Fisher (National Weather Service)

Panelists:

- **Dr. Jack Hayes**, Assistant Administrator for Weather Services and Director, National Weather Service
- **Colonel John Egentowich (PhD),** Deputy Director of Weather, Headquarters, United States Air Force
- **Dr. Michael Hesse**, Chief, Space Weather Laboratory, NASA Goddard Space Flight Center
- **Dr. Richard Behnke,** Head, Geospace Section, NSF
- **Dr. David Applegate,** Associate Director for Natural Hazards, U.S. Geological Survey (USGS)

- Panel moderator Ms. Maria Pirone introduced the panelists and the session topic.

- Dr. Jack Hayes began his remarks by stating that the potential for major impacts on advanced technologies speaks to why we need a unified national space weather capability. We need to continue to optimize and coordinate U.S. space weather investment and extend these capabilities worldwide, he said. The Unified National Space Weather Capability is a Federal interagency partnership facilitated by the OFCM to improve weather science and services for the 2013 solar maximum and beyond and to optimize the capabilities we have now. OFCM, along with its National Space Weather Program partners, will facilitate the development of a national framework and develop an action plan. Dr. Hayes listed the near-term goals of the plan and the strategy for the long term.

- Colonel John Egentowich described Air Force space weather capabilities and initiatives. He emphasized that teamwork was key to success in this mission area and highlighted Air Force Weather (AFW) partnerships with NOAA, NSF, and NASA. Colonel Egentowich told the forum that future priorities include improving AFW's ground-based space environment sensing capability over the next 5 years and improving analysis and forecast capability. AFW has four initiatives to upgrade observing capabilities and is pursuing spiral development of the Space Weather Analysis and Forecast System. The Global Assimilation of Ionospheric Measurements (GAIM) model provides 24-hour forecasts of ionospheric conditions and a follow-on "full -physics" upgrade should be operational in 2012-2013. He concluded by saying that AFW's goal is to ensure exploitation of space weather expertise for space situational awareness to meet special missions and operational needs.

- Dr. Michael Hesse told the audience that NASA plays a key role in all aspects of space weather forecasting: knowledge (research), data/information, models, and dissemination. It provides unique observations of the Sun with the Solar Terrestrial Relations Observatory (STEREO), Solar Dynamics Observatory (SDO), and Solar and Heliospheric Observatory (SOHO) missions and critical measurements from the ACE satellite for short-term (approximately 30 minutes) warnings of coronal mass ejections (CME) and impending GMSs. He explained that NASA's Space Weather Laboratory (SWL) provides a world-leading display, analysis, and dissemination system. The SWL disseminates information to NASA's robotic missions and to the Johnson Space Center Space Radiation Analysis Group (SRAG) for human missions. Also developed at NASA's Goddard Space Flight Center is the Solar Shield project, which uses advanced models to predict hazardous GMS-induced currents in the North American power grid. Finally, he echoed the sentiment that partnerships across the Federal government, industry, academia, and international communities are very important for advancing U.S. space weather capabilities.

- Dr. Richard Behnke told the audience that NSF's role in space weather is to provide fundamental research, modeling, ground-based facilities, education, and interagency partnership. He encouraged the forum to think of the national space weather enterprise as a system of systems that engages the entire community by providing broad unifying goals. He pointed out that the NSF-funded Center for Integrated Space-Weather Modeling (CISM) is transitioning the first large-scale, physics-based space weather model into operations at NOAA's SWPC. NSF will begin construction this summer of the Advanced Technology Solar Telescope (ATST) which will allow observation of the Sun and its magnetic activities with high spectral, spatial, and temporal resolutions. Dr. Behnke emphasized that NSF is actively engaged in the education of the next generation of space scientists through summer school programs and supporting faculty development in space science. He summed up by saying NSF has extensive international collaborations, interagency collaborations with the National Space Weather Program partners, and direct collaborations with NASA and DOD.

- Dr. David Applegate described USGS roles and responsibilities, which include providing geomagnetic observatories in support of NOAA and AFW GMS forecasts. USGS has a new Hazards Science Strategy Planning Team (H-SSPT), which reports directly to the Director, USGS, on near and longer term science goals, including geomagnetism. He told the audience that the USGS Geomagnetism Program monitors the Earth's magnetic field using 14 ground-based magnetic observatories at a program cost of $2 million per year. USGS collaborates at the international level through the INTERMAGNET Program, which consists of 104 observatories supported by 52 institutes in 39 countries. Data from these sites could be made available for real-time operational use provided sufficient communications and connectivity were established. He finished his remarks saying that the role of USGS in the Unified National Space Weather Capability would be to provide the ground-based component of observations and tracking of magnetic storms, to work with NSWP partners to deliver indices of storm intensity, and to promote global cooperation by building on existing partnerships through INTERMAGNET and working with both economically developed and economically emergent countries.

