

Space Weather Advisory Group (SWAG)

Virtual Public Meeting

Meeting Minutes

Thursday, March 17, 2022

10:00 AM – 2:00 PM

Meeting Attendees

Committee

Nongovernmental End User Representatives

Dr. Tamara Dickinson, Committee Chair, Science Matters Consulting

Mr. Mark Olson, North American Electric Reliability Corporation

Mr. Michael Stills, United Airlines (retired)

Mr. Craig Fugate, One Concern

Dr. Rebecca Bishop, Aerospace Corp.

Commercial Sector Representatives

Dr. Jennifer Gannon, Computational Physics, Inc.

Dr. Conrad Lautenbacher, GeoOptics, Inc.

Dr. Seth Jonas, Lockheed Martin

Dr. W. Kent Tobiska, Space Environment Technologies

Dr. Nicole Duncan, Ball Aerospace

Academic Community Representatives

Dr. Tamas Gombosi, University of Michigan, Ann Arbor

Dr. Delores Knipp, University of Colorado, Boulder

Dr. Scott McIntosh, National Centers for Atmospheric Research

Dr. Heather Elliott, Southwest Research Institute

Dr. George Ho, 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

Mr. Bill Murtagh, NOAA

Dr. Elsayed Talaat, NOAA

Ms. Jenn Sprague, National Weather Service

Mr. James Platt, DHS

Meeting Minutes

10:00-10:02: Welcome (Dr. Jennifer Meehan, SWAG DFO)

Dr. Meehan welcomed everyone to the second Space Weather Advisory Group (SWAG) meeting, in which they continued discussion on how best to implement Section 60601 of the Promoting Research and Observations of Space Weather to Improve the Forecasting of Tomorrow (PROSWIFT) Act.

Dr. Meehan provided a brief review of the PROSWIFT Act, which directs the National Oceanic and Atmospheric Administration (NOAA) to establish the SWAG to advise the White House Space Weather Operations Research and Mitigation (SWORM) Subcommittee. All 15 non-governmental representatives of the SWAG were appointed by the SWORM Interagency Working Group with three-year terms. The PROSWIFT Act directed SWAG members to receive advice from the academic community, the commercial space weather sector, and space weather end users that would inform the interests and work of the SWORM.

10:02-10:10: Opening Remarks and Recap of Meeting 1 (Dr. Tamara Dickinson, SWAG Chair)

Dr. Dickinson gave a quick overview of what was discussed at the December 1, 2021 meeting. There was a round of introductions and discussion of the charter; a briefing from the SWORM co-chairs, a briefing on the Abt Associates report; discussion on how to proceed with the user needs survey, including potential sectors and survey methods; and a public comment session.

Dr. Dickinson reminded members that Dr. Meehan had sent them a draft copy of the minutes from the first meeting. No members reported any major issues. Members were asked to submit minor edits to Dr. Meehan. Dr. Knipp moved to approve the minutes with any changes that might come in. The motion was seconded and passed without opposition.

This meeting's agenda would center around the user needs survey. There would also be an update from the SWORM. On the second day, members would discuss possible scenarios, timing, and next steps for the survey, and there would be an opportunity for public comment, followed by a session devoted to related activities, and a committee brainstorming roundtable.

The group had a brief introduction, with members stating their names and institutions.

10:10-10:50: User Survey Discussion – Process (Dr. Tamara Dickinson, SWAG Chair)

The PROSWIFT Act directed SWAG to conduct a comprehensive survey of user needs to identify research, observations, forecasting, prediction, and modeling advances required to improve space weather products. There were six requirements for the user survey:

- (1) Assess the adequacy of federal government goals for lead time, accuracy, et cetera
- (2) Identify options and methods to advance the above goals
- (3) Identify opportunities for the collection of data to address the needs of space weather users
- (4) Identify methods to increase coordination of R2O2R
- (5) Identify opportunities for new technologies, research, and instrumentation to aid in understanding, monitoring, modeling, prediction, and warning of space weather
- (6) Identify methods and technologies to improve preparedness for space weather

Based on one-on-one discussions with SWAG members, Dr. Dickinson proposed the following process: use one or more space weather scenarios to illustrate impacts; use a set of common questions developed by SWAG in collaboration with the National Weather Service (NWS) Social, Behavioral, and Economic Program and reviewed by SWORM, possibly with additional sector-specific questions; define sectors, dividing the SWAG into sector-specific subgroups, possibly doing a pilot on one or two sectors; develop sector-specific plans; and assimilate the results into one or more products. Dr. Dickinson provided this basic concept to the SWORM for feedback. She asked what sectors should be surveyed, when the results would be most useful, and how the SWAG user needs survey would complement ongoing or completed work.

Dr. El Talaat presented on SWORM's response.

SWAG Question: Should space weather event scenarios be used? Should the survey consist of a common set of questions developed by SWAG members in collaboration with survey experts?

SWORM Response:

- Agree with the process proposed
- Suggest developing a core set of questions to ask each sector, building off of the questions used in the Abt Associates report
- Add additional tailored questions appropriate for different sectors, such as a scenario-type approach for the emergency management community
- NOAA had scenarios that could be shared with SWAG, which could be a good opportunity for entrepreneurial startups that were not aware of space weather impacts

SWAG Question: What sectors should be surveyed? Should there be a pilot user needs survey for a sector or two before rolling it out to more sectors? Should only high-priority or under-surveyed sectors be addressed first in the survey?

