Space Weather Advisory Group Meeting 3

June 13-14, 2022
10:00 AM – 2:00 PM EST

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 SWORM Interagency Working Group

- 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

Mark Olson
North American Electric Reliability Corporation

Michael Stills
United Airlines (retired)

Craig Fugate
One Concern

Rebecca Bishop
Aerospace Corp.

SWAG Commercial Sector Representatives

Jennifer Gannon
Computational Physics, Inc.

Conrad Lautenbacher
GeoOptics, Inc.

Seth Jonas
Lockheed Martin

Kent Tobiska
Space Environment Technologies

Nicole Duncan
Ball Aerospace

SWAG Academic Community Representatives

Tamas Gombosi
University of Michigan, Ann Arbor

Delores Knipp
University of Colorado, Boulder

Scott McIntosh
National Centers for Atmospheric Research

Heather Elliott
Southwest Research Institute

George Ho
Johns Hopkins University Applied Physics Laboratory

Welcoming Remarks from the Chair

Dr. Tamara Dickinson

SWAG Chair

Nongovernmental End User Representative

President, Science Matters Consulting

Recap of Meeting 2

- Reached consensus on User Survey – Process, Common Set of Questions, Sectors, Scenarios, Timing
- Update from the SWORM
- Briefings on related activities
  - SSB Space Weather Roundtable
  - SSB Heliophysics decadal
  - NASA Space Weather Council
- Brainstorming on potential activities to undertake
- Public comment session

Agenda Day 1

- Welcome and Recap of Meeting 2
- User Survey – Progress since March
- SWORM Co-Chair remarks
- Sector Subgroups Questions and Process
- BREAK 12:30 - 1:00 PM
- SWORM Co-Chair remarks
- Sector Subgroups Questions and Process (continued)
- Closing Remarks
- Adjourn Day 1

Agenda Day 2

- Welcome and Recap of Day 1
- Sector Subgroups Questions and Process (continued)
- Input from NWS Social, Behavioral, and Economic Sciences Group
- Committee Discussion on Sector Questions and Processes
- Seeking Community Input
- Public Comments
- BREAK 12:15 - 12:45
- Related Activities - Update
- Next SWAG Activity
- Closing Remarks
- Adjourn Day 2

User Survey

Progress Since March

Process Overview

1. Use one or more s**pace weather scenarios** to illustrate possible impacts
2. Use a set of **common questions** developed by SWAG in collaboration with NWS Social, Behavioral, and Economic Program
    a. May have additional **sector specific questions**
    b. Have questions reviewed by SWORM
3. **Define space weather sectors**
    a. **Divide SWAG into sector specific subgroups**
    b. Possibly do pilot on one or two sectors
4. **Develop sector specific plans to conduct user survey**
5. Assimilate results into o**ne or more products**

Proposed Sectors and Leads

- Electric Power Grid – Olson, Gannon, Jonas, Fugate
- Satellite – Duncan, Knipp, Lautenbacher, Ho
- Global Navigation Satellite System – Bishop, Gombosi, Stills, Jonas
- Aviation – Stills, Tobiska, Ho
- Emergency Management – Fugate, Jonas, Ho
- STM/SSA - Knipp, Bishop, Duncan, Tobiska, McIntosh
- Radio Frequency Application (comms and Radar) - Bishop, Fugate, Stills, Jonas
- Human space flight – Tobiska, Ho, Gannon
- National Security – Jonas, Ho, Gannon, Elliott
- Research – McIntosh, Knipp, Gombosi, Elliott , Jonas, Duncan

Abt Associates Conversational Guide

- Identify technological components affected by space weather
- Describe the 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.
- Describe desired format of space weather information

PROSWIFT Act - User Survey

In general:

The SWAG shall conduct a comprehensive survey of the needs of users of space weather products to identify:

- space weather research,
- observations,
- forecasting,
- prediction, and
- modeling advances required to improve space weather products.

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.