Comments, Questions, and Answers

(Q): Dr. Devrie Intriligator (CRC Inc.) stated she was disappointed at what's happening with the space weather program. Academia and the commercial sector are currently being left out of the discussion. In fact, the academic and commercial sectors are advocating for a coordinator for the space weather program in the OSTP to decrease redundant efforts in the Federal government. This program must be reorganized to get input in a timely manner.

(A): Dr. Jack Hayes: We have just started down this coordination path, and we don't intend to be exclusionary in any way. The first step is to get the Federal space weather community working effectively together. Ultimately, we must combine resources with the academic and commercial sectors in these tough economic times.

(Q): Ms. Maria Pirone: Might you include academia in this discussion when you develop this action plan (which was alluded to in this session's presentations).

(A): Dr. Jack Hayes: We are open to those types of things.

(Q): Dr. Ming Ji (NWS/Ocean Prediction Center): It's logical that the World Meteorological Organization (WMO) (1) focuses on space weather warning forecasts and (2) serves the needs of other international agencies. Is there a consensus that WMO be the source for space weather information?

(A): Dr. Jack Hayes: The WMO has a global observing system program, but there is not a similar program at the WMO for space weather. The WMO has a challenge with 180 organizations (member states). The big challenge is to convince developing states that there is a space weather threat and therefore a reason to take this issue on in tight budget times. So there is a risk with using the WMO as the source for space weather information. But, we must continue to partner with the international community.

(Q): Dr. Tom Mehlhorn (NRL): For those at DOD who are not involved in this Unified National Space Weather Capability initiative, what is the best way to get integrated into this initiative?

(A): Jack Hayes: We are open to an alliance. Sam Williamson (OFCM) said that, as a next step, we want to bring in policy-level folks: those who are able to make a decision. Dr. Fred Lewis represents DOD on the OFCM-sponsored National Space Weather Program Council, so OFCM is looking to Dr. Lewis to vet this issue within DOD. OFCM's Federal infrastructure may not allow full membership of academia and industry, but the OFCM does allow these sectors to provide input to plans and to let these two sectors serve as subject matter experts. It's a question of how to take advantage of capabilities and to bring those capabilities to bear. We are looking beyond solar max and looking in the future to build capabilities.

(Q): Dr. Bodo Reinisch (Lowell Digisonde International): The Digital Ionosphere Sounding System is the system being replaced by the Next Generation Ionosonde (NEXION) system. Why are you not switching over to a 5-minute reporting cadence so that the data can be available and useful to the academic community?

(A): Col John Egentowich and Lt Col Kelly Doser (DOD): A 5-minute sequence is not required to support DOD operations; but we will take the question back to DOD.

(A): Dr. Jack Hayes added that this question is an example of how partnerships can be formed and how a little tweaking can benefit multiple parties.

Note: Speaker and audience remarks are paraphrased and not verbatim quotes.

Session 5: Strategic Communications, Education, and Outreach
Moderator: Mr. David Jones, StormCenter Communications
Coordinator: Mr. Michael Bonadonna (OFCM)

Panelists:

- **Ms. Victoria Jaggard,** Space Editor, National Geographic News Online
- **Mr. Robert Irion**, Director, Science Communication Program, University of California, Santa Cruz
- **Lieutenant Lesley Lykins**, Director, Emerging Media Integration, Department of the Navy, Office of Information
- **Dr. W. Jeffrey Hughes**, Director, Center for Integrated Space Weather Modeling (CISM), Boston University
- **Mr. Clay Anderson,** Senior Media Representative, Pepco Holdings, Inc.

- Ms. Victoria Jaggard stated that the National Geographic Society's mission is to inspire people to care about the planet. An important part of that goal is to help readers understand the ways space phenomena can influence the Earth. The National Geographic News Online service has over 3.5 million readers each month and has an extensive following on Facebook (6.3 million), Twitter (720 thousand), and Breaking Orbit—their dedicated space blog. She went on to say that the National Geographic Society provides extensive daily coverage of space weather. Aurora Sky shows have over 821,000 hits and the number of international readers is rapidly increasing. Ms. Jaggard also stated that scientists need to be sensitive to requests from journalists. We need to convey what we are doing about the potential threats/impacts of space weather. The National Geographic Society wants to provide a full, well-rounded picture.

- Mr. Robert Irion told the audience that stories about the Sun have a built-in public audience—it's the only "sensory" astronomical body. Space weather is a natural, compelling detective story. We are unraveling complex, mysterious events while preparing for possible calamity. He then told the forum about his published articles on space weather in the *Smithsonian* magazine in December 2010 and April 2011 as offering informed science for science phobic readers. He said good stories have vivid characters like Karel Schrijver (Lockheed Martin Solar and Astrophysics Laboratory) and Philip Scheerer (Sanford University). He then urged the scientists in the audience to be available to reporters; share your stories, your frustrations, your revelations; convey why this research matters to you, and why it should matter to the reader; and always keep your audience in mind. In closing, Mr. Irion noted that space weather gets a lot of media coverage and that we need to ensure the coverage effectively informs and educates the public.

