

# Space Weather Advisory Group (SWAG)

Virtual Public Meeting  
Meeting Minutes  
December 1, 2021  
10:00 AM – 2:00 PM EST

## Meeting Attendees

### Committee

#### **Nongovernmental End User Representatives**

- **Dr. Tamara Dickinson (Committee Chair)**, President, Science Matters Consulting
- **Mr. Mark Olson**, Senior Engineer and Manager, North American Electric Reliability Corporation
- **Mr. Mike Stills**, Retired, (former) Director, Flight Dispatch Network, United Airlines
- **Mr. Craig Fugate**, Chief Emergency Management Officer, One Concern
- **Dr. Rebecca Bishop**, Principal Scientist, Aerospace Corp.

#### **Commercial Sector Representatives**

- **Dr. Jennifer Gannon**, VP of Research and Development, Computational Physics, Inc.
- **Dr. Conrad Lautenbacher**, Executive Chairman, GeoOptics, Inc.
- **Dr. Seth Jonas**, Principal, Lockheed Martin
- **Dr. W. Kent Tobiska**, President, Space Environment Technologies
- **Dr. Nicole Duncan**, Heliophysics Mission Area Lead, Ball Aerospace

#### **Academic Community Representatives**

- **Dr. Tamas Gombosi**, Distinguished Professor, University of Michigan
- **Dr. Delores Knipp**, Research Professor, University of Colorado Boulder
- **Dr. Scott McIntosh**, Deputy Director, National Centers for Atmospheric Research
- **Dr. Heather Elliott**, Staff Scientist, Southwest Research Institute
- **Dr. George Ho**, Chief Scientist (Instrumentation), Johns Hopkins University Applied Physics Laboratory

### Designated Federal Officer

- **Dr. Jennifer Meehan**, National Space Weather Program Manager, National Weather Service

### White House Space Weather Operations, Research, and Mitigation Subcommittee Principals

- **Ms. Ezinne Uzo-Okoro (Co-Chair)**, Assistant Director for Space Policy, Office of Science and Technology Policy
- **Dr. Louis Uccellini (Co-Chair)**, Assistant Administrator for Weather Services, NOAA, and Director, NWS
- **Mr. Robert Kolasky (Co-Chair)**, Assistant Director, CISA, DHS, and Director, National Risk Management, DHS
- **Mr. William Murtagh**, NOAA
- **Dr. Elsayed Talaat**, NOAA
- **Mr. James Platt**, DHS
- **Ms. Kenyetta Blunt**, FEMA
- **Ms. Karen Shelton-Mur**, FAA
- **Dr. Gavin Hayes**, USGS
- **Mr. Christopher Hallam**, EPA
- **Ms. Mara Winn**, DHS
- **Dr. James Spann**, NASA

- **Ms. Peg Luce, NASA**
- **Mr. Clinton Wallace, NOAA**
- **Dr. Uwe Arp, NOAA**
- **Dr. John Allen, NASA**
- **Dr. Christoph Englert, NRL**

## **Meeting Minutes**

### **10:00 - 10:05 AM, Welcome (Dr. Jennifer Meehan, SWAG DFO)**

Dr. Jennifer Meehan opened the meeting by welcoming everyone to the historic meeting, bringing together all corners of the Nation's space weather enterprise, by law, to conduct the very first Space Weather Advisory Group Meeting (SWAG).

She introduced herself as the National Weather Service, National Space Weather Program Manager, the Executive Secretary for the National Science and Technology Council's Space Weather Operations, Research, and Mitigation (SWORM) Interagency Working Group, and the designated Federal Officer for this group.

Given this was the very first meeting of the SWAG, she reminded meeting attendees of the SWAG establishment. In the fall of 2020, Congress passed unanimously, both in the House and the Senate, the Promoting Research and Observations of Space Weather to Improve the Forecasting of Tomorrow Act, better known as the PROSWIFT Act. Soon thereafter, the President signed this Act into Public Law: 116-181. In accordance with section 60601 of the PROSWIFT Act, NOAA established the first ever advisory group to advise the SWORM Interagency Working Group. All 15 non-governmental representatives of the SWAG were appointed by the SWORM Interagency Working Group with 3-year terms beginning on October 1, 2021.

The PROSWIFT Act directs SWAG members to receive advice from the academic community, the commercial space weather sector, and space weather end users that will inform the interests and work of the SWORM. Each SWAG member here today serves as a representative member to provide stakeholder advice – that is, advice reflecting the views of the entity or interest group they are representing, such as industry, academia, or consumers.

Dr. Jennifer Meehan then provided an overview of the agenda and introduced the SWAG Chair, Dr. Tammy Dickinson who was appointed by the Under Secretary of Commerce for Oceans and Atmosphere and NOAA Administrator, Dr. Rick Spinrad.

Tammy currently owns her own consulting business, Science Matters Consulting, LLC. Prior to that she spent 6 years in the White House Office of Science and Technology Policy, serving as the Director of the Energy and Environment Division. This Division included work on a broad range of topics including space weather. She worked with Federal and non-Federal partners to write the first ever Federal Space Weather Strategy and Action Plan.

She has extensive experience working with partners across the Federal government - she has worked at the U.S. Geological Survey, NASA (HQ, Goddard, and Johnson), the National Science Foundation, and the National Academies of Science, Engineering and Medicine. Her background

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is in geology and planetary science but she has spent most of her career in program management and policy.

She thanked Tammy for taking the helm of the group noting we all look forward to her leadership of the SWAG in the years ahead.

**10:05 - 10:25 AM, Opening Remarks and Committee Introductions (Dr. Tamara Dickinson, SWAG Chair)**

Dr. Tamara Dickinson thanked Dr. Jennifer Meehan, welcomed everyone again to the meeting, and noted she is happy to Chair the prestigious group of SWAG.

She highlighted the SWAG as the culmination of efforts, more than a decade long, to formalize a whole of community approach to reduce the Nation's vulnerability to space weather.

She then recapped how we got here.

She served in the White House Office of Science and Technology Policy (OSTP) from 2011 to 2017. In February 2012 she took over the space weather portfolio. Just a month earlier, OSTP was directed by the President to move forward with space weather mitigation efforts.

This was largely in response to the NASA Authorization Act of 2010, which recognized that space weather "could have significant societal, economic, national security, and health impacts", and charged OSTP with improving the Nation's ability to prepare and respond to the "potentially devastating" impacts of space weather events.

In 2014, following a period of assessment and review by the OSTP-led Geomagnetic Interagency Working Group, John Holdren, Director of the White House Office of Science and Technology Policy, directed the establishment of a space weather interagency subcommittee under the National Science and Technology Council. The Subcommittee would be responsible for "defining, coordinating, and overseeing goals with respect to space weather."

This essential watershed step resulted in the formation of the Space Weather Operations, Research and Mitigation interagency task force, commonly known as "SWORM" in November 2014.

The goal of the SWORM Task Force was to unite the national- and homeland-security enterprise with the science and technology enterprise to formulate a cohesive vision to enhance national preparedness for space weather.

In Oct 2015, the SWORM released the National Space Weather Strategy and the National Space Weather Action Plan.

In the accompanying statement by John Holdren, Director of OSTP, he emphasized that "this challenge requires the Nation to work together to continually improve understanding, prediction, and preparedness to enhance the Nation's resilience against severe space-weather events." And that addressing risks associated with space weather that will "necessitate sustained engagement among government agencies and the private sector."

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In November of 2015 OSTP briefed the Senate Committee on Commerce, Science, and Transportation on the recently released National Space Weather Strategy and Action Plan. Following this briefing, Congress embarked on developing legislation that would codify the ongoing activities being carried out by SWORM.

After several unsuccessful efforts to pass legislation, in October of 2020 Congress succeeded with the passage of the Promoting Research and Observations of Space Weather to Improve the Forecasting of Tomorrow Act or the PROSWIFT Act.