SWORM Response:

- First focus on sectors not addressed in the recent Abt Associates report, particularly for space situational awareness and national security impacts. The primary concern was the effect on military installations and overall operations.
- Next reassess the sectors addressed in the Abt Associates report, reaffirming and segmenting the sectors, identifying any new scope or evolution in those sectors that needed further evaluation
- Call for comments by the public. There could be sectors that needed to be engaged but had not been.
- Then make a list of the sectors that could be re-surveyed with additional scope or new sectors to be surveyed and allow the SWORM to prioritize those sectors. The sectors could be prioritized by impact. It was necessary to understand the interrelationships of each sector, particularly for national critical functions.
- For the better known sectors, the SWAG could focus on determining if improved forecasting would aid in resilience and if so, define how.
- As an alternative, the SWAG survey could be centered on the most recent major storms and identifying what was impacted. There was a plan in place that required all power companies be prepared to mitigate a 100-year storm by 2028.
- When conducting the survey, SWAG should engage with the various sectors during meetings, conferences, or via email to communicate the value of the survey for their sector

- Entities SWORM was most concerned with might not be engaged with the space weather enterprise or realize their vulnerabilities to space weather. SWAG should think about how to ask targeted questions, how to interface with less commonly known users, and how to utilize professional societies for outreach.
- Leverage the DHS Critical Infrastructure Partnership Advisory Council for feedback on questions, et cetera

SWAG Question: When would the results be most useful to the SWORM? Should the results be released sector by sector, or when the report was finalized?

SWORM Response: Would appreciate the chance to review the results sector by sector.

SWAG Question: How would the SWAG user needs survey complement or build upon other work, completed or underway now?

SWORM Response: The SWAG user needs survey should identify any missing elements or changing needs from those assessed by the Abt Associates report rather than duplicate the effort.

Dr. Knipp asked if SWAG should modify its survey questions to address the plan requiring power companies to prepare for a 100-year storm. Mr. Platt suggested one of the questions could be whether a 100-year storm was the best benchmark to use. Mr. Olson pointed out that power grid users were involved with the Abt survey, and added that he would like to see SWAG build on that. Dr. Knipp asked if there were two forks to preparedness, one having to do with electromagnetic pulse (EMP), the other with geomagnetic disturbance. Mr. Olson replied that the standards being discussed mostly had to do with space weather, and that the power grid did not have a standard for weaponized events like EMPs. Mr. Platt added that the two types of events were completely different, with unique sets of mitigation strategies.

Dr. Gombosi suggested that SWAG consider coincident scenarios when drafting survey questions, not just the magnitudes of events. Dr. Dickinson agreed that was a good point.

Dr. Bishop asked if involvement with Department of Defense (DoD) was something SWAG should consider as part of its charter. Dr. Meehan said she would double check, but did not believe SWAG's charter constrained it to just civil applications. There was also the question of how much SWAG could do in the unclassified realm. Mr. Allen said he did not have information to answer Dr. Bishop's question fully, but that DoD's mission was global in scope. Dr. Talaat added that DoD was a significant part of SWORM, which SWAG advised. Dr. Meehan confirmed that there was nothing in SWAG's charter precluding it from military applications.

Dr. Bishop commented that when defining scenarios from a space weather perspective, it was necessary to translate it using the jargon and parameters of a specific sector. Dr. Dickinson agreed.

Dr. Elliott cautioned about the danger of making survey questions too open-ended on the one hand and too leading on the other. Dr. Dickinson said the next session would actually focus on a common set of questions, with Ms. Sprague providing concrete examples of good and not-so-good questions.

Dr. Elliott noted that some of the recommendations in the report were currently actionable. Dr. Dickinson pointed out that the Space Weather Prediction Center (SWPC) had in fact taken action on many of them. Mr. Murtagh confirmed that SWPC had looked at the recommendations, and there had been some modifications, but there was still a lot left to act on.

Dr. Ho said that Applied Physics Laboratory (APL) had recently conducted some scenario exercises, and he had found them helpful, but that setup took a while, and it was important to illustrate the effects on each sector. Dr. Dickinson said Mr. Murtagh would present a couple scenarios to the group later on in the meeting.

Dr. Duncan asked if there was any consensus on what type of information in the Abt report was most useful. Dr. Talaat suggested that SWPC be the first to answer that question. Mr. Murtagh said there was a lot of useful information in the report that SWPC had taken under consideration, but there were a few areas that it would like to hear more on. Dr. Talaat said the most useful thing to him was the product improvements that the different sectors identified, and how that translated into different or enhanced observations.

Dr. Jonas asked how SWORM envisioned SWAG going through the user survey to the identification of needs, whether it was SWORM or SWAG that did the analysis. Dr. Dickinson said she believed it was the SWAG's role to provide advice, which the SWORM could then take or leave. Dr. Talaat added that there were action working groups in the SWORM that would take SWAG's advice and work it through implementation recommendations for the interagency group to do. Dr. Dickinson added that Dr. Meehan would provide a briefing on SWORM and its activities.

