Space Weather Advisory Group Meeting 9

September 13, 2024

This webinar is a SWAG public meeting and will be recorded and transcribed. If you have a public comment, you acknowledge you may be recorded and are aware you can opt out of the meeting.

Welcome!

- In accordance with section 60601 of the PROSWIFT Act - NOAA established the SWAG to advise the White House SWORM Interagency Subcommittee

- All 15 non-governmental representatives of the SWAG, were appointed by the SWORM Subcommittee with 3-year terms beginning on October 1, 2021

- Each SWAG member here today serves as a representative member to provide stakeholder advice reflecting the views of the entity or interest group they are representing. 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

Roll Call

SWAG Nongovernmental End-User Representatives

Tamara Dickinson, SWAG Chair
Science Matters Consulting

Rebecca Bishop
Aerospace Corp.

Craig Fugate
Bent Ear Solutions (former FEMA Adm)

Mark Olson
North American Electric Reliability Corporation

Michael Stills
United Airlines (retired)

SWAG Commercial Sector Representatives

Nicole Duncan
BAE Systems, Inc.

Jennifer Gannon
Computational Physics, Inc.

Seth Jonas
Lockheed Martin

Conrad Lautenbacher
GeoOptics, Inc. (former NOAA Adm)

Kent Tobiska
Space Environment Technologies

SWAG Academic Community Representatives

Heather Elliott
Southwest Research Institute

Tamas Gombosi
University of Michigan, Ann Arbor

George Ho
Southwest Research Institute

Delores Knipp
University of Colorado, Boulder

Scott McIntosh
Lynker (previously UCAR)

Welcoming Remarks from the Chair

Dr. Tamara Dickinson

SWAG Chair

Nongovernmental End User Representative

President, Science Matters Consulting, LLC

Recap of Meeting 8 (April 2024)

- Brief out and discussion of finding and recommendations of the User Needs Survey
- Approved preliminary findings and recommendation for Electric Power Grid, Aviation, Emergency Management, Space Traffic Management and Coordination, and Human Space Flight
- Guest speakers
    - SWORM Co-Chair, Jinni Meehan
    - Space Weather Roundtable, Geoff Crowley
    - NASA Space Weather Council, Nicole Duncan

Past Meeting Minutes

- March 2023
- April 2023
- March 2024
- April 2024

Agenda

- Opening Remarks, Recap of Meeting 8 and Past Meeting Minutes
- Overview of Today's Meeting
- Status of User-Need Survey
- Discussion and Approval of User-Needs Survey Report Findings and Recommendations
  - Update affiliations for all
- Public Comment
- Lunch Break
- Discussion and Approval of User-Needs Survey Report Findings and Recommendations (if needed)
- Discussion of Next Public SWAG Meeting and Space Weather Summit (September 25-26, 2024)
- Next Steps and Closing Remarks
- Adjourn

Status of User Needs Survey

PROSWIFT Act - User Survey

User Survey Requirements:

1. Assess the adequacy of Federal Government goals for lead time, accuracy, coverage, timeliness, data rate, and data quality for space weather observations and forecasting;
2. Identify options and methods, in consultation with the academic and commercial space weather sectors, to advance the above goals;
3. Identify opportunities for collection of data to address the needs of space weather users;
4. Identify methods to increase coordination of space weather R2O2R;
5. Identify opportunities for new technologies, research, and instrumentation to aid in understanding, monitoring, modeling, prediction, and warning of space weather; and
6. Identify methods and technologies to improve preparedness for space weather.

Sectors for SWAG User Survey

2023-2024

- Electric Power Grid*
- Space Traffic Management/ Coordination
- Emergency Management*
- Aviation*
- Human space flight
- Research
- GNSS*

2024+

- Satellite*
- National Security
- Radio Frequency Application (comms and Radar)
- GNSS

* Sector in Abt 2019 report

User Survey Process

- Virtual and/or in-person focus groups
- Chatham House Rules
- Sessions were recorded for note taking purposes only
- High-level anonymized summary created by Science and Technology Policy Institute (STPI) for the SWAG