Abt Questions ⇒ PROSWIFT Act

- Convert Abt Questions to Topic Areas
  - Becomes Baseline Topics
- Add additional areas to cover PROSWIFT required survey points
- Sectors compose specific questions, scenarios, or other methods
- Advantages:
  - Has some linkage to previous Abt survey questions
  - Provides each sector flexibility while providing an overall common framework
  - Could still have some questions in common across the sectors
- Disadvantages:
  - Each sector will have their own set of questions, scenarios, etc.
  - Does not ensure equal types or depth of information among all sectors related to PROSWIFT Survey points.

Baseline Topics

1. Technological systems or components affected by space weather **
2. Current risk reduction and resilience activities
3. Future risk reduction and resilience activities
4. Future space weather information required
5. Improved space weather communication methods
6. Improved space weather observations and forecast formats
7. Utilized space weather observations and forecasts
8. New or non-traditional sources of space weather data
9. Next generation technologies, research, instrument, and models to address space weather

- **Not likely to be able to create common questions cross sectors possible

Baseline Topics V2

1. Current space weather observations, information, and forecasts utilized
2. Current technological systems or components affected by space weather
3. Current risk reduction and resilience activities
4. Future space weather information required (communication methods, observations, and forecast products (format, etc))
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

Red type – additional areas to cover PROSWIFT required survey points

Next Steps

1. Write individual questions for each of the 7 Baseline Topics
2. Determine preferred survey type(s): written, interview, scenario
3. Develop 1-2 top-level questions for each Baseline Topic
4. Identify necessary questions not addressed in the 1-2 top-level questions and determine if they are a priority to your sector, if so they will be sector specific questions.
5. Present questions to all sectors
   a. Any common ones would become “Baseline Questions”
   b. Any necessary and priority questions not in common would become “Sector-Specific Questions”

SWAG User Survey Tranches

- PRA #1 SWAG Years 1-2 Tranche I
  - Use survey questions we have prepared
  - Sectors to survey in year 1 –
    - GNSS 1 (e.g. timing, P/N subset)
    - STM/SSA
    - Emergency Management
    - Aviation
    - Power Grid
    - Human Space Flight
    - Research
  - Sectors to survey in year 2
    - GNSS 2 (e.g. timing, positioning)
    - Other aspects of sectors from year 1?

Note: Year 1 begins after PRA #1 approval obtained.

- PRA #2 SWAG Years 3-4 Tranche II
  - Revised Survey Questions as needed/appropriate
  - Sectors to survey
    - Satellites
    - RF App.
    - National Security
    - Other aspects of sectors from years 1 and 2?

SWORM Update

SWORM Co-Chair Remarks

Ezinne Uzo-Okoro

Assistant Director for Space Policy, Office of Science and Technology Policy

Co-Chair, Space Weather Operations, Research, and Mitigation Subcommittee

Sector Subgroups Readout Questions and Process

Proposed User Survey Questions for Space Traffic Management Sector

Delores Knipp

Sector Lead

Team Members:

Rebecca Bishop, Nicole Duncan, Kent Tobiska and Scott McIntosh

Space Traffic Management (STM)

- New sector
  - Pared down from Space Traffic Management & Space Situational Awareness
  - STM needs focused attention
    - SWPC forecasting
      - Space Weather Workshop Presentation on February 2022 Starlink situation (T-W Fang et al.)
    - Broader community interest
      - General increasing reliance on space operations
      - Concerns about mega constellations and collision avoidance
        - Viasat report: "Managing Mega-Constellation Risks in LEO" January 2022
      - Commercial interest in Very Low Earth Orbit (VLEO)
        - How Low Can Satellites Go?
      - Concerns about orbital debris, launch window availability, space tourism, etc
- Alignment with User Survey Question Format
  - Asking the right question(s) is as important as getting the right answer(s)

Space Traffic Management (STM)

Methods and Questions

- Method will be via interview
  - ‘Mature’ satellite operators
  - New players (how to identify?)
  - Constellation operators
  - Other interested parties

- Questions
  - Seven Questions, with sub-questions appropriate to sector
    - Five questions align with previous Abt User Survey
    - Two questions to align with PROSWIFT interests