The PROSWIFT Act established that it is the policy of the United States to prepare and protect against the social and economic impacts of space weather, and we should do so by engaging all sectors of the space weather community, including academia, the commercial sector, end users, and international partners.

Dr. Tamara Dickinson noted, today, we embark on this important initiative to help inform the interests and work of the SWORM interagency working group.

The new advisory board equips the SWORM with a brain trust that will help navigate the many complex and challenging issues we face in building a space-weather-ready Nation.

She thanked the SWAG members for their willingness to commit their time and expertise to serving on this important advisory group. She looks forward to working with them all.

Dr. Tamara Dickinson then allowed each advisory group member to briefly introduce themselves. Each committee member gave their name and a brief bio.

**10:25 - 11:00 AM, SWORM Interagency Working Group Co-Chair Remarks (Dr. Tamara Dickinson, SWAG Chair)**

Dr. Tamara Dickinson then introduced the SWORM Co-chairs for their comments to the group.

Ms. Ezinne Uzo-Okoro, the Assistant Director for Space Policy at the Office of Science and Technology Policy at the White House. Ezinne became Co-chair of SWORM in April 2021, and currently leads OSTP efforts to address risks associated with space weather.

Mr. Bob Kolasky is the Director of the National Risk Management Center in the DHS Cybersecurity and Infrastructure Security Agency. Bob has been a member of SWORM since its inception in November 2014, and replaced Caitlin Durkovich as Co-chair of SWORM in January 2017.

Dr. Louis Uccellini is the Assistant Administrator for Weather Services in NOAA and Director, National Weather Service. Louis is one of the three original Co-chairs of SWORM. She noted she was proud to serve by his side as one of the other original Co-chairs of SWORM, along with Caitlin Durkovich, who is currently a Special Assistant to the President and the Senior Director of Resilience and Response at the White House National Security Council.

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Before the Co-Chairs gave remarks, Dr. Tamara Dickinson noted the many SWORM principals in attendance at the meeting.

Ms. Ezinne Uzo-Okoro thanked the SWAG for the opportunity to talk at the inaugural meeting. She noted that earlier this year, she joined OSTP and took on a broad portfolio that includes space weather and that she was honored to join Louis Uccellini and Bob Kolasky, as Co-chair of SWORM. In her role as Co-chair of the Space Weather Operations, Research, and Mitigation Interagency Working Group, she oversees the implementation of the activities and milestones identified in the National Space Weather Strategy and Action Plan. For over a decade, OSTP has been coordinating interagency efforts to improve the Nation's ability to prepare for and respond to space weather events. OSTP is committed to enhancing the resilience of critical infrastructure to the adverse effects of space weather.

She acknowledged the United States will build capabilities to improve the safety and security of our critical infrastructure; and ensure that the United States is the global leader in space weather observations, research, and forecasting. Upon assuming the role of SWORM Co-chair, she was immediately struck by how tight knit this community is, and was impressed by the extraordinary body of work underway to address vulnerabilities to space weather across so many elements of our critical infrastructure.

She discussed how the SWORM is an interagency group made up of over 30 Federal departments and agencies and even though much has been accomplished through SWORM, we still face many challenges in defining and implementing the actions necessary to protect the Nation during space weather events. She continued to state that it requires a whole-of-Nation approach, with the government engaging all relevant stakeholders. The private sector owns and operates the majority of the nation's critical infrastructure. It is critical for the government to partner with the private sector to ensure security and resilience of our Nation's critical infrastructure.

And in regards to the research, observations and prediction of space weather, she noted how she has heard Louis Uccellini on several occasions say that NOAA can't do it alone. NOAA relies on the three main sectors that contribute to the understanding and forecasting of space weather – academia, government, and commercial space weather service providers. Each sector plays a critical role in building a Space Weather-Ready Nation.

Ms. Ezinne Uzo-Okoro sees today's event as a culmination of sorts, as we set in motion the final steps in implementing a whole-of-Nation approach. Both the 2015 National Space Weather Strategy and Action Plan and the 2019 update, emphasize the importance of leveraging public and private networks of expertise and capabilities to improve the ability to manage risks associated with space weather, and to deliver space weather services more efficiently and cost effectively. The establishment of the Space Weather Advisory Group is a significant step in implementing a formal role for the private sector and ensuring a whole-of-Nation approach to building a Nation resilient to space weather.

She concluded her remarks by stating that the PROSWIFT Act directs OSTP to coordinate the activities of SWORM through the development and implementation of Federal Government space weather activities to prepare for, avoid, mitigate, respond to, and recover from potentially devastating impacts of space weather. She stated we will do this better through engagement with the SWAG and she looks forward to the group's discussions on how best to advise the SWORM,

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and the SWAG's contribution as we work together to implement more effective and efficient strategies to address space weather.

Mr. Bob Kolasky thanked the group for the opportunity to speak with the SWORM Co-Chairs. He noted that he has been in the SWORM role across 3 administrations and has been involved from the very first meeting in the EEOB and it has been great to see consistent government activity around addressing the risks associated with space weather for the past 10 years with real progress made. He noted the SWORM is one of the best interagency coordination bodies within the National Security and Science and Technology space.

He thanked the members of the SWAG for stepping up to serve in this role and thanked them again for letting him provide remarks.

He acknowledged he is not a space weather expert but in his role in cyber security he helps serve as the National Coordinator of Critical Infrastructure Security and Resilience. DHS's job in the National Coordinator role is to implement legislation and policy to coordinate activities to elevate the level of critical infrastructure security and resilience in the face of a variety of risks.

He noted how space weather affects certain critical infrastructure sectors such as energy, communications, water, transportation, and critical manufacturing, etc, and DHS has established structures to work with the inter-agencies to identify vulnerabilities and risks and make plans to address these. DHS's work is mostly voluntary since CISA can not require critical infrastructure owners and operators to take steps to make their operations more secure and resilient but look for opportunities once those requirements are in place to make critical infrastructure more secure.

He discussed how DHS is used to public-private partnerships through the structures established such as the sector coordination councils and have been meeting for about 15 years now establishing trust between government and industry. This is all done of course to help reduce the risk to the Nation's critical infrastructure and to do that we use an all hazards approach including high consequence, low probability type risk with systemic impact such as space weather. To address this type of risk, DHS will improve the availability of information that hopefully encourages and incentivises owners and operators of critical infrastructure to take the steps necessary to protect their systems. Also to address this risk, DHS looks into cost effective solutions or investing in reducing risks.

Bob acknowledged this approach is taken when working with the SWORM. He mentioned DHS has been working with the science community to make sure as the science and benchmarks are improved that this information is usable by owners and operators to make mitigation decisions. DHS has worked on vulnerability assessments of priority systems and assets that are affected by space weather. Better information and understanding of risks is needed for mitigation steps. DHS also makes additional investments in planning and exercises to become more prepared. We have to ask ourselves if we are ready to deal with long term power outages or impact to communication systems.

He concluded by discussing additional overlaps with the space weather community including Position, Navigation, and Timing, as well as Electromagnetic Impulse that DHS is responsible for and looks forward to the work of the SWAG.

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Dr. Louis Uccellini thanked the group for the opportunity to address the inaugural meeting of the SWAG. He noted SWORM was a big success, in establishing in both the legislative and executive branch, the importance of space weather and the recognition of the roles across the federal government, including the roles in observations, research, and services. He celebrated the SWORM's ability to get 35 different Federal Departments, Agencies, and Offices at the table at the same time agreeing to it. It brought together, for the first time, all elements of the scientific, operational, and the homeland security enterprises of the Federal Government, laying out the mitigation needs with a sense of urgency. He noted it also very importantly established the requirements for research to operations that require many of the federal agencies to work together. The SWORM compressed about 70 years of terrestrial weather collaborative advancements among the research and operations agencies, into 3-4 years which is remarkable.