Dr. Dickinson said she had not heard any issues with following the process she had proposed. It was moved that SWAG accept it as the overarching process. The motion was seconded and passed without opposition.

10:50-11:15: User Survey Discussion - Common Set of Questions (Ms. Jenn Sprague, NWS Social, Behavioral, and Economic Program)

Ms. Sprague gave an overview of the Paperwork Reduction Act (PRA), which was enacted to minimize the paperwork burden for individuals, small businesses, educational and nonprofit institutions, contractors, state and local governments, and other persons resulting from the collection of information. The Office of Management and Budget (OMB) oversaw PRA and approved all information collection requests. The PRA applied to any request that obtained, solicited, or required disclosure of facts or opinions by 10 or more persons within a year, or included both voluntary and mandatory collections, data collections conducted under cooperative agreements or federal contracts, those conducted at the request of the agency or as part of the terms and conditions of the grant, or from federal employees outside their duties. The PRA process ensured the greatest possible public benefit from and maximized the utility of information, improved the quality and use of federal information, minimized costs to the federal government, and ensured the integrity, quality, and utility of the federal statistical system. The PRA required agencies to go through public notice and comment and receive approval from OMB before information was collected. The length of the process varied, but it generally took four to six months. Clearance was good for three years.

Dr. Valerie Were, a Social and Behavioral Science Program Analyst with the Cooperative Institute for Research in the Atmosphere (CIRA), presented on survey development basics. The first step was to define a clear goal, avoiding unnecessary and insignificant questions. The next thing to consider was the delivery method, such as web, telephone, or face-to-face interview. The last thing to consider was sample size. Dr. Were recommended prioritizing representation over large sample size. The appropriate question length depended on the type of question, but generally shorter ones yielded better response rates. Dr. Were suggested 20-25 questions that could be

answered in 10 minutes, and using questions that allowed for year-to-year comparisons. The wording should be kept simple. The more important questions should be closer to the front, but the order should be logical and sequential. Question format was also important. Closed-ended questions were easier to answer and analyze than open-ended ones. Once the survey was formulated, it needed to be tested. Survey questions should avoid leading, assuming the respondent's habits or perceptions, asking more than one thing, jargon, double negatives, and overlapping answer options. Dr. Were presented a list of bad questions and better alternatives.

Dr. Dickinson asked if different sectors could do the survey in different ways. Ms. Sprague said they could, but it was important to collect all the relevant information. Dr. Were added that the group could have a focus group with one sector the first year and if it worked, expand it to other sectors in subsequent years.

Dr. Elliott cautioned that some space weather scenarios might not be helpful if the end user did not understand them. Dr. Dickinson said the group might use scenarios with some sectors, but she did not feel that it had to use them. Mr. Murtagh insisted that there was value in scenarios and understanding how the end user would respond. Dr. Elliott asked if the scenarios were being tied to outages of different quantities and resources. Mr. Murtagh said the scenarios provided the context for people to fully understand what space weather meant to them. It was necessary to know when the end users needed what kind of information to make the most effective decisions.

Dr. Were urged the group not to focus on culling everything immediately. The first step was to formulate questions, and it could finesse things from there.

Dr. Duncan stressed the importance of understanding who the stakeholders were, and what kind of information they needed to make decisions. Dr. Dickinson agreed that was a good point and promised to put it in the parking lot.

11:15-12:30: User Survey Discussion - Sectors (Dr. Tamara Dickinson, SWAG Chair)

The group had started this discussion at its first meeting, at which it had proposed the following sectors:

- Electric power grid*
- Satellite*
- Global navigation satellite system (GNSS)*
- Aviation*
- Emergency management*
- SSA/STC
- Radio frequency application (comms and radar)
- Human space flight
- National security
- Research

*Covered in the Abt survey

Dr. Tobiska noted that other modes of transportation besides aviation, such as trains, were susceptible to GPS outages. He suggested a narrow scope the first three years, but possibly broadening it when the survey was up for review. He added that it might be useful to examine DHS' list of critical infrastructure sectors.

Dr. Bishop pointed out that no matter how they defined the sectors, there was a danger of overlap, and that the overlap should be minimized as much as possible. She suggested mapping the survey's categories with those on the DHS list. Dr. McIntosh agreed that was a good idea, and added that putting sub-bullets under the proposed categories might make it easier to see where there was overlap. Dr. Jonas echoed concerns regarding overlap, observing that national security could arguably cover every category on the proposed list. Dr. Bishop felt the list was manageable but that the group should bound what was meant by each sector.

Dr. Gannon said it was unclear how the research sector was defined, that it seemed overly broad. Dr. Dickinson agreed. Dr. Tobiska noted that the sectors addressed in the Abt survey seemed more global in nature, and suggested that the other categories could fit under them. He preferred a simplified list of sectors to an expanded one. Mr. Murtagh felt both GNSS and national security were both too broad. Dr. Dickinson suggested that the subgroups looking at each sector could determine if there were specific areas in a sector that merited greater focus. Dr. Bishop proposed that each group determine the scope of its sector.