Common Questions

- Q1: Current space weather observations, information, and forecasts utilized
- Q2: Current technological systems or components affected by space weather
- Q3: Current risk reduction and resilience activities

- Q4: Future space weather information required (communication methods, observations, and forecast products (format, etc.)
- Q5: Future risk reduction and resilience activities

- Q6: New or non-traditional sources of space weather data
- Q7: Next generation technologies, research, instrument and models to address space weather

Space Traffic Management (STM)

Q1: Current space weather observations, information, and forecasts utilized

- **Baseline:**
  - Which environmental conditions and parameters are important for your application/system/component operations?
  - Does your application/system/component consider space weather information in STM decisions?
    - If yes, what information do you use?
    - If yes, where and how do you get the space weather information?
- **Sector Specific:**
    - If yes, does your system monitor for relevant space weather conditions?

Highlighting indicates sector specificity

Space Traffic Management (STM)

Q2: Current technological systems or components affected by space weather

- **Baseline:**
  - Which general aspects of system operations are affected by space weather?
- **Sector Specific:**
  - Please describe space weather effects for common and specialized activities
    - Common to most space operators:
      - Launch operations
      - Tracking
      - Guidance-Navigation & Control (GNC)
      - Station-keeping
      - Collision Avoidance and Debris Awareness
      - De-orbit and Re-entry
    - Specialized or newer/developing capabilities
      - Autonomous Operations
      - Orbit-Raising
      - Rendezvous
    - Others (please explain)

Space Traffic Management (STM)

Q3: Current risk reduction and resilience activities

- **Current risk reduction and resilience activities**
- **Baseline:**
  - What technological mitigation is used to reduce vulnerabilities or risk?
  - What operational changes/mitigation is used to respond to adverse conditions?
  - What other steps, not yet discussed, do you take to reduce risk and increase resilience?
  - Have you developed and implemented a tabletop exercise to explore space weather sensitivities to severe or extreme geomagnetic storms?
- **Sector Specific:**
  - Do you consider NOAA Space Weather scales in your STM decisions?
  - Are specific altitude or latitude regimes more problematic for your operations?
  - Do any of your reduction/resilience activities rely on GNSS data availability?

Space Traffic Management (STM)

Q4: Future space weather information required (communication methods, observations, and forecast products - format, etc.)

- **Baseline:**
  - What lead-times for space weather forecasts, lead-times and products are needed to implement future operational mitigations?
- **Sector Specific:**
  - What type of information related to neutral density/drag issues and space/upper atmosphere conditions would be useful for operational mitigations, or technical mitigations?

Space Traffic Management (STM)

Q5: Future risk reduction and resilience activities

- **Future risk reduction and resilience activities**
- **Baseline:**
  - How can operations be modified to compensate for periods of predicted or known space environment variations?
  - What are/is the limiting factors to the proposed operation modifications? (e.g., lead-time, max operation mode duration, 24/7 in-person monitoring, etc.)
  - Are there known barriers or challenges to implementing the proposed mitigations?
  - What other steps, not yet discussed, do you plan to take to reduce risk and increase resilience?
- **Sector Specific:**
  - What operational system improvements are required to compensate for neutral density or wind perturbations?

Space Traffic Management (STM)

Q6: New or non-traditional sources of space weather data

- **Baseline:**
  - Do your operations produce new and/or nontraditional Space Weather data or models?
  - What are they and how long is the information and/or data kept?
  - Can this information be shared outside of the application, company, or community? (if not, what are the challenges in doing so, e.g., cost, anonymization?)

Space Traffic Management (STM)

Q7: Next generation technologies, research, instrument and models to address space weather

- **Baseline:**
  - Are there any new technologies related to the application/component being developed that will mitigate known space weather impacts?
  - Are there any current or planned collaborations with the environmental research communities focusing on improving the resilience of the application/component?