- Lieutenant Lykins' presentation focused principally on social media, noting that over 50 percent of Americans are on Facebook. She said that, although Google is the #1 trafficked site on the internet, people spend much more time on Facebook. Lt. Lykins emphasized that social media allows the user to manage the influx of information and that organizational control of communications is an illusion. She noted that the Navy has found social media to be an effective communications medium. Today's communications landscape demands dialog. Content must reach people on a human level or offer something cool to fans that they can pass along to friends. She advised the forum that there are risks and considerations for participating in social media; however, education and training are the keys to minimizing these risks.

- Dr. W. Jeffrey Hughes stated that space physics education is almost exclusively at the graduate level; very few undergraduates get any exposure. Only about a dozen universities have space physics programs, and the graduate programs educating the next generation of research specialists are often very specialized. Dr. Hughes framed the issue by asking where non-researchers can get a broad

- Mr. Clay Anderson stated that Pepco's biggest need is for advanced warnings for all hazards. Protection of the electric grid is a homeland security issue, and high voltage transmission lines are particularly vulnerable. Pepco is looking at renewable energy options to provide system backup in the event of blackouts. He emphasized that communication and education are big issues, and much needs to be done to improve both areas.

Comments, Questions and Answers

(C): Mr. Alan Roth (Advanced Fusion Systems LLC) commented that, to address the entire issue of impacts on the electric grid, we need to consider both nuclear and non-nuclear electromagnetic pulse (EMP).

(C): Mr. Jonathan Malay (Lockheed Martin Corp., President, AMS) commented that, with regard to space weather publications and articles, we need to answer the questions: "Who are we reaching?" and "Who are we missing/need to reach?"

(Q): Dr. Steve Tracton (CWG): What role does station management play in the material that is presented by the broadcast meteorologists?
(A): Mr. David Jones: In general, station management supports the efforts of their broadcast meteorologists to educate the public on issues like space weather as long as they have the knowledge and content to back it up and make top quality presentations.

(Q): Dr. Thomas Mehlhorn (NRL): How do journalists validate information?
(A): Mr. Robert Irion: Journalists gain credibility by producing reliable, well-written articles that cite reliable, authoritative references.
(A): Lt. Lykins: Regarding social media, we need to get involved, participate, and correct misinformation that finds its way to social media.
(A): Ms. Jaggard: National Geographic has a long-standing reputation for producing reliable information.

(Q): Dr. Bodo Reinisch (Lowell Digisonde International): How can AMS help change the attitude of the academic community regarding the atmospheric science community's need to understand space weather? It was noted that space physics/weather is only pursued at the graduate level.
(A): Dr. Louis Uccellini noted that Millersville University has an undergraduate program in space weather.
(A): Mr. Jon Malay: As current AMS President, I'll work with Dr. Uccellini, the next AMS president, to continue increasing the attention that space weather gets within the AMS.

Session 6: Forum Warp-up and Summary of Key Points

Note: Speaker and audience remarks are paraphrased and not verbatim quotes.

Dr. Paul Try
Senior Vice President and Program Manager, Science and Technology Corporation
Coordinator: Mr. Michael Babcock (OFCM)

- Dr. Try recapped the Space Weather Enterprise Forum and highlighted the following key take-away points:

  - We are Vulnerable in Several Areas
    - Vulnerability may be increasing
  - Potential for Extreme Societal Impact
    - Risk of 130 million without power (NAS Study)
  - Threat Not Well Recognized
    - Greater outreach/education needed
  - Improved Prediction Needed
    - Global impacts—global capabilities
    - Interagency/international collaboration needed
  - Time is Right for the Unified National Space Weather Capability
    - OFCM to facilitate agency efforts

  Dr. Try stated that space weather could have significant societal impacts like other extreme events; i.e., the Asian tsunami, Hurricane Katrina, and the Fukushima nuclear disaster. He posed the question, "What if the May 1921 solar superstorm occurred today?" and showed a U.S. map of vulnerable transformers with areas of probable system collapse encircled that could cause 130 million people to go without power. (Reference: National Academy of Sciences report, *Severe Space Weather Events—Understanding Societal and Economic Impacts*). He concluded with the ominous question, "Will this be the next extreme event?"

- Mr. Samuel Williamson then closed the forum by thanking all the speakers, guests, and staff. He said he was very pleased with the outcome of the SWEF and looked forward to continuing the effort to coordinate our national effort to improve space weather services.