User Survey Topics

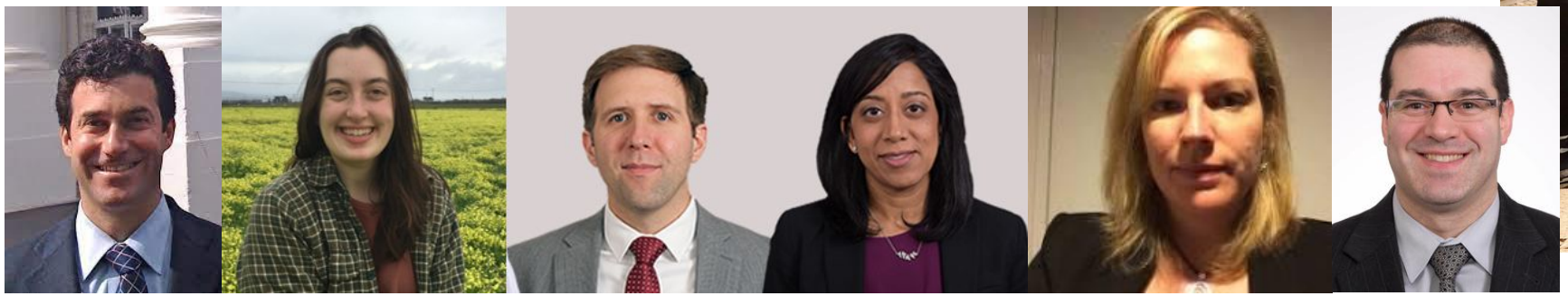
1. Current use of space weather observations, information, and forecasts
2. Current technological systems, components or elements affected by space weather
3. Current risk reduction and resilience activities
4. Future needs of space weather observations, information and forecasts
5. Future risk reduction and resilience activities
6. New or non-traditional sources of Space Weather Data
7. Next generation technologies, research, instrument, and models to address Space Weather

Thanks to the Team

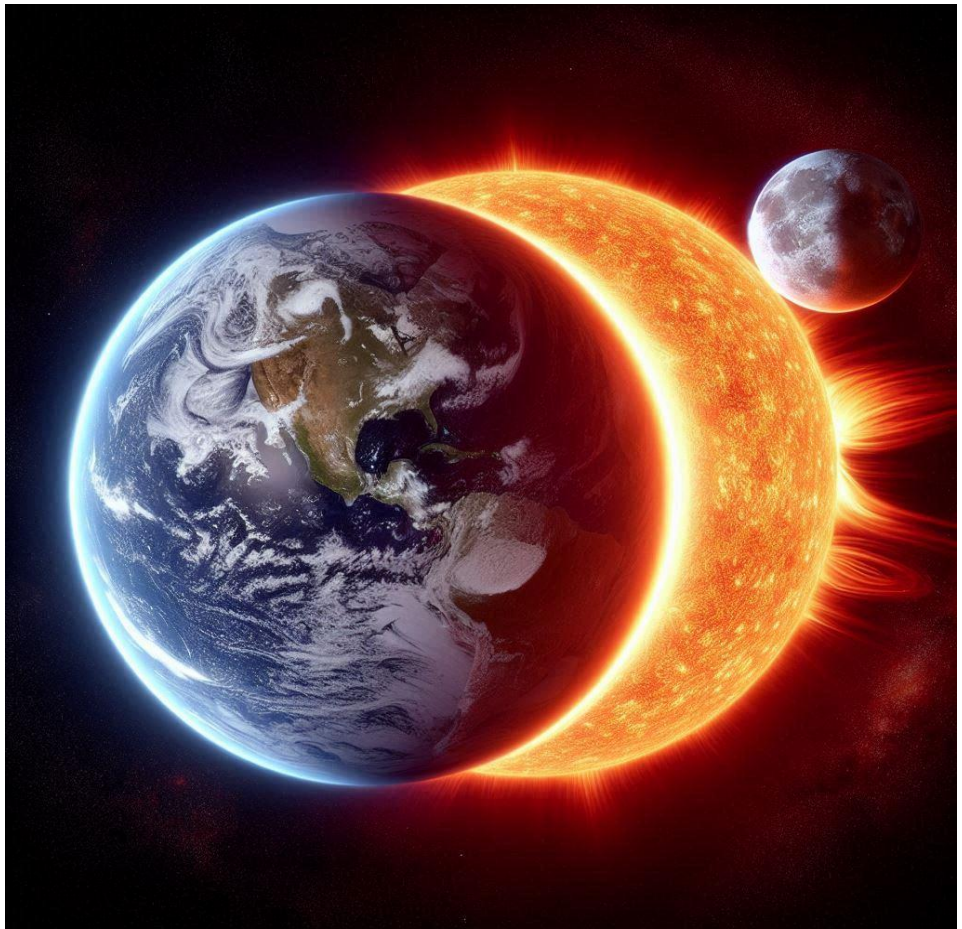
- Jinni Meehan and Amy Macpherson, NWS
- Val Were - CIRA at NWS/OSTI/SBES
- Science and Technology Policy Institute (STPI) staff
  - A sha Balakrishnan,Chris Cannizzaro, Sharon Williams, Dan Pechkis, Mark Mancuso, and Casey Roepke
- SWAG members - especially the chairs and co-chairs of the sector working groups