Summary: Common Questions

- Q1: Current space weather observations, information, and forecasts utilized
- Q2: Current technological systems or components affected by space weather
- Q3: Current risk reduction and resilience activities

- Q4: Future space weather information required (communication methods, observations, and forecast products (format, etc.)
- Q5: Future risk reduction and resilience activities

- Q6: New or non-traditional sources of space weather data
- Q7: Next generation technologies, research, instrument and models to address space weather

Space Traffic Management (STM)

Questions?

Proposed User Survey Questions for Electric Power Grid Sector

Mark Olson

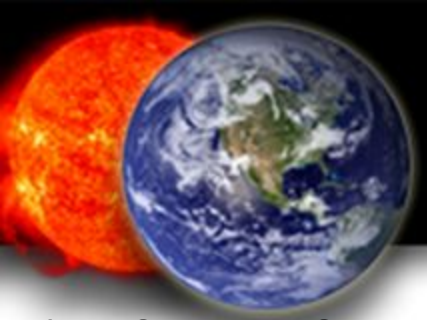
Sector Lead

Team Members:

Jenn Gannon, Seth Jonas, Craig Fugate

Electric Power Grid - Overview

- SWAG Power Grid Sector Team designed questions to provide a comprehensive survey of the sector's space weather product needs
  - ❑ Abt Survey questions were a good starting point, but were focused on **grid operations**
  - ❑ Additional questions developed to assess space weather information needs that support **grid planning and engineering design**
- Set of questions will give SWAG and SWORM insights into:
  - ❑ How current space weather products are used for electric grid resilience
  - ❑ What future products are needed and how grid resilience would be improved
  - ❑ What other data and information is used by the sector to reduce space weather risk, and its availability to the space weather community
- Survey Approach: Interviews with North American grid owners and operators through NERC technical committees



Electric Power Grid - Questions

1. <u>Current Space Weather observations, information, and forecasts used</u>
   - Do you consider Space Weather conditions in planning and operating the power system and equipment? If yes, what space weather information do you use and how do you get it?
   - Do the space weather services that you use support engineering design or operations?
2. <u>Current technological systems or components affected by space weather</u>
   - Review how space weather affects systems and components needed for reliable operation of the power grid. Consider power transformers, voltage support equipment, **supporting infrastructure (fuel, telecom)**
   - How have the risks to power systems and components changed (or are they changing), and how does the changing risk inform the frequency that requirements for space weather resilience should be reviewed?
3. <u>Current risk reduction and resilience activities</u>
   - Describe how space weather information is used in **operating procedures** to reduce risk and improve resilience of the power system to space weather.
   - Describe how space weather information is used for **engineering designs** that have been adopted to reduce risk and improve resilience of the power system to space weather

Electric Power Grid - Questions

4. <u>Future space weather information required (communication methods, observations, and products, etc)</u>
   - What do engineers and operators within this sector need in future space weather information and how will this information be used?
   - What feedback do you have for providers of current products to help them meet your needs?
5. <u>Future risk reduction and resilience activities</u>
   - What additional actions could be taken with the help of improved space weather products, information, or services? Consider both short-term (within next 1-2 years) and longer term (within 5-10 years).
   - What may be limiting the power sector's ability to take these actions? Lack of education, lack of understanding, lack of resources? How could better education and training improve capabilities?

Electric Power Grid - Questions

6. <u>New or non-traditional sources of Space Weather Data</u>
   - What other data or information are used to support engineering design or operating actions that reduce risk from space weather, and how is it used? **Do you monitor GIC or magnetic field data**?
   - For the above data, how long is it maintained and **can it be shared with space weather community**?
7. <u>Next generation technologies, research, instrument, and models to address Space Weather</u>
   - Are there any new technologies, research, instrument, and models that are needed to address space weather in the electric power sector?

Proposed User Survey Questions for Aviation Sector

Mike Stills

Sector Lead

Team Members:

Kent Tobiska, George Ho

Aviation

REGULATORY ENVIRONMENT

ADMINISTRATION OVERSIGHT

CURRENT INDUSTRY PRACTICE

SPECIFIC AREAS – COMMUNICATION, NAVIGATION AND HUMAN FACTORS

Aviation

CURRENT SPACE WEATHER OBSERVATIONS, INFORMATION, AND FORECASTS UTILIZED

- Does your enterprise utilize space weather observations, information or forecasts?
- If yes, Is there a regulatory or policy requirement for your enterprise to utilize Space Weather observations, information or forecasts?
- If yes, what are the sources of Space Weather for your enterprise?
- If yes, should SMS (Safety Management System) protocols be incorporated into Space Weather products and notifications?