He remarked that NASA, NSF, NOAA, and DOD will sign a MOU to ensure the R2O and O2R effort is codified in law and is a part of the National Space Weather Strategy and Action Plan. Having the academic community involved in the SWAG along with the end users and commercial providers is incredibly important and it took the PROSWIFT Act to make it happen. In terrestrial weather, it took about 40 years for the government to embrace the private sector. The community involvement outlined in the PROSWIFT Act should not be underestimated. Across the whole value chain, the Federal Government cannot do this alone. It is representative of the needs of society and businesses for this type of information.

Dr. Louis Uccellini noted we are at an important junction. He thanked SWAG members Dr. Tamara Dickinson and Dr. Seth Jonas for their extraordinary efforts in the creation of SWORM and the development of the National Space Weather Strategy and Action Plan. Dr. Seth Jonas also did a remarkable job bringing the Benchmarks forward as the first chapter in the Plan so we could address the mitigation steps in a quantitative way. He also emphasized Dr. Tamara Dickinson was the LEAD chair of SWORM, not the Co-Chair! Her leadership was tremendous.

He thanked SWAG member Dr. Lautenbacher, who in 2005, along with Jack Kelly, recognized the importance of the Space Environment Center and felt it needed to be operationalized. It was their efforts that led to the creation of the Space Weather Prediction Center. Dr. Louis Uccellini's role in that important move was the naming of the Space Weather Prediction Center because nobody on the Hill quite knew what the space environment meant. This was an important step in the provision of space weather services.

Dr. Louis Uccellini then mentioned his encounter with Dr. Tamas Gombosi during a very important trip to the University of Michigan where he was first exposed to the space weather modeling efforts and the huge impact it had on him. In comparison, all weather modeling was developed in government laboratories back in the 1940s, 50s, and 60s because it was the only place with the resources, computing power, and infrastructure to develop and run these models in real-time. That is not the case for space weather. We entered the era of operational space weather with zero capacity to develop the models within the government. We had to turn to the research and academic community to get it done. SWORM helped accelerate that effort and today we have a paradigm of forecast, watch, warning, like we have in terrestrial weather.

All the models run in operations are from the academic and research community and have all gone through the R2O process. Dr. Louis Uccellini noted what he means by O2R is a continued development going on to where we upgrade these models based on their continued research and development. Examples include, the ENLIL model from George Mason University, Geospace

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model from University of Michigan, WAM-IPE model in collaboration with University of Colorado, Boulder, ground based models obtained through USGS, and radiation models from FAA. Also, used is the GONG network which was developed for research but is now operational through the efforts of SWORM.

Also Dr. Louis Uccellini gave a shout out to SWAG member Craig Fugate. A decade ago, Craig, with his excellent knowledge of space weather, was very instrumental on getting space weather on the radar of leadership at the White house including the President. Dr. Uccellini recalled one of Craig's first public appearances as FEMA Administrator, at a hurricane seasonal outlook when Louis was in the back of the room. After Craig gave his remarks, he received a question from a reporter that asked what keeps him up at night. Craig told the room that what keeps him up at night is another Carrington event. Those in attendance were very confused given many did not know what the Carrington event was - a space weather event.

He asked Craig after the event why space weather rose to the top during his very first public appearance. He recalled Craig acknowledging space weather could be a global event and we're only prepared to handle local, regional, to state events where you can preposition assets within your own country which would not be the case for space weather.

Dr. Louis Uccellini mentioned his retirement on January 1, 2022 but told the group to rest assured because the National Weather Service leadership team understands the importance of space weather and the advances that we have made and the attention it demands given its role within OSTP.

He thanked the SWAG members for their willingness to serve, noting the group's success is only possible through their commitment of time and effort. He noted advances in the space weather enterprise of this country will be reliant on the advice and the information the SWAG will provide.

Dr. Louis Uccellini mentioned SWAG member Dr. Kent Tobiska and the early meetings at the SEC workshop. He enjoyed meeting with the private sector to have very candid conversations.

He concluded by saying his association with everyone in the space weather enterprise over the years has been a tremendous experience for him and he would like to thank everyone that he learned so much from over the years.

Dr. Tamara Dickinson closed the session by thanking the Co-chairs for their leadership of the SWORM Interagency Working Group and for their dedicated service and thoughtful contributions towards building national preparedness for space weather events. She also took the opportunity to thank Dr. Louis Uccellini for all his efforts toward building a space weather resilient Nation, acknowledging his retirement announcement after 43-years in public service, and over 25 years involvement in space weather. In the fall of 2014, she, along with other leaders in OSTP, selected Dr. Louis Uccellini as one of the first three Co-chairs of SWORM. They knew at the White House that they could count on him to effectively lead National efforts to address space weather. He helped mold the SWORM into a cohesive body made up of over 30 Federal departments and agencies, bringing together all elements of the scientific and the homeland security enterprises of the Federal Government. He oversaw the implementation of dozens of actions in the national space weather strategy and action plan. His extraordinary leadership inspired, empowered and expanded efforts at every level to further national preparedness for space weather events. She



thanked him again for all he has done for the space weather community, and for the Nation, and that we will miss him.

**11:00 - 12:00 PM, PROSWIFT Act (Dr. Tamara Dickinson, SWAG Chair)**

Dr. Tamara Dickinson gave a highlight of the PROSWIFT Act.

Section 60601 codifies roles and responsibilities for the Federal Departments and Agencies, clearly defining roles in support of observations, research, and operations. Note that this includes the DOD and the DOD is an important player in SWORM, so the SWAG should keep that in mind as issues of national security come up.

Section 60601 also codifies the SWORM and OSTP's role to coordinate the activities of the SWORM. This is important because SWORM, it's membership, and OSTP's role are all now codified in law.

And, of course 60601 directs the formation of the Space Weather Advisory Group. She pointed out that Section 60602 specially calls on SWAG to advise SWORM on the development of a strategy for coordinated observation of space weather, and Section 60604 advises that SWORM, "upon consideration of the advice of the advisory group", develop formal mechanisms for R2O2R.

PROSWIFT requires SWAG to have 5 members each from the academic, commercial sector, and end users communities. The SWAG is to advise the SWORM and she noted appreciation that many of the SWORM members were able to join the meeting today.

The SWAG will advise on: Overarching goal of advancing the space weather enterprise; improving ability to prepare for, mitigate the impacts of, respond to, and recover from space weather events; enable coordination/facilitation of R2O2R; and, develop and implement an integrated strategy for space weather. This strategy is called for in PROSWIFT and is the responsibility of OSTP in collaboration with SWORM with advice from SWAG. Her guess is that SWORM will be tasked by OSTP to draft the strategy.

Dr. Tamara Dickinson then moved to the first task of the SWAG, to conduct a user survey. The PROSWIFT Act directs the SWAG to conduct a comprehensive survey of user needs of space weather products to identify research, observations, forecasting, prediction, and modeling advances needed to improve space weather products. They should build on work already done and coordinate with SWORM.

The PROSWIFT Act also states that we SHALL (must) consider the following: assess the adequacy of Federal Government goals for lead time, accuracy, coverage, timeliness, data rate, and data quality for space weather observations and forecasting; identify options and methods, in consultation with the academic and commercial space weather sectors, to advance the above goals; identify opportunities for collection of data to address needs of space weather users; identify methods to increase coordination of space weather R2O2R; identify opportunities for new technologies, research, and instrumentation to aid in understanding, monitoring, modeling, prediction, and warning of space weather; and identify methods and technologies to improve preparedness for space weather. The user survey will be briefed to Congress, published and made public when completed.