Dr. Duncan asked if there had been a comprehensive effort to identify new sectors and if not, whether such an effort would be in SWAG's purview. She feared that generating a list of things SWAG already knew about would be a self-fulfilling prophecy. She suggested polar domain awareness was also a topic worthy of discussion. Dr. Knipp cited health fields and the use of implantable devices as something worth looking at.

Mr. Stills cautioned against defining the sectors too narrowly. Dr. Dickinson said she was getting the sense that the proposed sectors were more or less the right ones. The question was how to package them. The other members did not object to this assessment.

Dr. Elliott noted that new users often did not understand that GPS could be affected by space weather. Dr. Jonas observed that SWPC had a large subscription database, and that it might be possible to categorize those subscribers. Dr. Dickinson said each of the subgroups could work with SWPC to figure out what area(s) to dive into. Mr. Murtagh was intrigued by Dr. Jonas' idea, and offered SWPC's support. Mr. Stills said he felt 10 was a good number of topics, but that it was possible to tweak them to make sure they covered what they needed to. Dr. Dickinson said she was hoping to prioritize the topics. It was possible SWAG only had the bandwidth to focus on some of them.

Dr. Ho thought the proposed list of questions was a good start. He recalled a space weather meeting at FAA where the presenters displayed a chart of everything space weather affected and suggested seeing if that chart was available. Dr. Dickinson said she was not familiar with the chart. Dr. Knipp said she remembered a flow-down diagram in 2008. Dr. Ho said this chart was more recent. Mr. Murtagh said he knew of the chart and could share it with the group. Dr. Dickinson instructed Dr. Meehan to obtain the chart and distribute it to the members.

Dr. Elliott asked how the group would deal with national security, which overlapped with several other categories. Dr. Dickinson suggested that the group working on national security identify which aspect it wanted to address. The various groups would need to coordinate to avoid overlap. Dr. Elliott asked if there was anything related to national security that did not fall into one of the other topics. Dr. Dickinson said she did not think SWAG had figured out what would be included in the national security bucket. Dr. Jonas suggested something similar might be necessary for emergency management. Dr. Dickinson said it would probably be necessary for each category, maybe for some more than others.

Dr. Gombosi asked if EMP was part of national security. Dr. Jonas said everything was. Dr. Dickinson said she did not know if SWAG's charter put it in the EMP realm.

Dr. Bishop moved that SWAG accept the proposed 10 categories with the caveat that each group would specify the scope of each topic. The motion was seconded. Dr. Jonas proposed a second caveat that allowed some to be subsumed into others and for the titles to change slightly through the process of review. Dr. Bishop accepted Dr. Jonas' condition. The motion passed without opposition.

Group membership was agreed to as follows:

- Electric power grid: **Olson**, Gannon, Jonas
- Satellite: **Duncan**, Knipp, Lautenbacher
- GNSS: **Bishop**, Gombosi, Stills, Jonas
- Aviation: **Stills**, Tobiska
- Emergency management: **Fugate**, Jonas
- SSA/STC: **Knipp**, Bishop, Duncan, Tobiska, McIntosh
- Radio frequency application (comms and radar): **Bishop**, Fugate, Stills
- Human space flight: **Tobiska**, Ho, Gannon
- National security: **Jonas**, Ho, Gannon, Elliott
- Research: **McIntosh**, Knipp, Gombosi, Elliott

Dr. Dickinson instructed the group leads to work together on a common set of questions. The chairs of groups focused on topics covered in the Abt report should look at what had changed and what, if anything, SWAG should address in its survey.

12:30-1:00: Break

1:00-1:30: Update from the SWORM (Dr. Jennifer Meehan, SWAG DFO)

Dr. Meehan reminded SWAG that SWORM was organized within the Executive Office of the President of the United States, Office of Science and Technology Policy (OSTP), National Science and Technology Council (NSTC), and the Committee for Homeland and National Security (CHNS). It was led by three co-chairs, one from OSTP, one from DOC, and one from DHS. It had three objectives and two co-leads for each objective. Two of the six co-leads came from DHS, two were from DOC, one was from DoD, and one was from NASA. A partnership among 34 departments, agencies, and offices, its purpose was to coordinate efforts to prepare the nation for space weather events. In 2019, the White House released an updated strategy and action plan and a new executive order coordinating national resilience to electromagnetic pulses. The following year, the PROSWIFT Act codified SWORM into law and directed NOAA to stand up the SWAG to advise the SWORM. SWORM priorities included:

- R202R framework for space weather forecasting
- Space weather event benchmarks
- U.S. space weather scales
- Space weather hazard mapping of the United States
- Observations and forecasting support for human spaceflight
- Space weather observations and modeling to improve space traffic coordination and space situational awareness

- Space weather observations and modeling necessary to maintain safe operations for aviation
- Response, recovery, and operations plans and procedures for space weather events across sectors and stakeholders
- Continuity of an operational satellite mission that provided coronagraph, solar wind, energetic particles, and other measurements essential to space weather forecasting along the sun-earth line, and seek novel space-based observations to further enhance forecasting

Dr. Knipp asked if work on the benchmarks had been completed or if it had been handed back to federal employee scientists to work on further. Dr. Meehan said the benchmarks were currently being assessed. Mr. Murtagh added that there were two key phases, the first of which was complete. Dr. Knipp asked whether work on the benchmarks would lead to a revision of the space weather scales. Mr. Murtagh said they were linked, and both had been identified as priorities.