Aviation

CURRENT TECHNOLOGICAL SYSTEMS, COMPONENTS OR ELEMENTS AFFECTED BY SPACE WEATHER

- Which systems or components of your operation or enterprise are affected by Space Weather?
- Which elements of your operation or enterprise are affected by Space Weather?

Aviation

CURRENT RISK REDUCTION AND RESILIENCE ACTIVITIES

- What are the current risks to your enterprise or operation from Space Weather?
- How would you classify the risks (personnel/equipment safety, economic, operational)?
- How would you assess the risks on a scale of severe to inconvenient?
- Does your enterprise or operation have policies or procedures to mitigate the risks currently associated with Space Weather?
- If any, what is the duration of actions directed by current policies and procedures? What precipitates an end to any actions implemented?

Aviation

FUTURE SPACE WEATHER INFORMATION REQUIRED (COMMUNICATION METHODS, OBSERVATIONS, AND FORECAST PRODUCTS (FORMAT, ETC.)

- Does your enterprise rely on the SWPC website as the primary source of Space Weather? If so, should the Aviation tab remain as stand alone? If yes, should it be enhanced as directed by users?
- Does your enterprise use other sources of Space Weather? If so, which sources and for what purposes? Does your enterprise use commercial space weather sources and if so, for which information?
- What educational tools, formats or vehicles would best assist the aviation sector to better understand Space Weather?
- Does your enterprise have an assessment of the specific impact of Space Weather on communication, navigation and human health? If yes, do you use specific limits and thresholds for decision making?
- Does your enterprise or operation foresee enhancements or changes to current information dissemination?

Aviation

FUTURE RISK REDUCTION AND RESILIENCE ACTIVITIES

- Does your enterprise or operation perform any simulations or exercises to enhance risk mitigation of future events?

- Does your enterprise or operation require new or other sources of Space Weather in order to mitigate risks?

Aviation

NEW OR NON-TRADITIONAL SOURCES OF SPACE WEATHER DATA

- Does your enterprise or organization utilize multiple sources of Space Weather information? If so, which sources and for what reasons?

Aviation

NEXT GENERATION TECHNOLOGIES, RESEARCH, INSTRUMENTS AND MODELS TO ADDRESS SPACE WEATHER

- What information would enhance monitoring of Space Weather for your enterprise or organization? Is there specific research that could produce such information?
- What measurements or observations would enhance monitoring of Space Weather for your enterprise or organization?
- What modeling information would enhance policy and procedure for your enterprise or operation?
- Would your organization deploy research, instrumentation, or modeling activities itself to obtain that information or rely on 3rd party sources?

Proposed User Survey Questions for Emergency Management Sector

Craig Fugate

Sector Lead

Team Members:

Seth Jonas, George Ho

Emergency Management

1. Current space weather observations, information, and forecasts utilized
   - What space weather products do you currently use in your emergency planning?
   - Have you run a space weather exercise?
     - Do you have lessons to share?
2. Current technological systems or components affected by space weather
   - Rather than a question, this should be a briefing on current space weather forecast tools and the impacts of space weather on critical infrastructure or systems for emergency managers.

Emergency Management

3. Current risk reduction and resilience activities
   - Do current emergency plans account for effects of space weather in your jurisdiction?
   - What information on space weather effects do you require to update your emergency plans?
   - Other than space weather forecasts and associated effects, what other information do you need to plan for space weather events and their effects on critical infrastructures or systems?