Results of the First National Survey of User Needs for Space Weather

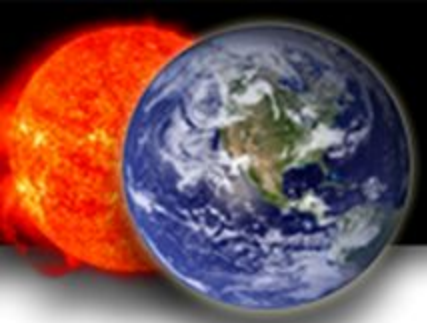


Discussion and Approval of User Needs Survey Report Findings and Recommendations

- Executive summary - new taken from report
- Chapter 1 - Introduction - new including Gannon Storm discussion
- Chapter 2 - Electric Power Grid - no changes
- Chapter 3 - Aviation - a few changes
- Chapter 4 - Human Space Flight - no changes
- Chapter 5 - STM/C - some consolidation of findings and recs
- Chapter 6 - Emergency Management - no changes
- Chapter 7 - Research - numerous changes including addition of education findings and recs
- Chapter 8 - GNSS
- Chapter 9 - Overarching - new

Discussion and Approval of User Needs Survey Report Findings and Recommendations

- Report contains two types of recommendations that are clearly labeled.
  - Recommendations that follow directly from the input from the users
  - SWAG recommendations
    - SWAG member lead the focus groups but did not participate in them
    - Issues the SWAG wanted to highlight that did not come up in focus groups



Executive Summary and Introduction

- Executive Summary
  - Language mostly taken from the chapters
  - Summary of Overarching Themes (Chapter 9)
  - Summary of the sector chapters (Chapters 2-7)
  - Path Forward
- Chapter 1 - Introduction
  - Putting our report in the context of the Gannon Storm
    - Impacts on sectors - electric power grid, aviation, STM/C, and GNSS
  - Background
  - Previous and Related Work
  - User Needs Survey Process
  - Next Steps and Challenges for Phase 2
  - Use of this Report

Electric Power Sector

Electric Power Sector

No major changes from the March 2024 version. Only minor edits.

Aviation Sector

Aviation Sector

Finding 3.2. There is a lack of measurements, reporting, limits, education, and hazard mitigation pathways for radiation exposure across the aviation industry.

Recommendation 3.2.5. SWORM agencies should coordinate radiation research findings from agencies, academia, industry, and entities such as ICAO, ISO, and WMO to disseminate best practices, guidelines, and standards on a global scale. International radiation exposure procedures should be harmonized across the industry.

Aviation Sector

Finding 3.5. There is a lack of threat awareness, protocols, planning tools, and oversight across the aviation industry.

Recommendation 3.5.3. FAA, in collaboration with the aviation industry, should set limits and thresholds as part of an SMS to identify hazards and mitigation strategies.

Recommendation 3.5.4. FAA, in collaboration with the aviation industry, should direct the use of tools that incorporate space weather conditions and alerts into briefing packets and flight planning applications. These products should include color-coded, graphical representations of space weather impacts on aviation decision points for ease of pilot use.