Dr. Tobiska asked if SWORM had looked at the development of test beds and operational systems to build a redundancy of national capabilities. He also expressed curiosity about the role of international partners. Mr. Murtagh said a lot was happening and a lot had to happen in terms of both bilateral and multilateral cooperation. One of the things SWORM was exploring was the role of the U.N. World Meteorological Organization and International Civil Aviation Organization (ICAO). Several countries had adopted the NOAA space weather scales. Mr. Murtagh said he would be traveling to the U.K. shortly to discuss data sharing opportunities. Dr. Meehan added that SWORM was engaged in conversations with the private sector to hear about their capabilities and innovation. Dr. Talaat said that SWORM was continually updating its situational awareness of what was commercially available. It had issued an RFI for sources of commercial space weather data.

Dr. McIntosh asked about ground-based facilities. Dr. Meehan assured him that they were included.

1:30-1:55: Committee Discussion

Dr. Dickinson pointed out that SWAG was scheduled to brainstorm things it would like to address the following day. She urged members to think about what was covered in the group's charter and where SWAG could provide useful input in terms of SWORM priorities. Since the group had reached consensus on all the topics it had discussed that morning, there was no need to circle back to anything.

Dr. Bishop noted a tendency to emphasize extreme events and stressed the importance of considering day-to-day occurrences as well.

Dr. Knipp commented that there was a lot of parallel activity going on both at the National Academy of Sciences and the individual organizing groups in the various disciplines. She asked how the recommendations of those entities affected SWAG's activities. Dr. Dickinson agreed that there were a lot of ongoing activities with the potential for overlap. She pointed out that Mr. Charo and Mr. Spann were set to discuss those activities with SWAG the following day. Good coordination and collaboration were essential. Dr. Meehan added that she and Dr. Dickinson had attended the first meeting of the NASA Space Weather Council, at which that group had expressed an interest in SWAG's activities. Dr. Dickinson said she would be addressing the Committee on Solar and Space Physics (CSSP) the following week, and it was possible she would

speak at the next Space Weather Council meeting. She added it was unlikely SWAG would be able to host a large workshop with over a hundred attendees, but a lot depended on the budget.

Dr. Gombosi feared an overabundance of advisory groups, each with different recommendations, would confuse policymakers, and felt that significant overlap was necessary. Dr. Dickinson asked if he had any suggestions for what she should be doing. Dr. Gombosi said she was doing it, noting that she had talked with his department chair, who led CSSP. Dr. Dickinson promised to continue reaching out to other groups. Dr. Knipp echoed Dr. Gombosi's concerns. Dr. Meehan pointed out that she and Dr. Dickinson would be addressing the National Academy of Sciences. Dr. Gombosi and Dr. McIntosh expressed worry that space weather was not particularly important to the heliophysics community. Dr. Bishop stressed the need to be careful in writing recommendations, adding that current research often did not directly address end user needs. Dr. Meehan and Dr. Dickinson noted that the language in SWAG's charter was taken directly from the legislation. Dr. McIntosh felt that a systems approach was vital. Mr. Fugate suggested concentrating on how to achieve certain outcomes instead of asking what type of research was possible. Dr. Elliott asked if SWAG could evaluate the recommendations of other groups. Dr. Dickinson said there might be a way to wrap it into a report, but it was not part of SWAG's charge to critique other groups' projects. Dr. Elliott suggested making a recommendation based off another group's recommendations. Dr. Dickinson said they could look into that.

1:55-2:00: Closing Remarks (Dr. Tamara Dickinson, SWAG Chair)

Dr. Dickinson thanked members, presenters, and attendees. Dr. Meehan adjourned the meeting at 1:50 p.m.

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Mr. Bill Murtagh, NOAA
Dr. Elsayed Talaat, NOAA
Dr. James Spann, NASA

Meeting Minutes

10:00-10:02: Welcome (Dr. Jennifer Meehan, SWAG DFO)

Dr. Meehan welcomed SWAG members to Day 2 of the meeting and conducted the roll call. She turned the meeting over to Dr. Dickinson to give her opening remarks.

10:02-10:15: Opening Recap of Day 1 (Dr. Tamara Dickinson, SWAG Chair)

Dr. Dickinson thanked the SWAG and SWORM members for attending Day 2 of the meeting. She gave a quick recap of what occurred on Day 1 then briefly reviewed the agenda for Day 2.

10:15-11:00: User Survey Discussion - Scenario (Mr. Bill Murtagh, NOAA SWPC)

Mr. Murtagh briefed SWAG on a scenario used for a space weather exercise prepared by the FEMA exercise division and their counterparts in Europe. In the scenario, a large, magnetically complex sunspot cluster emerged on February 19-20, producing several major solar flares over the next few days, culminating in a powerful eruption on February 24, measuring R5 on the NOAA space weather scales. The event resulted in the disruption of high frequency (HF) communications, air traffic radar systems, and classified and unclassified DoD systems for tens of minutes to several hours. A powerful and fast coronal mass ejection (CME) was observed soon after the flare and was expected to impact the earth in approximately 20 hours. Ten hours after the flare erupted, radiation storm levels crossed the extreme S5 level. Numerous satellite anomalies were experienced. Great confusion across the aviation community resulted in flight delays and cancellations. An intense geomagnetic storm generated currents that tripped several static compensators, resulting in significant electric power disruptions. Power stations reported numerous transformers out of commission, with projected repairs taking weeks to months. This raised immediate concern of a critical infrastructure collapse with loss of water distribution, sewage disposal, hospital care, phone service, fuel resupply, and more. Most of the interstate rail transport was interrupted.