Emergency Management

4. Future space weather information required (communication methods, observations, and forecast products (format, etc))
   - Based on the above questions, what additional space weather information and forecast timeframes need to be addressed for emergency managers?
5. Future risk reduction and resilience activities
6. New or non-traditional sources of space weather data
   - Not applicable for Emergency Managers
7. Next generation technologies, research, instrument, and models to address space weather

BREAK

12:00 - 12:30 pm ET

SWORM Co-Chair Remarks

Mary Erickson

Deputy Assistant Administrator for Weather Services,

Deputy Director, National Weather Service

Co-Chair, Space Weather Operations,

Research, and Mitigation Subcommittee

Proposed User Survey Questions for GNSS Sector

Rebecca Bishop

Sector Lead

Team Members:

Mike Stills, Seth Jonas, Tamas Gombosi

GNSS - Overview

- GNSS Sector is extremely large with many types of applications and technologies relying on GNSS data.
  - Broken into two focus areas where applications either depend on:
    - Precise timing
    - Position/Navigation
- Each area broken into community groups
- Communities then ranked in-terms importance/impact of the degradation of GNSS

Precise Timing Communities	Position/Navigation Communities
Finance	Transportation
Communication Networks	Public Safety & Services
Social Services	Data Markets
Manufacturing	Land Usage
Distribution	

GNSS - Survey Plan Summary

- GNSS survey takes place over 2 years
  - Year 1: Three Timing and two Position/Navigation communities surveyed
    - Communication Networks, Manufacturing, Distribution
    - Land Usage, Public Safety & Services
  - Year 2: Two Timing and two Position/Navigation communities surveyed
    - Finance, Social Services
    - Transportation, Data Markets
- Combination of web/paper survey and individual in-depth interviews depending on the community
- Equally important to get definitive information that space weather does not impact a community as it is that it does and by how much.
- Survey questions are a combination of baseline and sector specific questions
  - Sector specific questions required for Topic 2 (technology systems), Topic 3 (current risk reduction/resilience), Topic 5 (future risk reduction/resilience)

GNSS - Survey Questions

1. Current space weather observations, information, and forecasts utilized
   a. Which environmental conditions and parameters are important for your application/system/component operations?
   b. Does your application/system/component consider Space Weather conditions?
      i. If yes, what information do you use?
      ii. If yes, where and how do you get the Space Weather information?

2. Current technological systems or components affected by space weather
   a. Which general aspects of system operations are affected by space weather?

3. Current risk reduction and resilience activities
   a. What technological mitigation is used to reduce vulnerabilities or risk?
   b. What operational changes/mitigation is used to respond to adverse conditions?
   c. What other steps, not yet discussed, do you take to reduce risk and increase resilience?

GNSS - Survey Questions

4. Future space weather information required (communication methords, observations, and forecast products (format, etc.)
   a. What lead-times for space weather forecasts and products are necessary to implement future operational mitigations?
   b. What type of information related to GNSS timing issues or space/upper atmosphere conditions would be useful for operational mitigations, or technical mitigations, or both?

5. Future risk reduction and resilience activities
   a. How can operations be modified to compensate for periods of predicted or known space environment variations?
   b. What are limiting factors to the proposed operation modifications? (e.g., lead-time, max operation mode duration, 24/7 in-person monitoring, etc.)
   c. Are there any known barriers or challenges to implementing any of the proposed mitigations
   d. What other steps, not yet discussed, do you plan to take to reduce risk and increase resilience?

GNSS - Survey Questions

6. New or non-traditional sources of space weather data
    a. Does your application/system/component monitor environmental conditions?
    b. What are they, how are they currently used, and how long is the information and/or data kept?
    c. Can this information be shared outside of the application, company, or community? (if not, what are the challenges in doing so, e.g., cost, anonymization?)

7. Next generation technologies, research, instrument and models to address space weather
    a. Are there any new technologies related to the application/component being developed that will mitigate known space weather impacts?
    b. Are there any current or planned collaborations with the environmental research communities focussing on improving the resilience of the application/component?