Recommendation 3.5.5. FAA and DOT, in collaboration with relevant SWORM agencies, should develop a suitable oversight process that ensures all facets of the aviation sector are able to utilize mitigation strategies and solutions for space weather-related disruptions. Elements of these would include: awareness of all current tools available to industry; awareness of developments within the scientific community that may assist operators; and assignment of responsibility for coordinating issues related to space weather within the industry.

Aviation Sector

Finding SWAG 3.1. Aviation industry needs to identify or create an organization best suited to develop policies related to mitigation of space weather hazards for aviation.

> **Recommendation SWAG 3.1.1. SWORM agencies should coordinate an analysis to identify an organization best suited to enable mitigation strategies and provide actionable solutions for space weather-related disruptions to aviation. SWORM agencies should provide leadership in encouraging broad space weather enterprise collaborations.**

Finding SWAG 3.2. There is a need for continuing space weather enterprise engagement across the aviation industry.

> **Recommendation SWAG 3.2.1. SWORM agencies should create suitable processes across agencies, academia, and industry that ensure all facets of how space weather affects the aviation sector can be utilized to provide fundamental knowledge, quality measurements, validated models, and actionable solutions through user-friendly tools for space weather-related disruptions.**

Aviation Sector

SWAG Findings and Recommendations:

Finding SWAG 3.3. There is a need for using guidelines from the National Council on Radiation Protection and Measurements (NCRP) and the International Commission on Radiological Protection (ICRP) to define the status of aviation crew members as workers in an enhanced radiation environment.

> **Recommendation SWAG 3.3.1. SWORM agencies should create a suitable process across the national space weather enterprise that ensures discussion and resolution to the issue of crew members working in an enhanced radiation environment, which may require risk assessment and mitigation of identified hazards.**

Discussion

Human Space Flight Sector

Human Space Flight Sector

No major changes from the March 2024 version. Only minor edits.

Discussion

Space Traffic Management/Coordination

Space Traffic Management /Coordination

Merged most of the SWAG recommendations into the regular recommendations

Rewording of a few findings and recommendations for clarity

Space Traffic Management /Coordination

Finding 5.9. STM/C users need clarity on ND model update cadence and notifications of abrupt changes in ND forecasts via alerts, advisories, and other products.

Recommendation 5.9.1. SWPC should expand dissemination of ND alerts, forecasts, and products.

Recommendation 5.9.2. SWPC should conduct regular testbed exercises and focus groups meetings to determine and further refine specific user requirements that could not be discerned in a 2-hour user needs survey session.

Space Traffic Management /Coordination

Finding SWAG 5.1. There is a need for an ND forecast strategy.

Recommendation SWAG 5.1.1. SWORM should develop a strategy for observing, modeling, and forecasting thermospheric ND for space traffic management and coordination.

Space Traffic Management /Coordination

SWAG Recommendations

Finding SWAG 5.2. There is an immediate need for progress and consistency in validation of data, models and associated uncertainties.

Recommendation SWAG 5.2.1. SWPC should expand their feedback to data providers on the suitability of their data for SWPC use in nowcasting or forecasting through on-going engagements such as testbeds and meeting focus groups. **(became 5.5.2)**

Recommendation SWAG 5.2.2. When the SWPC testbed becomes fully operational, NOAA should ensure that sufficient resources and means are available to use the testbed for validation of data sets and models. **(became 5.8.3)**

Recommendation SWAG 5.2.3. SWAG and SWORM should coordinate with the Space Weather Roundtable to convene a meeting on needs and progress in thermosphere and ionosphere data and model validation with the intent to gain more understanding of the current state of the art. **(became 5.6.3)**

Space Traffic Management /Coordination

SWAG Recommendations

Finding SWAG 5.3. SWPC's WAM-IPE should be two-way coupled

Recommendation SWAG 5.3.1. SWPC should ensure that the WAM-IPE becomes two-way coupled in order to achieve its full potential as a forecast model that assimilates thermospheric data in support of STM/C needs. **(became 5.5.3)**

Finding SWAG 5.4. There is long-term interest in ensemble modeling capability that parallels ensemble capabilities in terrestrial weather forecasting.

Recommendation SWAG 5.4.1. Relevant SWORM agencies should develop a framework to support ensemble model development. **(became 5.6.3)**

Space Traffic Management /Coordination

Discussion

Emergency Management Sector

Emergency Management Sector

No major changes from the March 2024 version. Only minor edits.