Dr. Dickinson asked Mr. Murtagh if he foresaw using this one scenario and building out the impacts for the various sectors as needed. Mr. Murtagh said he would be interested in that discussion. He planned to tailor it a little to suit the different groups, but the big picture needed to be contained for everyone to see.

Dr. Bishop expressed concern that SWAG would bias itself by including such an extreme scenario with the survey. She suggested including a second scenario focused on a more common everyday event. She added that she was interested in quantifying what the impacts would be to the individual users. Mr. Murtagh said he was certainly sensitive to the extreme event scenario, but cautioned that people were not always aware of their vulnerabilities.

Dr. McIntosh asked how much of the impact was due to the storm and how much was due to misreading the thermosphere. Mr. Murtagh said the geomagnetic storm was used as a proxy for the heaving, which he admitted was not a great way to go, but he added that a new model was out which should be better.

Dr. Tobiska urged caution on the star link satellite loss scenario because of SpaceX's philosophy of minimum viable product (MVP). He supported Dr. Bishop's suggestion to include a more everyday scenario. He sought more clarity on what SWAG hoped to achieve with the survey. Dr. Dickinson noted Mr. Fugate was one of the leading advocates for a scenario-based survey, and asked him to weigh in. Mr. Fugate said he wanted the group to look into one or more scenarios that would force the user to do something different.

Dr. Elliott said it looked like the scenario was phasing in the problems that would happen in order of how things would progress geophysically through the event. Mr. Murtagh said that was an accurate assessment. She worried about people who did not know they were relying on things that could be affected by space weather. Mr. Murtagh agreed that was a valid point considering how pervasive GPS was in society.

Dr. Bishop stressed the importance of knowing if there were ways to mitigate these impacts. The group did not want to overstate the impacts of space weather on infrastructure and technology systems, but it also did not want to understate them. Mr. Murtagh agreed. Dr. Gannon said a lot of the end users already knew some of the impacts, which could help the SWAG support the mandate to improve space weather products.

Dr. Dickinson asked if there were prepackaged scenarios available, or if SWAG needed to develop them. Mr. Murtagh said there were a number of scenarios of varying intensity freely available to share. Dr. Knipp asked if SWAG wanted to provide the background exclusively in the NOAA storm scales, or if it wanted to provide something more specific, noting that some of the newer users' problems were not aligned with the scales as they currently existed. Mr. Murtagh said the survey could provide something more specific.

Dr. Tobiska suggested evolving a set of recommendations in terms of indices in the different areas after the survey was done. Mr. Murtagh thought this comment was spot on, and added that an initiative on the revision of scales was underway.

Dr. Gombosi agreed with Dr. Bishop's assessment that there should be two scenarios, one extreme and one moderate. It was important to translate the scenario into language the operating engineers understood.

Dr. Dickinson asked for volunteers to work with Mr. Murtagh on creating an everyday scenario. Dr. Gombosi, Dr. Ho, Mr. Olson, and Dr. Elliott offered to serve in this capacity.

Dr. Gannon recalled that the group had discussed keeping the survey under 10 minutes, which would constrain the complexity of the scenarios. Dr. Dickinson pointed out that the 10-minute limit was just a suggestion. Dr. Meehan added that the scenario could just lead into the survey without being a part of it.

Dr. Meehan reminded the group that this was a decisional agenda item. Dr. Dickinson was not sure SWAG could make a decision before seeing the second scenario. Dr. Meehan asked if the group wanted to make a decision to use scenarios. Dr. Dickinson said she thought the group made the decision to use scenarios the previous day. No one disagreed with that assessment.

11:00-11:45: User Survey Discussion - Timing and Next Steps

Dr. Dickinson outlined what SWAG needed to do in the nearer term. She suggested that the sector leads work with her, Dr. Meehan, Ms. Sprague, and Dr. Were to develop a common set of questions by mid-May. The questions would be reviewed by SWORM, and then each section would brief SWAG at its next meeting. For the sectors in the Abt Associates report, the subgroups would review the report, identify any gaps or subsectors needing additional work, develop any sector-specific questions that might be needed, and start to develop the process to do the survey in each sector. For additional sectors, the subgroups would follow a similar process but would first need to define what was in the sector and what, if anything, they wanted to focus on.

The meeting was tentatively scheduled for May 19-20. In addition to the sector briefings, SWAG would also hear from the subgroup tasked with creating the second scenario. Dr. Dickinson hoped to have Abt Associates sector gaps identified, the other sectors defined, and a draft set of questions by April 1. By April 15, the goal was to refine the common set of questions to a reasonable number and draft specific questions for all sectors. A draft of the process to conduct the survey was expected by the end of April. On May 6, SWAG would submit the documents to SWORM for review and comment.