GNSS Sector Specific Survey Questions – Precise Timing

2. Current technological systems or components affected by space weather
    a. Which GNSS constellations or other Radio Navigation systems (e.g., SBAS) are currently used and are expected to be used in the future and what frequencies are utilized?
    b. Which components/systems depend on GNSS?
    c. At what point in the technological system or application is GNSS **timing** used and at what point is it obtained?
    d. What type of receiver is used? (i.e., single/dual frequency, automotive, chip vs. self-contained receiver)
    e. What is the order of magnitude of the accuracies/precision and sampling rate *required* by the technological system and/or application? (e.g., minutes, seconds, microseconds)
    f. What is the order of magnitude of the accuracies/precision and sampling rate *currently achieved* by the technological system and/or application? (e.g., minutes, seconds, microseconds)

GNSS Sector Specific Survey Questions – Precise Timing

3. Current risk reduction and resilience activities
    a. Does the technological system or application note degradation in GNSS **timing** values? How does it check?
        i. If yes, how often is a degradation noted? How often does it prevent the application from meeting minimum performance?
    b. What happens when the **timing** error exceeds the operational threshold requirement?
    c. Does the system/technology depend on or use as a backup any other source of **timing** information?

5. Future risk reduction and resilience activities
    a. How can operations be modified to compensate for periods of predicted or known **timing** errors?
    b. What software/data system improvements are required to compensate for **timing** errors? (e.g., quality threshold changes, optimizing **timing** accuracy needs with required performance)
    c. What hardware system improvements are required to compensate for **timing** errors? (e.g. multi-GNSS **timing** values, reduced network latency, etc.)
        i. Are these actively being pursued? If so, what is the timeline to implementation (i.e., 3-year, 5-year, 10-year, etc.)

GNSS Sector Specific Survey Questions – Position/Navigation

2. Current technological systems or components affected by space weather
    a. Which GNSS constellations or other Radio Navigation systems (e.g., SBAS) are currently used and are expected to be used in the future and what frequencies are utilized?
    b. Which components/systems depend on GNSS?
    c. At what point in the technological system or application is GNSS **position/navigation** used and at what point is it obtained?
    d. What type of receiver is used? (i.e., single/dual frequency, automotive, chip vs. self-contained receiver)
    e. What is the order of magnitude of the accuracies/precision and sampling rate *required* by the technological system and/or application? (e.g., minutes, seconds, microseconds)
    f. What is the order of magnitude of the accuracies/precision and sampling rate *currently achieved* by the technological system and/or application? (e.g., minutes, seconds, microseconds)

GNSS Sector Specific Survey Questions – Position/Navigation

3. Current risk reduction and resilience activities
    a. Does the technological system or application note degradation in GNSS **position/navigation** values? How does it check?
        i. If yes, how often is a degradation noted? How often does it prevent the application from meeting minimum performance?
    b. What happens when the **position/navigation** error exceeds the operational threshold requirement?
    c. Does the system/technology depend on or use as a backup any other source of **position/navigation** information?
5. Future risk reduction and resilience activities
    a. How can operations be modified to compensate for periods of predicted or known **position/navigation** errors?
    b. What software/data system improvements are required to compensate for **position/navigation** errors? (e.g., quality threshold changes, optimizing **position/navigation** accuracy needs with required performance)
    c. What hardware system improvements are required to compensate for position/navigation errors? (e.g. multi-GNSS **position/navigation** values, reduced network latency, etc.)
        i. Are these actively being pursued? If so, what is the timeline to implementation (i.e., 3-year, 5-year, 10-year, etc.)

Proposed User Survey Questions for Human Space Flight Sector

Kent Tobiska

Sector Lead

Team Members:

Jenn Gannon, George Ho

Human Space Flight

1. **Current space weather observations, information, and forecasts utilized**
    - Are there federal, state, corporate regulatory or policy requirement for your organization to use space weather observations, information or forecasts?
        - does your organization use space weather observations, information or forecasts?
        - what are the current sources of your space weather information?

2. **Current technological systems or components affected by space weather**
    - What are the current vulnerabilities of your organization's systems to space weather?
    - Does your organization have operations that are affected by space weather?
    - Does your organization have space-based, atmosphere-based, or ground-based systems or components?
    - How best can your organization's vulnerability assessment be better supported?