Discussion

Research Sector

Research Sector

Planning and Investment

Finding 7.1. The national space weather enterprise needs to take a strategic, systems-based approach to develop and implement a comprehensive, structured, and stratified roadmap for optimizing U.S. and international investments in space weather research with the goal of addressing observations and modeling gaps necessary to meet current and future needs of the space weather stakeholder (e.g., infrastructure owners and operators and humans traveling to Mars).

Recommendation 7.1.1. NASA, NOAA, NSF, USGS, and DOD should develop, in consultation with the research community (Federal, commercial, and academic), a framework based on OSSE analysis to prioritize space weather observations.

Recommendation 7.1.2. SWORM should create a coordinated observations and research development and implementation plan that uses the OSSE (R.7.1.1) as a basis to prioritize investments in space weather research and operations to meet existing and future user needs.

Research Sector

Planning and Investment (continued)

Finding 7.2. Focusing on the full R2O and O2R cycle is critical to improving space weather nowcasting, forecasting, and mitigation.

> **Recommendation 7.2.1. NOAA, NASA, NSF, USGS, and DOD should improve coordination across the entire R2O-O2R pipeline and the implementation process to include development standards and consistent procedures for testing, nowcasting, and forecasting capabilities and feeding operational needs back into the research pipeline.**

Research Sector

Planning and Investment (continued)

Finding 7.3. Users need reliable data access to historical and ongoing critical observations, and improved spatial and temporal resolution of key parameters, to sustain and advance R&D programs and prediction capabilities.

Recommendation 7.3.1. NASA, NOAA, NSF, USGS, DOE, and DOD should ensure the continuity of key long-term, historical space, ground, and airborne network and sensor data through ensuring existing and new observations have the appropriate level of redundancy and capability to sustain these multi-decadal data sets in perpetuity.

Recommendation 7.3.2. NASA, NOAA, DOD, DOE, NSF, and the commercial sector should collaborate to ensure access to ancillary data are included as part of observational data sets.

Research Sector

Planning and Investment (continued)

Finding 7.3. Users need reliable data access to historical and ongoing critical observations, and improved spatial and temporal resolution of key parameters, to sustain and advance R&D programs and prediction capabilities. (continued)

Recommendation 7.3.3. NASA, NOAA, NSF, DOE, and DOD should ensure that archived data is comprehensive, cross-referenced, well documented, well calibrated, interoperable, and artificial intelligence and machine learning (AI/ML) accessible.

Recommendation 7.3.4. NOAA, NASA, NSF, USGS, and DOD should augment infrastructure and instrumentation capabilities to obtain real-time or near-real-time observations.

Research Sector

Planning and Investment (continued)

Finding 7.4. Users need next-generation computational resources and data analysis techniques for advancing space weather research and applications.

> **Recommendation 7.4.1. NASA, NOAA, NSF, and DOE should expand investment in, and use of, new computing architectures and resources.**

Research Sector

Observational Capabilities

Finding 7.5. Users need improved spatial and temporal observations to enhance space weather forecasting.

Recommendation 7.5.1. NOAA, NASA, NSF, USGS, and DOD, in collaboration with commercial providers, should utilize current and future ground-, air-, and space-based sensors along with improved downlink and associated ground infrastructure to increase the resolution and coverage of key space weather, solar, space physics, and geophysical data.

Recommendation 7.5.2. NASA, NOAA, and DOD should work with commercial providers and the research community to develop robust platforms to reduce risk and cost, and prioritize increased reliability, availability of space-based systems.

Research Sector

Education and Workforce Diversification

Finding 7.6. Education and outreach is important for the future of space weather research not only to ensure we have the necessary skilled workforce, but also to educate the public on the importance of space weather since public interest and support are necessary to ensure sufficient funding for space weather research.

Recommendation 7.6.1. NSF, NASA, and other relevant SWORM agencies should prioritize grants and other funding mechanisms that promote and broaden participation in space weather-related science, technology, and engineering starting at the undergraduate level.

Recommendation 7.6.2. NSF, NASA, NOAA, and other SWORM agencies should develop programs to increase the range of perspectives, experience, and education across the space weather community through cross-training and the integration of non-traditional and applied sciences, engineering, and mathematics to advance the state of space weather research.