Dr. Meehan had provided share space on the SWAG drive for each sector subgroup. Subgroups were free to meet virtually or electronically. Dr. Dickinson asked them to keep her and Dr. Meehan in the loop. Both were willing to join as many meetings as possible. Dr. Were and Ms. Sprague were available to answer questions.

Dr. Jonas worried that some of the sector-specific questions may need to be drafted before the common set of questions in order to capture the sector's needs. Dr. Dickinson admitted that might be necessary. There would need to be cross-group communication, but she felt it would be easier to break into subgroups than work as one big group. Each subgroup would report back to the full SWAG, so all members would have a chance to weigh in on each topic.

Dr. Duncan wanted to make sure SWAG was meeting every stakeholder's need. Dr. Dickinson asked which stakeholders she was referring to. Dr. Duncan said she meant the people who would receive SWAG's report. Dr. Dickinson said the primary group reviewing the report would be SWORM, followed by Congress. She assured Dr. Duncan that all the SWORM agencies would have a chance to offer their input.

Dr. Gombosi said he was not available on May 19, and he hoped that date was not final. Dr. Knipp expressed concern that the group was moving a little too fast. Dr. Meehan said the date would need to be determined before too long, but it was not set in stone, and if the group needed to adjust its timetable, it could. Dr. Dickinson said this was not the best format for setting dates and asked Dr. Meehan to send out a Google poll. She recommended moving the end part out but otherwise sticking as close to the original timeline as possible to get the group moving. Dr. Knipp said even a week of breathing room would help. Dr. Gombosi said early June would work well for him. Dr. Bishop suggested seeing how far the group got by April 1 and adjusting from there. Dr. Dickinson agreed that might work. Dr. Elliott proposed online edits to expedite SWAG's work. Dr. Dickinson said that was fine for the subgroups, but when SWAG met as a whole it had to be open to the public. Dr. Knipp said she could not meet the April 1 deadline.

The next item on the agenda was a public comment period, which could not begin before its scheduled start time, 11:45. Dr. Dickinson gave SWAG the option of taking a break or circling back to a prior topic. The group chose the former.

11:45-12:00: Public Comments

Dr. Meehan invited members of the public to provide input. Those interested in commenting could click on the raise hand feature and/or type in questions in the chat box. Speakers were limited to two minutes. There were no immediate commenters. While waiting for someone to speak, Dr. Meehan read written remarks submitted by individuals when registering for the meeting:

- Bryn Jones said space weather impacts to and mitigations for critical infrastructure required international collaborations. Dr. Meehan replied that everyone could agree to that.
- An individual shared a link for an article which Dr. Meehan promised to share with the group after the meeting.
- Another individual expressed an interest in topics relating to atmospheric modeling.

Jonathan Parham of MIT asked if there were planned missions to replace the instrumentation on the Defense Meteorological Satellite Program (DMSP) satellites or to take advantage of low earth orbit (LEO). Dr. Bishop said one of the new paradigms was using the proliferating LEO constellations to gain some of the same measurements and observations that DMSP obtained before.

Nicholas Gorgone asked what the biggest breakthroughs in space weather prediction were that would have an impact on taxpayers. Mr. Fugate said a better understanding of space weather impacts would allow preventive measures that could save the taxpayers a lot of money by eliminating or reducing damages and disruptions. Dr. Tobiska said the heightened risk due to the increasing number of objects populating LEO was a major issue. A major effort to manage space traffic was underway. Part of the effort included strengthening the U.S. Space Force 18th Space Defense Squadron. Dr. Meehan asked Mr. Stills what improved forecasting skills for aviation he would recommend. Mr. Stills said the aviation industry currently relied mostly on real-time forecasting and modeling. The most important thing was determining what could impact a flight. More lead time allowed for more and better choices. Dr. Jonas said there were a lot of great new products, such as NOAA's geoelectric field mapping. Dr. Elliott said a lot of everyday life now relied on new technology that used things affected by space weather. Dr. Knipp said there were new technologies and data methods which would allow end users more bang for the buck.

Dr. Meehan invited Dr. Talaat to comment on NOAA's plans for DMSP. Dr. Talaat said NOAA was working with DoD to address the intersection of their respective requirements. NOAA planned to have capabilities in LEO primarily through partnerships with DoD and other agencies. A system scope was being developed. Commercial space weather also had a role to play.

12:00-12:30: Break

12:30-1:15: Related Activities (Dr. Art Charo, Senior Program Officer, Space Studies Board, NASEM, and Dr. Jim Spann, NASA Space Weather Council DFO)

Dr. Charo presented on the National Academies Space Weather Roundtable and delivered a few words about decadal surveys and the Committee on Solar and Space Physics. He reminded SWAG that the PROSWIFT Act assigned roles and responsibilities to agencies involved in space weather research and called for coordination between the government and nongovernmental community, including academia, the commercial sector, and international partners. Section 60606 called for NOAA, in collaboration with NASA and NSF, to enter into an arrangement with the National Academies to establish a roundtable consisting of representatives from the government, academic community, and commercial space weather sector to:

- (1) Facilitate advances in space weather prediction and forecasting
- (2) Increase coordination of space weather research to operations and operations to research (R2O2R)

(3) Improve preparedness for potential space weather phenomena

In addition to the 15 roundtable members, NOAA, NASA, and NSF were each invited to designate a federal representative as an ex officio member.