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Dr. Tamara Dickinson then discussed the 2015 National Space Weather Strategy and Action Plan and the call for NOAA to conduct a comprehensive survey of space weather data and product requirements needed by user communities to improve service. NOAA contracted with Abt Associates to conduct a user survey. The Abt Associates report was published in 2019 and was also provided to the SWAG as a read ahead. Abt Associates had conversations with 5 users for each of 5 sectors: Electric power grid, Satellite, Global navigation satellite system (GNSS), Aviation, and Emergency management. Listed in the slide are the topics that they covered in their conversations with users: identify technological components affected by space weather, describe steps already undertaken to reduce vulnerabilities, determine actions that could be taken to further reduce these vulnerabilities, describe specific attributes of space weather information needed to further reduce these vulnerabilities, describe potential improvements in how space weather information is communicated to increase its usability, and describe desired format of space weather information.

Dr. Tamara Dickinson introduced Mr. Rob Steenburgh from NOAA's Space Weather Prediction Center to give a high-level briefing on the Abt Associates survey. Rob Steenburgh is the acting Lead of the Space Operations Center at the NOAA Space Weather Prediction Center. Bob oversees SWPC's 24-7 mission to provide operational space weather monitoring and forecasting for civil applications. Rob worked as a meteorologist in the US Air Force for 20 years before moving into space weather for the last 3 years of his Air Force career serving as a liaison to the Space Weather Prediction Center. After retiring from the USAF, he worked for ~1.5 years at NASA's Johnson Space Center in the Space Radiation Analysis Group then moved back to SWPC in 2010, first as a forecaster, then as a space scientist.

Rob discussed lessons learned from the Abt Associates survey. The goal of the survey was to identify and describe current and potential users of SWPC products and services along with their requests for improvements. Some findings extended across all sectors. SWPC is moving to more refined geographical locations in the products they issue. This was something heard from all sectors along with improved lead time. Other findings across all sectors were the desire for improved access to historical data to learn from past experiences, idea behind benchmarking - how bad can it get? What does the environment look like during a particular space weather event? Finally, people were interested in an "All-Clear" notification. Improvements to the NOAA scales were requested and is part of the ongoing SWORM efforts.

Geology matters for space weather impacts as well, taking into consideration this when putting out hazard products. We now have short-term E field forecasts for the planet. Users are wide ranging and need plain language products and an easily accessible format. Also, education and outreach were requested. The aviation community needs improved forecast granularity and precision for flight planning and non-technical and impact-based products. Rob noted SWPC has been doing this type of service since the 1960's and these products were developed and tailored for a specific kind of user. As our user community has exploded, we need to recognize and tailor the products more for the end users. Emergency Managers need SWPC-facilitated education and communication on a continuous basis given the prolonged solar cycle.

In conclusion of the Abt Associates report, one thing discussed was the feasibility of the recommendations in the short term. Improving access to historical information should be a fairly easy lift, and plain language products require working with social sciences given the interpretation of products. There is an ongoing effort across NWS to make products more user friendly.

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Rob gave tips for conducting a successful survey such as having the right people working together from the beginning on this like Jen Sprague. Also, he suggested casting a wide net. They started with a list of people but realize this process is driven by the scope of the project and the resources available. If he could do it over again, he would cast a wider net and reach out to more people by either going to annual meetings or give them a place to go to provide comments because a wider perspective might lead to some unexpected results. He mentioned if you do this you have to be prepared to scrutinize the responses. In conclusion, it's important to know the difference between feasibility and fantasy but do not exclude the big ideas. Need to think outside the box and prepare for what could be possible down the road. SWPC took a conservative approach with the Abt Associates survey and recommends the SWAG take it a step further and widen the horizons a bit.

Dr. Tamara Dickinson thanked Rob and asked him to please introduce Jen Sprague to the committee. Jen introduced herself as the National Weather Service Social Science Program Manager and she has been working on social behavior and economic science issues for 13 years to have a solid interaction of the social and physical sciences. She began working many years ago under SWAG member Dr. Lautenbacher when he was NOAA Administrator. She said it takes a lot of pushing to get a physical science entity to understand there is true value in the social behavior and economic sciences for example. You can make a great forecast but if you are not good at articulating what that forecast means to emergency managers, decision makers, the public, then in many ways we feel like we have failed. Some finds in this study that Rob highlighted are very similar to severe weather - flooding, heat, and tropical. More lead time, plain language impact-based products. She was delighted to read the PROSWIFT Act section on the user survey that embraces the importance of this and delighted that the SWAG took a look at the Abt Associates report and will build on it because you do not want to reinvent the wheel. She also appreciates the PROSWIFT Act calls for the user survey to be updated every 3 years because the users change and their needs change. Need to know this in order to provide products and services that accurately meet user needs.

Dr. Tamara Dickinson opened up the floor for committee discussion.

Question from Dr. Tamas Gombosi: when you have questions like regional forecasts, did it have an impact on priorities for R2O2R research because some of these are pretty tough research questions?

Answer from Rob Steenburgh: we looked for targeted opportunities, places where we thought we could improve those things, for example the Electric Field model combined with information from USGS MT surveys has allowed us to produce a model that has regional characterizations of the environment. Some of the other things we do on the international front is provide space weather information to the aviation industry via the International Civil Aviation Organization (ICAO) where we are required to begin investigating more regional products. Regional in a sense of "this 30-degree latitude sector of the globe may see an issue." We have to consider whether or not some of these things are feasible. What we do not want to represent a capability that we do not have.

Follow up from Dr. Tamas Gombosi: the last couple of years, NASA and NSF had a number of announcements for opportunity for R2O and O2R. Is there interagency coordination so that those funding opportunities address the questions that came out most important?

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Answer from Rob Steenburg: Yes, to a degree. And keep in mind this is my perspective from an operations point of view. We have worked with NASA to better understand the radiation problem . We have worked with a group on CME forecasting. To the extent this drives things, the survey has had interagency impact.

Answer followup from Dr. Jim Spann: there are several levels of opportunities regarding the R2O2R activities. Terry Onsager has just put in the chat that I would like to mention, every year the ROSES R2O2R opportunities the agencies get together, NSF, NASA, NOAA, and DOD, and discuss topic areas we would like to identify for the next opportunity that will be provided. In that respect, we do focus the ROSES opportunity based on the users and operational needs. For some of the other opportunities that have been made available such as the joint NSF and NASA Space Weather Quantification of Uncertainties, it is unclear if there was much interaction between the operational agencies as it was an open call. That one was not as well coordinated for user needs. Circling back on the R2O2R ROSES call, the agencies also get together to review the recommendations for selections and at times we have adjusted that selection list based on input and generally it is an adjustment to fund additional proposals based on funding made available.

Question from Dr. Delores Knipp: Asked a little more about the effects supporting ICAO has had, is anyone in the ICAO world engaged with the user community in the same way this survey was?

Answer from Rob Steenburg: Yes, noted there are folks that participate in the ICAO meetings and participate indirectly through the FAA. Also, SWPC's Bill Murtagh has organized meetings with the Airlines for American trade association, but it is really hard to get feedback from the airline industry. Because you cannot see space weather it is difficult to pinpoint it as the cause of issues versus if it were hailstones, you can visually see the problem.

Follow up Question from Dr. Knipp: In regard to the GNSS survey, did you get down to the level where you were talking to folks who were operating harbors or shipyards and ask about the effects there?

Answer from Rob Steenburg: Rob could not remember but has received feedback from the National Geodesy Survey about GNSS scintillation impacts. Will need to review the interview list.

Question from Dr. Heather Elliott: Looking at this discussion box on the slides, improve access to historical data, I would like to add historical access to space weather forecasts for model validation to see how well forecasting improves with improved modeling. I have seen the ionospheric community making maps with their results which would be helpful to the GNSS and communications communities. In conversations with people that make total electron content maps, it is well known that different receivers will see different results. The private sector does not want to reveal their vulnerabilities but it would be helpful to know what type of receiver is being used and where it is located.

Answer from Rob Steenburg: That is a great point. Knowing the vulnerabilities of systems is essential to determine mitigation steps.