Research Sector

Education and Workforce Diversification (continued)

Finding 7.6. Education and outreach is important for the future of space weather research not only to ensure we have the necessary skilled workforce, but also to educate the public on the importance of space weather since public interest and support are necessary to ensure sufficient funding for space weather research. (continued)

Recommendation 7.6.3. NSF, NASA, NOAA, and other SWORM agencies should develop programs, public outreach, and engagements to educate the public on the importance of space weather and broaden public awareness and interest in space weather science and risks.

Recommendation 7.6.4. SWORM agencies should coordinate across the national space weather enterprise to sustain human capital and ensure the long-term health of the community by supporting professionals throughout their careers.

Research Sector

SWAG Findings and Recommendations:

Finding SWAG 7.1. Non-Keplerian observations can improve forecast lead time and accuracy.

> **Recommendation SWAG 7.1.1. NASA should develop and demonstrate pointing stabilized alternative propulsion methods and satellite buses to explore, and station keep at, positions along the Sun-Earth line, off the Sun-Earth line, and out of the ecliptic plane.**

Discussion

GNSS Sector

GNSS Sector

Discussion of what has been done to date but no findings or recommendations.

Overarching Themes

Overarching Themes

Overarching Theme 1. Regionalization and Impacts

The relevant recommendations in this report include:

Electric Power: **R2.2.3**	STM/C: **R5.5.1 and R5.5.2**
Aviation: **R3.2.1, R3.3.1, R3.3.2, and R3.4.1**	EM: **R6.2.1, R6.2.2, R6.3.1, R6.3.2, and R6.4.1**
HSF: **R4.1.1, R4.1.3, and R4.1.4**	

Recommendation Overarching 1.1. SWORM, through its member agencies, should take a consolidated, enterprise-wide, risk-informed, systems-based approach (using OSSEs) to identify and implement the most impactful and cost effective investments in observations, data, and modeling that enable more regionalization and specificity for forecast products and associated impacts.

Recommendation Overarching 1.2. NOAA, in collaboration with SWORM agencies, should use this report as a starting point to engage across sectors to further identify priority forecasts and products that need longer lead times and specificity (accuracy, parameterization, resolution, etc.).

Overarching Themes

Overarching Theme 2. Education and Testbeds

The relevant recommendations within this report include:

Electric Power: **R2.3.1**	EM: **R6.1.1**
Aviation: **R3.1.4, R3.2.2**	Research: **R7.6.1-3**
STM/C: **R5.2.2, R5.3.1, R5.9.2, R5.11.2**	

Recommendation Overarching 2.1. SWORM, through its member agencies, should coordinate to expand programs and opportunities for broadening the range of disciplines that contribute to advancing space weather-related science, engineering, and technology starting with vocational and undergraduate education.

Recommendation Overarching 2.2. NOAA and SWORM agencies should collaborate to develop a regular cadence of testbeds and exercises for each sector (and cross-sector where appropriate) to advance sector understanding of and preparedness for space weather events and use of products. Additionally, these should serve as an opportunity to better understand sector needs and advance operations-to-research activities. Summaries and other products from testbeds and exercises should be made public, where possible.

Overarching Themes

Overarching Theme 3. Data Archives, Access (Latency), and Automation

The relevant recommendations in this report include:

Electric Power: **R2.1.1, R2.2.1, R2.2.4**	STM/C: **R5.1.1, R5.2.1, R5.3.2, R5.4.1-2**
HSF: **R4.2.3**	Research: **R7.3.1-4**

Recommendation Overarching 3.1. SWORM agencies should coordinate, and engage relevant user sectors, to evolve and enhance space weather data archives (including indices, metadata, and uncertainties) to reduce latency, increase interoperability and machine readability, ensure uptime and access, and enable AI/ML usability.

Recommendation Overarching 3.2. NOAA should facilitate and coordinate the automation of forecasting tools and dissemination of products to increase speed of delivery and decision through minimizing human intervention in the delivery process.