The National Academies' decadal surveys involved broad community outreach for ideas and input via white papers and community-based presentations. Members were selected carefully for their scientific, technical, and policy expertise. Work was done independent of outside influence. The surveys assessed the current status of an entire scientific discipline, including the state of the profession and the health of the enterprise. They prioritized the key scientific questions and developed a strategy to address them and then provided actionable recommendations to the funding agencies.

The Committee on Solar and Space Physics was a standing discipline committee of the Space Studies Board. It provided an independent, authoritative forum for identifying and discussing issues in solar and space physics with the research community, federal government, and interested members of the public and advised the government on the implementation of decadal survey recommendations. Except in limited circumstances, it did not write reports, but could help organize ad hoc studies, workshops, or meetings of experts.

Dr. Spann gave an overview of NASA's Space Weather Council (SWC). The SWC was a standing subcommittee of the Heliophysics Advisory Committee. It was established as a means to secure the counsel of community experts on matters relevant to space weather in support of the NASA Heliophysics Division. Its members included representatives of academia, government, and industry.

Dr. Dickinson observed that in her experience sitting on NASA advisory committees, they preferred issuing memoranda with recommendations to large reports. She asked if this was true of SWC. Dr. Spann said it was. Dr. Dickinson asked if the roundtable could do workshop summaries in lieu of reports. Dr. Charo said it did not issue any written products at all. It provided advice, just not in writing.

Dr. Elliott asked if either presenter had ideas for collaborating with SWAG. Dr. Spann suggested representatives from SWAG and SWC each attend the other's meeting and provide a short briefing about their group's activities. There was currently no formal link between the two groups. Dr. Dickinson proposed that the chairs and DFOs of SWAG, SWC, and the roundtable meet to discuss common interests. She planned to sit in on as many relevant meetings as possible. Dr. Elliott suggested SWAG members receive reminders for when their counterparts were meeting. Dr. Charo said members of the SWAG could not be on the roundtable, but there was no prohibition against SWC members from doing double duty. He added that he had been in discussions with Dr. Dickinson and Mr. Murtagh about coordinating efforts.

Dr. Gombosi expressed fear that the recommendations of each group would contradict one another, leading to a state of confusion. He suggested that the chair of the decadal survey be made a member of the SWC and a permanent invitee to SWAG meetings. Dr. Meehan offered to create a curated invite list and make sure SWAG reached out to the other committees. Dr. Spann praised that pragmatic approach and assured Dr. Gombosi that all the groups wanted to be on the same page.

Dr. Gannon noted there was significant overlap between SWAG and the roundtable in terms of R2O2R. Dr. Dickinson said she was largely waiting for the SWORM's interagency document to be made public before addressing R2O2R. Dr. Charo said he had not given it much thought either, instead concentrating on some of the other areas highlighted.

Dr. Tobiska said he viewed SWORM as kind of a coordinating body, and asked if its roles included conflict resolution among the different advisory groups and prioritization of different activities. Mr. Murtagh said they did, that SWORM was formed as a recognition that so many departments and agencies were doing different things that there needed to be a cohesive national strategy that brought them all together.

1:15-1:55: SWAG Brainstorming

Dr. Dickinson reminded SWAG members that anything the group did needed to be within the purview of its charter. She presented a list of things members had said they would like SWAG to do in one-on-one conversations with her:

- Space weather satellite mission concepts
- Strong voice for observations and forecasting
- Expert review of SWORM products
- Benchmarks
- Space weather scales
- Resilience and preparedness
- What is the role of the commercial sector?
- Build constituency base
- Data output formation and curation
- Space traffic coordination

In the brainstorming session, members said they would like to see the following things:

- Benchmarks related to important sector thresholds
- Best approach for useful information gathering
- Close the "wild west factor" - gap between government and commercial planning
- Education for sectors - baseline education and a platform to push it out (start with aviation). Also EM community
- Recommendations for international partnerships
- Security and availability of data for R2O2R
- All-clear notification after an event passed
- Make archived forecasts available for model validation

Dr. Talaat shared a list of potential activities SWORM would like to see:

- DoD, including Space Force, and national security interests should be considered in the SWAG effort
- The SWAG should focus on trying to understand what operational requirements were being hindered by the lack of research and development. If the SWAG bridged that gap and identified that information, SWORM could use that to turn to the appropriate agencies and identify who should do the R&D.
- The SWAG should communicate and coordinate space weather priorities with the National Academies' solar and space physics decadal survey
- Advice on new elements and/or emphases on national space weather strategy and action plan, at beginning, middle, and/or end
- SWAG could independently articulate the value of space weather services and efforts to national security, economic vitality, and STEM advancements to support American leadership in space initiatives, both for extreme events and everyday impacts over time

1:55-2:00: Closing Remarks (Dr. Tamara Dickinson, SWAG Chair, and Dr. Jennifer Meehan, SWAG DFO)

Dr. Dickinson thanked members, presenters, and other attendees. Dr. Meehan adjourned the meeting.