Question from Dr. Rebecca Bishop: When reading through the report, it seems there is a lot of excitement from the application and end users to get access to historical data but it did not seem like there was enough explanation on getting end user's historical data back into SWPC or the research community to aid in the development of the forecasts. Over the last year, we found a

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number of datasets out there that are just sitting there that people may be willing to share. Is there any motivation to try to have a two-way communication with data sharing instead of just one way with the end users?

Answer from Rob Steenburg: There is definitely interest in that. The questions were aimed at what SWPC could provide to the users but that feedback and that information is essential. It is problematic based on the community and what they are willing to share so that can be a hurdle. One recent development from NERC for the grid, G3 storms and higher, they collect data and make it available and as a consequence we are able to take that and look at the predictions we made and see where improvements can be made and where we nailed it. There have been efforts made to crack open some of the work in the spacecraft community and others but that is an ongoing need essential for research and essential for operations to verify forecasts. We are shifting from environmental characterization to the impacts, focusing on integration decision support services and to do that well you have to understand the impacts.

Follow up from Mark Olson: Rob is absolutely right; the electric industry is collecting geomagnetically induced current information on the North American grid during strong storms. And NERC is rolling out a plan to make this information available to the research community. There is a challenge in using GIC data without detailed grid information and NERC does not possess that information. On the survey, as an end user we help people get together on this and one of the challenges with end user surveys is they know what they know about their system and about their environment but there are limitations when you are talking about rare, extreme events like this. So, I wonder if there are tips if we are working on developing a survey how we can help bridge the understanding from the researcher community what these rare risks will look like to the end user so they can then respond from a perspective of "if this is the scenario, what would you need to reduce the risk?" It can be very common now for the grid operators to say, "well I don't see a lot of storms so we may not need a lot of information but I need better information and I need it earlier." If we were to have a more extreme event that picture would change and they may need help through a survey to imagine a scenario and develop their response from their perspectives that would lead to those space weather data needs.

Question from Dr. Seth Jonas: Will there be access available for the survey process in regard to who was interviewed or engaged for the Abt Associates report and to the survey instrument itself?

Answer from Jen Sprague: Need to go back and review the survey folder but do not see any issues sharing this information.

Another question from Dr. Seth Jonas: was it asked during the survey, comparing terrestrial weather to space weather, given the broad diversity of technologies and the myriad of effects that space weather can have on these technologies, do we know the extent to which the private sector provided additional tailored, localized specific forecasts on top of or in addition to the SWPC forecast. Was that explored at all in this survey?

Answer from Rob Steenburg: For the purpose of this survey, it focused on what types of things SWPC could do to improve and what other offerings we should make. To my knowledge, no, the commercial sector was not explored.

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Question/Comment from Craig Fugate: In the survey with emergency managers, they do not spend a lot of time on low probability, high consequence events. If you asked them about pandemic planning before 2020 they would say, yeah that is CDC. What I have found is if you want to know what emergency managers need you have got to give them a scenario that has consequences. That they can go, okay if GPS goes out, what does that mean to me locally? If I deal with a geomagnetic storm that is significant enough where utilities are now mitigating through outages what is the duration for that, what happens? Also getting them to understand this is hemispheric. Best approach here is to give emergency managers a scenario that has consequences then ask them what type of information they need and in what timeframe. Putting it in the context of consequence at local, state, and federal response levels.

Follow up from Rob: that is an awesome point and it gets to Mark Olson's point too. I think if I were to build a survey from scratch, I would want it to be built by someone who can translate the impacts into the language Emergency managers and grid operators understand. This could give better survey results.

Comment from Dr. George Ho, the main difference I see between the survey done in 2019 and what we are about to take on is not only do we need to identify the user needs but we need to identify a way to move the modeling, technology, and opportunity forward to meet the user needs. In the 2019 survey, did people suggest a way to do this? How would you advise asking the community on such a thing because this is suggesting a way of how we get there.

Answer from Rob Steenburg: Yes, this is a good point. When I said feasible versus fantasy, one of the issues is people do not necessarily know what is possible or allow themselves to think bigger. Need to know where science is right now to know what is possible.

Answer follow up from Jen Sprague: With social science you can do mixed methods. You can start with a survey then you can follow up with focus groups to glean more information out. So if you are looking to build off of the Abt Associates study, that would be something you can draft in the statement of work to have the mixed method survey. You can say something like okay we asked you what your needs were, here are some potential opportunities, would this help or not?

Question from Dr. Jen Gannon: how were the interviewees selected? For example, you will get very different answers from a small generator facility operator to a big utility company who likely has a space weather expert on staff. How did you go about selecting them?

Answer from Rob Steenburg: we made a list and brainstormed, beginning with who we knew then asked who else we should be talking to. Answers will vary depending on who you talk to and the different perspectives they bring but this can be alleviated by casting a wider net.

Comment from Dr. Louis Uccellini: Responding to a few of the comments may be useful. He wanted to also acknowledge additional people that were instrumental in his space weather journey. Ernie Hilder, former director of now-SWPC, tried to make the research work in real-time. There are advantages in this as the field transitions research to operations. Both the research and the operations must work together closely to transition models and data. Also called out Bill Murtagh, essential to assisting Dr. Louis Uccellini with the ins and outs of all things space weather. Also acknowledged Dr. Jennifer Meehan as being right up there with Bill in supporting him with space weather. He then discussed SWPC's planned Space Weather Prediction Testbed and mentioned how tremendously successful the other NWS national centers were with their co-

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located testbeds such as National Hurricane Center and Severe Weather Prediction Center. This effort will accelerate the R2O and is part of the quad-agency MOU. It is in the president's budget, programmatic aspects, but cannot start new programs in a continuing resolution. Urged the SWAG to put this on their list of things they want to know about because a lot of questions are asked about R2O2R. R2O2R is not just for modeling but also for observations. On the front end of observations for space weather and this is critical for the research community and the private sector. In terms of the social sciences, he acknowledged he is on a learning curve as well, but what he has learned in the terrestrial weather community is there are changing risk preferences prior to and during an event. If we extend the forecast range to 10 days it makes the forecast less certain but there are groups out there that will want to understand this uncertainty because there are decisions that may have to be made 10 days out, 5 days out, 4 days out. It isn't you just flip the switch on when the event happens and all of a sudden, you're interacting with the folks who are making the decisions. So that scenario sequence Craig pointed out is essential for understanding how people are going to react to the uncertainty as they are making decisions because we have to know, the collective we - the commercial and government providers, need to know how to convey that information. This is social science and you must break those barriers between physical and social science. One of the things he learned as the NWS director promoting this 10 years ago with the building of the Weather-Ready Nation was that it is not just the accuracy or the uncertainty, it is the consistency. One of the things that has happened in the terrestrial weather community is there is a better interaction between the private and public sector behind the scenes prior to and during an event. There are folks in the emergency management community that work with the public sector but have a private sector provider for some of the tailor products they need to make decisions. There is an increasing challenge for consistency when you have a private and public provider but it is not instrumental. We have shown we can work together prior to an event; we do not tell each other what to say but just the awareness of where we are going with our products and services make a difference for the users. Going back to the R2O2R and the difficult research questions, the European business model is that a ton of research, including basic research, is done with the operational model. It not only helps to accelerate the R2O2R process but the O2R component of it may actually lead to some research breakthroughs so it is really important to not forget how the O can help the R. This is important to consider in the new R2O2R quad-agency MOU and take advantage of this in the SWAG because it opens up a lot of possibilities. The last thing he noted is his learning experience with the private sector is government operations need to be clear in what they say they are going to do and what it is not going to do. Once that is clarified, good things happen. One of them is the growth in the services and the creation of jobs in the private sector. That is an important step and it took a while for terrestrial weather to learn that.