Discussion

Report Approval

- **Any further discussion needed?**

Public Comment Period

Update Affiliations

(See Appendix 3)

Break

Affiliations

End Users:

- Tamara Dickinson, President, Science Matters Consulting, LLC. Washington, DC (Chair)
- Rebecca Bishop, Principal Scientist, The Aerospace Corporation., El Segundo, CA
- Craig Fugate, Senior Advisor, Bent Ear Solutions, Former FEMA Administrator, Gainesville, FL
- Mark Olson, Senior Engineer and Manager, Reliability Assessments, North American Electric Reliability Corporation, Atlanta, GA
- Michael Stills, Director of Flight Dispatch (retired), United Airlines, Chicago, IL

Affiliations

Commercial Providers:

- Nicole Duncan, Strategic Planning Manager, Civil Space, BAE Systems Inc. (??? to present); Heliophysics Mission Area Lead, Ball Aerospace, Boulder, CO (until ?????)
- Jennifer Gannon, VP of Research and Development, Computational Physics, Inc. Lafayette, CO
- Seth Jonas, Principal, Lockheed Martin, Bethesda, MD
- Conrad Lautenbacher, Executive Chairman, GeoOptics, Inc., Dunwoody, GA
- Kent Tobiska, President, Space Environment Technologies, Pacific Palisades, CA

Affiliations

Academia:

- Heather Elliott, Staff Scientist, Southwest Research Institute, San Antonio, TX
- Tamas Gombosi, Distinguished Professor, University of Michigan, Ann Arbor, MI
- George Ho, Senior Program Manager, Southwest Research Institute, San Antonio, TX (December 2023 - present); Chief Scientist (Instrumentation), Johns Hopkins University Applied Physics Laboratory, Laurel, MD (until December 2023)
- Delores Knipp, Research Professor, University of Colorado, Boulder, CO
- Scott McIntosh, Vice President, Space Operations, Lynker Inc. (August 2024 - present); Deputy Director, National Centers for Atmospheric Research, Boulder, CO (until August 2024)

Discussion of Next SWAG Meeting
Sept 25-26

September 25 -26

September 25

- Morning White House Tour 9:00 AM for those who signed up (be there early).
- Afternoon SWAG meeting in EEOB 212
    - It will take time to get through security. Airport style security. Plan ahead.
    - You could eat at the cafe inside EEOB if you want.
    - Also there is a nice gift shop
- Welcome and voting on minutes
- Update from the Roundtable and the Council
- Public Comment
- Adjourn to administrative session to discuss Sept 26 meeting
- After our session - walk around/tour the EEOB
- Group dinner

September 25 -26

September 26

- Sessions start at 9 am
    - Plan ahead. Security line will be long
- Welcomes
- Gannon Storm session (Murtagh, Mark, Kent and Rebecca)
    - Community naming of the storm for Jenn
- Overview of the report - Tammy
- Panel 1 - Space Weather End-User Applications(Grid, Aviation, HSF, EM, and STM/C) (Moderators: Seth and Rebecca)
- Panel 2 - Research and Education (Moderators: Scott and Nicole)
- Discussion with SWORM on next tasks for SWAG 2.0

Hill Briefing September 27

- September 27 - 10-12 am ET
- Hill briefing on the report
- Participants

  Tammy - opening comments

  Mark - grid

  Kent - HSF and aviation

  Seth - EM and overarching

  Rebecca - STM/C

  Scott - research(??)

  Amy - DFO/Parent

- Need each of you to pick out the few things you want to highlight in your chapters and add them to the charts I have created


SSPACE WEATHER
ADVSAIRY GROUP

Next Steps

Closing Remarks

Adjourn

September 26

Panel 1 **Space Weather End-User Applications Panel (30 minutes opening comments)**

Moderators: Seth Jonas, Rebecca Bishop

- Electric Power Sector - Matthew Gardner, VP Electric Transmission at Dominion
- Aviation rep
- HSF - Nicky Fox (NASA HQ)
- STM/C - Jagdeep Shergill (LM)
- EM - Russell Strickland (Md)

Panel 2 **Space Weather Research and Education Panel (30 minutes opening comments)**

Moderators: Scott McIntosh and Nicole Duncan

- Makenzie Lystrup (GSFC)
- Richard Clark (Millersville Emeritus)
- Tuija Pulkkinen (U MI)
- Craig DeForest (SWRI)
- Robert Braun (APL)