Comments from Dr. Tamara Dickinson: She thanked Dr. Louis Uccellini and agreed with him about Bill Murtagh's efforts to stand up SWORM and being the recommended go-to person for all things space weather and for playing a key role in the White House initiatives.

**12:00 - 12:30 PM, BREAK 22423**

**12:30 - 1:40 PM, Committee Discussion - High-level Tasking (Dr. Tamara Dickinson, SWAG Chair)**

Dr. Tamara Dickinson turned the attention to how the SWAG is to fulfill the PROSWIFT requirement to conduct a user survey. She asked the questions: How do we build on the Abt

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Associates User Survey and other information already in the public sector? Do we build an actual survey, and if so, who does it? She acknowledged this is very difficult to do and need to consider question design so the responses are meaningful. Or can SWAG experts conduct an internal review in their respective community and then use that as our survey. Other things to address are what sectors should be included in the survey? The Abt Associates report only used 5 but there are other important ones missing. Other sectors to consider are human space flight, drilling and surveying, national security, and the research community. Are there issues that weren't covered in the Abt Survey in the questions they asked? They talked to 5 people, is that enough to get a good representation of the sector? Do we need to get input from more users in each sector? In some sectors. (ie that may be enough for some sectors and not for others). If so, how many is enough?

She reminded the group that the user survey must address the requirements in the PROSWIFT Act. She asked if there were other people we should have speak at a meeting? General people not sector specific people.

Then Dr. Tamara Dickinson opened the floor for discussion.

Question/Comment from Dr. Delores Knipp: In regard to upper atmospheric expansion, she wanted to know if space traffic management (STM) is within the satellite category or if it needs to be in a separate category of its own.

Response from Dr. Tamara Dickinson: she does not have a strong view one way or the other.

Response from Bill Murtagh: he does agree it should be a separate category.

Follow up from Dr. Delores Knipp: she is satisfied with that comment

Question/Comment from Dr. Kent Tobiska: he agrees with Dr. Delores Knipp and thinks upper atmospheric expansion tied to STM is a big issue these days. Over the next 2 years there will be a doubling/tripling of the number of objects in low-Earth orbit that are right at or right above the Space Station altitude. Another thing he mentioned was the Abt Associates report is a really nice start and appreciates that effort was done with the limitations already being pointed out. Rob Steenburgh mentioned it was very SWPC specific and did not go out to the other sectors to identify what is being created and what are the issues there. In a survey they do in whatever form it takes, the SWAG should include those other sectors more broadly.

Question/Comment from Dr. Bishop: She asked about the timeline for the survey because this will inform whether or not we should do an actual survey or an internal team effort. For the sectors, whereas the Electric Power Grid, aviation, emergency management, and satellite she agrees are very concise focused, the GNSS makes up a lot of other specific sectors or applications that have needs such as oil and drilling, finance for precise timing and precision ag, as well as autonomous cars. Each one has a slightly different take on space weather impacts based on their technology so she encourages maybe splitting this up into maybe navigation versus timing, with acknowledging the power grid on the timing. She leans more towards the SWAG experts doing an internal review due to timing constraints.

Follow up from Dr. Tamara Dickinson: as far as timing goes, the initial thought was to be done in the August time frame. Congress does not mandate when this has to be done, it mandates when



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it has to start so we do have some flexibility so it depends on what this group would like to accomplish.

Question/Comment from Dr. Tamas Gombosi: On the sectors, is space debris part of our purview?

Follow up from Dr. Jennifer Meehan: It could be included in Space Situational Awareness but it is up to the group to decide.

Follow up from Dr. Tamas Gombosi: Wanted to ask because it is another large area of concern. He then asked if the communication sector was a separate sector or part of something else? Because it is not only satellite communications but all kinds of communication like HF for aviation. He also noted if we want a meaningful survey, we need professional help with designing the questions. He mentioned at Michigan they have the institute of social research which invented open ended surveys. He also asked if we have funding to hire a professional because does not think we can do it alone.

Follow up from Dr. Jennifer Meehan: Funding for the SWAG was included in the President's FY22 budget but we are waiting for it to pass Congress.

Follow up from Dr. Tamara Dickinson: This is why she asked Jen Sprague to rejoin the group after lunch.

Follow up from Jen Sprague: It is always fun to go with the internal review approach but it is like the fox watching the hen house, you don't always ask the same questions in the same manner so results are not clear. She agrees with Dr. Tamas Gombosi and thinks a statement of work be drafted and let the professionals come in and tell you the method to approach it. Because this is a multi-agency effort, she thinks it would be wise to have a professional to help triangulate the finds and compare user needs in certain areas for certain entities. She feels this approach will give a better product if there is funding to do it. She is on standby to be helpful. Be intention, systematic, and thoughtful on the front end of this given it will need to be updated no less than every 3 years.

Follow up from Dr. Tamara Dickinson: She asked about the potential timeline for taking this approach.

Follow up from Jen Sprague: She estimates 1 year to 18 months. Be clear in the statement of work of the need, the gap, and the survey goal.

Question/Comment from Dr. Seth Jonas: He appreciates the logic model to help motivate where the SWAG needs to go for the survey. He pointed out that while they might not be mutually exclusive designing the questions and conducting the survey, doing it internally may not meet the mail. He does not feel the SWAG expertise covers the other sectors identified thus far.

Follow up from Dr. Jennifer Meehan: Dr Jonas raises a very good point but reminded the group that PROSWIFT Act directs the SWAG to coordinate with the SWORM so they could tap into that expertise as well.

Question/Comment from Craig Fugate: He circled back to GPS/timing signals acknowledging the huge vulnerability that very little people get to. Identifies a way to determine who needs to be

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surveyed. Go through the consequences of extreme space weather and who gets impacted by that then reach out to those trade organizations and ask if they even know their vulnerabilities to space weather. He proposes before getting into groups using our known space weather users, go back to what are the consequences of extreme space weather events, who is impacted and reach out to those trade organizations and start asking questions. That will build the user group and in some cases they may not even know about space weather. If you say timing signals will be disrupted and you have a single point of failure in GPS timing signals what is your backup plan? That would be a way to expand the user base and ensure we are not missing something. The second thing he mentioned is sending the Emergency Managers a survey is a waste of time. The responses will be based on the sophistication of the person you are asking the questions to - you can ask Emergency managers about weather and some are meteorologists and some turn to the weather channel and think they can do forecasting. He thinks that some of these groups where there is not a certain level of understanding he would look at user groups. He would reach out to these organizations, have a focus group with a facilitated discussion then ask the questions because until people understand what the consequences are, asking the questions without a scenario will not give you much.

Follow up from Dr. Tamara Dickinson: Jen Sprague, do we need to do that same thing for each sector given what Craig just mentioned we might need to facilitate getting the information in different ways for different sectors. Does that do something to the results?

Follow up from Jen Sprague: This is why you want to have the professionals because they can triangulate the results from the different surveys. Craig has great points; education may need to go with the questions for emergency managers.

Question/Comment from Dr. Heather Elliott: She thinks there are users the SWAG may not be aware of when it comes to automation of farming equipment and self driving cars. For emergency managers, what are the back up systems used for communications? If you have a hurricane hit at low latitude, the backup might respond to daily disturbances in the ionosphere and not work as well. Someone else brought up earlier the scenario approach, an example being emergency management, so maybe the questions should involve scenarios of what if you lose this resource, then what are you going to do?

Question/Comment from Dr. Scott McIntosh: Heading down Craigs path, some of these providers may not be aware of their points of failure? If you organize the survey around the points of failure versus the sectors you might receive better output because you have a better crosscut of the data. What are the things that are going to impact you? Is it GNSS, or some element of the system they rely on heavily? So if that is impacted, is it cascading? Rather than sector by sector, go by what their vulnerabilities are.

Question/Comment from Dr. Rebecca Bishop: In the proposal there was mention of the Space Environment Engineering and Science Application Workshop (SEESAW) which she helped organize back in June focused on precision agriculture and ionospheric effects. A public report will be available in January based on the findings. One of the things that came out of the workshop was that there was not a good way to report outages in GNSS for SWPC. One of things that also came out is there is an infrastructure with the Coast Guard that allows users to report GPS outages then they review it and assign whether it was space weather or not. Need to include assets like those that are available across the government that NOAA can take advantage over. For this example, maybe SWPC can include the Coast Guard link and if they are willing to share

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their reports/assessments or vice a versa. In regard to education/communication, even if we do not send surveys to everyone, she thinks it would be really helpful if they start advertising their group and what they are doing in some of these other application newsletters for example, precision agriculture has a monthly newsletter that goes out and sometimes mentions the ionosphere. Or we can say, "hey look here is an asset or resource that you can use". There are similar things for railroads. Might be useful to do this as the SWAG goes through the survey process to get more exposure and develop more contacts.

Question/Comment from Dr. Tamas Gombosi: Would like to suggest medical devices as another sector. He gave the example of pacemakers seeing impacts due to space weather. Separately, he would like clarification of what we mean by an extreme event, is it a Carrington event or an EMP event? The term "extreme event" is being used but the context is not defined.

Follow up from Dr. Tamara Dickinson: Referenced the benchmarks and suggested Dr. Seth Jonas could speak to it. And also mentioned it would be something this group would need to decide.

Question/Comment from Dr. Nicole Duncan: Thinks it is important for the work the SWAG will do for the individuals surveyed to be anonymous and for it to remain so in perpetuity. She understands the reasons why it is important to know who is being surveyed given responses may be wide ranging as Dr. Jennifer Gannon mentioned earlier and thinks we should cover as many axes as possible to get a good sample population. She would like to know if we do this professionally, if this is possible or will the SWAG have to do it themselves?

Question/Comment from Dr. Tamara Dickinson: She noted she would appreciate hearing from Mike Stills the aviation perspective on this discussion and asked if he had any comments he would like to make.

Question/Comment from Mike Stills: He thinks a survey can be very swift and targeted within the aviation community given it is highly regulated and has contacts and insight into who should be provided the survey. He thinks as far as polar routes, there are only 3-4 US based operators, but knows one in particular airline is training operators on space weather. Suggests also targeting international carriers that fly polar routes. Just about every airline has moved into safety risk assessments and how to mitigate. He saw in the chat a comment about high radiation levels at high latitudes, radio bursts as well. It depends on the aircraft and what they are equipped with. United for example, flies long range and had multiple assets available to them and there was some limited testing. Never saw impacts to navigation equipment but HF was impacted. Never saw impacts from Iridium and if you are below 82 N you never saw any direct impacts from Inmarsat comm. These are still things being looked at. A lot of crews ask the question of "well what happens to me if I am flying over the pole during an S5 event (solar radiation storm)." He doesn't know if we will ever get an empirical answer to that because if equated to flying through an ash cloud, an airliner will never fly intentionally through an ash cloud just to see what would happen. The goal is to mitigate so the airlines are not put in those situations.

Question/Comment from Dr. Tamara Dickinson: In determining a path forward, she pointed out a few upcoming meetings in the near future the group might be able to meet to determine next steps. Possibly a hybrid meeting at the American Meteorological Society meeting in Houston, TX January 2022 or the Monday of Space Weather Workshop in April. Given the discussion, she does not think completing the survey by August is a reasonable goal. She addressed a comment

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in the chat, noting we have 180 days to start the survey, not complete it. Keep in mind, like the first National Space Weather Strategy and Action Plan, it was not perfect but it was a start. The second Strategy and Action plan was able to build on it. She suggested that this survey does not need to be perfect but be good enough to build on as the SWAG moves forward.

Question/Comment from Dr. Heather Elliott: From previous experience for the Space Weather Workshop, a lot of attendees are from the military and the space industry and isn't sure the SWAG would see the breath of end users attend.

Follow up from Bill Murtagh: At the Space Weather Workshop, there are targeted activities and gave the example of 2 years ago when they hosted the aviation community. If the group would like to do as Dr. Tamara Dickinson has suggested at the workshop you can be sure they could organize several panels with the appropriate representation from the various sectors as they are always willing.

Follow up from Mike Stills: He seconded what Bill Murtagh said and noted carriers are aware of the impending solar max. Given the opportunity, the major airlines would attend to ensure they are well prepared. There is very much a need for education.

Follow up from Bill Murtagh: Agree with Mike and it is not just the carriers, there are the ground controls planning to have a side meeting already here so he is confident all the right people will be in attendance.

Question/Comment from Dr. Tamara Dickinson: At the Space Weather Workshop could you do something along the lines of Craig Fugate mentioned - scenarios or points of failures in a general sense?

Question/Comment from Dr. Tamas Gombosi: Does not think the American Meteorological Society is a good venue but thinks the Space Weather Workshop would be a perfect venue and is very broad which includes government, science, and industry.

Follow up from Dr. Tamara Dickinson: Just to clarify the SWAG could use the American Meteorological Society as a means to plan for the Space Weather Workshop.

Follow up from Craig Fugate: He thinks FEMA may partner and do some invitational travel to attend Space Weather Workshop if you set it up as a user group to talk about products and get feedback plus it is local to FEMA region 8 where they were tasked to be the space weather subject matter experts. He likes that idea and suggests reaching out to FEMA to get a working group with state and local emergency managers.

Question/Comment from Dr. Nicole Duncan: For the Space Weather Workshop, she does not think we will get a great cross section of attendance from the satellite operators or manufactures. She suggests the SWAG come up with a model approach to reach the user base and deploy it at a couple conferences.

Question/Comment from Dr. Heather Elliott: Thinks the SWAG should advertise what they are doing ahead and the American Meteorological Society with the impacts/point of failure approach because even though there will not be many space weather focused meetings, individuals from

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other natural disasters will be in attendance and might heighten the awareness then might volunteer to participate in the survey.

Question/Comment from Dr. George Ho: Agrees with Craig and Jennifer Sprague and thinks we should organize around focus groups and agrees organizing around the Space Weather Workshop is feasible.

Question/Comment from Dr. Tamara Dickinson: Is it the sense of this group that we should hire a professional to conduct this user survey?

Follow up from the group: Many heads shake yes and Dr. Tamas Gombosi verbally said yes and Dr. Seth Jonas said he is fine with that direction.

Question/Comment from Dr. Tamara Dickinson: She said if that is the sense of the group, would like to think of ways we can use the two conferences moving forward.

Question/Comment from Dr. Conrad Lautenbacher: He plans to attend the American Meteorological Society but thinks the SWAG needs to advertise their efforts across the country via newsletters or boards to build interest in their activities.

Question/Comment from Dr. Nicole Duncan: Thinks the Space Weather Workshop is a great place to brainstorm what the SWAG wants to include in the survey. Perhaps the SWAG can crowdsource information too. Thinks the SWAG should include the community in the question development with early input to ensure survey success.

Question/Comment from Dr. Tamas Gombosi: He agrees with Dr. Nicole Duncan, assuming best case scenario and Congress passes the FY22 budget, by the Space Weather Workshop we should have a contractor who will handle the survey and the Space Weather Workshop is a great opportunity to show the community the questions to get feedback because we need buy-in.

Question/Comment from Dr. Rebecca Bishop: She suggested the SWAG identify the sectors they should focus on and maybe they are not included in the Abt Associates report. Those that were not included and those that do not normally send representatives to the Space Weather Workshop, the SWAG should extend an invite so there is participation to review some of the survey ideas with the different sectors to get feedback.

Dr. Tamara Dickinson then moved to assign sector groups and leads of each.

Question/Comment from Dr. Conrad Lautenbacher: He feels the SWAG needs to get the word of space weather impacts out to the community because of how severe the threat can be instead of talking among ourselves.

Follow up from Dr. Tamara Dickinson: She noted the plan moving forward is to get others engaged but for today's meeting the SWAG needs to understand the task ahead.

Question/Comment from Dr. Heather Elliott: In regard to the Abt Associates report, she mentioned she was shocked to read the aviation community is relying on single frequency GPS receivers. She said this is something the SWAG can address now - educating this community on their vulnerabilities.

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Question/Comment from Mike Stills: Thinks A4A can be leveraged for the survey and may be one of the easier sectors to tackle for the overall survey. Not sure if GNSS or other sectors have similar groups?

Question/Comment from Dr. Seth Jonas: He pointed out that the proposed sectors are a mix of technologies, single systems, and broad areas that are very composite and heterogeneous and filled with many things. He does not know if it is useful to break these down or find a way to combine them or if this is the way it should look. For example, GNSS is a technology, satellites include GNSS and additional things. Sectors as it stands are not well defined and would like to know if this is a problem or if it will lead to a useful survey approach.

Question/Comment from Dr. Delores Knipp: She wanted to know if the SWAG has a sense if we need to engage the large constellations and whether or not they have to maintain "pointing" while communicating. This could possibly be included in Space Situational Awareness.

Dr. Tamara Dickinson then moved again to assign sector groups and leads of each.

Dr. Kent Tobiska volunteered Dr. Delores Knipp to lead the SSA/STM sector. She agreed.

Question/Comment from Dr. Scott McIntosh: Circling back to SSA/STM comment from Dr. Knipp, he mentioned he has been in contact with this community and they are very interested in data buy back and has some very important instrumentation that could be used by the community. Thinks this community could be eye opening in exploiting the commercial sector but notes there will be a cost associated with it.

Dr. Rebecca Bishop is willing to take on the Radio Frequency Application and help Dr. Knipp on SSA/STM.

Craig Fugate is willing to help Radio Frequency Application with Ham Radio.

Mike Stills is willing to help Radio Frequency Application with HF (notes it is not used much but is still the standard, Craig says HF is used during disaster response as a backup)

Dr. Heather Elliott sought clarification for satellite sector and noted she might have some ideas of where she might be able to contribute best.

**1:40 - 1:50 PM, Public Comment Period (Dr. Jennifer Meehan, SWAG DFO)**

Question/Comment from George Baker, retired National Security Council, is pleased with the SWAG and thanks the group for stepping up to address the difficult problems ahead. He suggested there needs to be attention to the communication sector, the long-haul carrier sector saying there have been problems with solar storms in the past such as the L4 cable that went through Illinois and Iowa some years ago. And as pointed out Dr. Tamas Gombosi made a good point about the environments to use, people need to identify what level the fields can reach in order to do their system affects assessments. Finally, suggests not to neglect the late time component of the high altitude for EMP because they are similar in characteristics in the GMD field and would be good to do those together. In the EMP community they are trying to take into account the GMD solar weather wave forms when they protect against EMP so it would be good to combine those.

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Response from Dr. Tamas Gombosi: a few years ago, he was a lead author on a paper titled anthropogenic space weather, which basically discussed the relationship between space weather and EMP.

Question/Comment from Alexei Pevtsov, National Solar Observatory, question is in reference to the data required for space weather forecasting. Early slides showed observations are part of the committee discussion but did not hear anything yet about what is needed and who will provide this data. He thinks these are important questions because data does not come for free, someone has to pay for that.

No response from the committee.

Question/Comment from Jonnie Becker, Des Moines Public School Iowa, she informed the committee she had a group of scholars tuning into the meeting and the group would like to know what would cause an EMP and what might be some impacts and mitigation strategies.

Response from Dr. Seth Jonas: The Coronal Mass Ejection is the portion of space weather that people are generally concerned about when it comes to a naturally driven electromagnetic pulse that would cause a geomagnetic disturbance that will drive induced currents and other things on and around Earth. Mitigation strategies - we need to know what technology, what infrastructure we are talking about. To some extent it will be dependent on that. One that is talked about a lot is the Electric Power Grid. Mark Olson is a member here and can speak to great detail about that but would say there are multiple strategies to mitigate. One of them is forecasting and predicting, knowing when something is coming and knowing the extent to which an impact will happen is very important to enable preparation. Also, to enable installation of engineering solutions and develop those engineering solutions before they are deployed. Understanding the severity of these events and where those events could happen and how it will affect technology is a fundamental thing we need to understand. And using that information to build in engineering solutions like a device that could mitigate, attenuate, or reduce the effect of space weather is one approach. Another approach is an operational approach. You might take actions that reduce the reliance on the piece of technology that might be affected for the duration of that space weather event. An example of the Electric Power Grid you could temporarily reduce the amount of load that is being transmitted and generated in a particular area and can compensate for that by purchasing and acquiring transmission and power from other areas to meet the overall demand. So you can take operational approaches or you can take engineering approaches that are widgets you would put into your system. All of this is predicated on having good, confident, and useful forecasting and prediction capabilities and that is why we are all here.

Response from Dr. Tamas Gombosi: EMP stands for electromagnetic pulse and the name goes back to wars where atomic bombs generated EMP and it was aimed at paralyzing the enemies' critical infrastructure. The Soviet Union and the United States experimented with EMPs before high altitude nuclear explosions were banned by the treaty. If you are interested in the connection between EMPs and space weather he offered up his email.

Dr. Jennifer Meehan read a comment in the chat from Art Charo, National Academy of Sciences. Before reading the question she reminded the group that the PROSWIFT Act established a National Academy Space Weather Roundtable in addition to the SWAG. Art asked where do we

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see the niche for SWAG among the government space weather advisory bodies, what do you see as the role of the space weather Roundtable?

Response from Dr. Tamara Dickinson: In my personal opinion, it will be important for all of these groups to work together so we duplicate each other or compete with each other but are adding to the betterment of the space weather enterprise as a whole. In her personal opinion. There are plenty of issues to work on among the groups and good coordination is key. As chair of the SWAG she is there to coordinate in any way she can. She sees the role of the SWAG similar to the Heliophysics committee at NASA where it is quick turn advice. In this case it will be quick turn advice to the interagency as a whole. The CSSP is starting the new decadal and that is the most important document coming in the near future and the whole community is looking forward to that. So the long term guidance from the Space Studies Board is essential and it will be very interesting to see how much the space weather community has grown in the last decade. She thinks the CSSP and Roundtable are better for convening large workshops and going more in depth with studies than the SWAG will be able to do. She challenges the Space Weather Roundtable to model previous Roundtables such as the Disaster Roundtable or the Resilient America Roundtable which have done a lot of excellent work with boots on the ground. They have gotten in there with local communities and industries and found creative ways to look at the issues and how those industries and communities address those issues. Like Craig Fugate said, Emergency Managers need to know what really could happen to them. This is something the Roundtable can dive in to and do some boots on the groundwork.

**1:50 - 2:00 PM, Closing Remarks (Dr. Tamara Dickinson, SWAG Chair)**

In her closing remarks she noted how It is gratifying that both the White House and Congress are in lockstep agreement that it will be the policy of the United States to prepare and protect against the social and economic impacts of space weather, and to do so, the Federal Government must engage with all sectors of the space weather community. The Space Weather Advisory Group will play a key role in achieving the objective to build a space-weather-ready Nation.

She thanked all the speakers and the committee members for their willingness to commit their time and expertise to serving on this important advisory group.

She also thanked the SWORM members who were able to attend. She also thanked Dr. Jennifer Meehan for keeping the SWAG in line today and for her excellent behind the scene and not so behind the scene help.

Finally, she thanked the public for attending the meeting.

**2:00 PM, Meeting adjourned.**

**Minutes Certification**



Tamara Dickinson, SWAG Chair

April 7, 2022

Date