Human Space Flight

3. **Current risk reduction and resilience activities**
    - What are the current risks to your organization's systems or operations from space weather?
    - Does your organization use limits and thresholds to assess the impact of space weather on human health and equipment?
    - Are the risks related to personnel/equipment safety, economic viability, or resilience?
    - What is your risk management process for space weather?
        - Risk identification?
        - Risk assessment?
        - Risk control?
        - Risk control review?

Human Space Flight

4. **Future space weather information needed (communication methods, observations, and forecast products (format, etc.))**
    - Would your organization incorporate currently unused agency, commercial, and academic sources of space weather? Which information from which sources?
    - What enhancements or changes to current information dissemination does your organization envision?

Human Space Flight

5. **Future risk reduction and resilience activities**
    - Does your organization use simulations or other activities to mitigate risk from future events?
    - How does your organization analyze historical big events relevant to your activity?
    - What different or new sources of space weather, not necessarily in existence yet, are needed by your organization to mitigate risks?

6. **New or non-traditional sources of space weather data**
    - Are there unused or new types of measurements or observations that would enhance space weather risk mitigation for your organization?
    - Are there new types of modeling information that would improve space weather risk mitigation for your organization's operations?
    - Would your organization develop research, instrumentation, and/or modeling activities itself to obtain that information or would it look to other sources?

Human Space Flight

7. **Next generation technologies, research, instruments and models to address space weather**
    - What new or unused measurements or observations would enhance monitoring of space weather for your organization?
    - What modeling information would improve space weather risk mitigation for your operation?
    - Would your organization use research, instrumentation, or modeling activities itself to obtain that information or look to other sources?
    - [NOTE: did we ask these questions already?]

Proposed User Survey Questions for Research Sector

Scott McIntosh
Sector Lead

Team Members:

Delores Knipp, Tamas Gombosi, Heather Elliott, Seth Jonas, Nicole Duncan, Kent Tobiska

Research - Approach

- Responses will be obtained using an interview format with leaders across:
  - Industry [LM, Ball, etc]
  - Research Institutes/Universities [NJIT, HAO, NSO, NRL, LASP, etc]
  - DOD Space Weather Activities [Space Command, AFRL, NRL, DARPA, AFW]
  - NASA [Helio]
  - NOAA [SWPC]
  - NSF [GEO/AGS]
- Results will be assembled and grouped for review by the SWAG research sector in a way that prevents attribution to individuals or entities.

Research

1. Current technological systems or components are potentially affected by space weather
   - *Which elements of your enterprise are potentially affected by space weather?*
2. Current space weather observations, information, and forecasts utilized
   - *Do you utilize space weather information (observations, forecasts, or alerts) in your enterprise?*
   - *If yes, what information do you use and on which quantities are you most reliant/susceptible?*
   - *If yes, what are the sources of your information?*
   - *If yes, have you identified improvements that could be made to that information that will improve your confidence?*
   - *If yes, are current data archives and curation methods adequate for your enterprise?*

Research

3. Current risk reduction and resilience activities
   - *What are the current risks to your enterprise from space weather?*
   - *What actions do you take to mitigate the effects of space weather on your enterprise?*
4. Future space weather information required (communication methods, observations, and forecast products (format, etc.)
   - *Based on your answers above, what space weather information (observations, models, or forecasts) would advance your enterprise?*
     i. *What observational capabilities would be needed?*
     ii. *What modeling capabilities would be needed?*
     iii. *What (software or hardware) infrastructure might be required to produce that information?*
   - *What educational tools, formats, or platforms would best assist in the communication of space weather information?*

Research

5. Future risk reduction and resilience activities
   - *What future risks to your enterprise do you anticipate from space weather?*
   - *What actions should be taken to mitigate those risks in your enterprise?*
6. New or non-traditional sources of space weather data
   - *Are there other sources of space weather information that are not readily available to users, but (in your opinion) could be broadly utilized?*
   - *What would be required to transition those to wider availability?*

Research

7. Next generation technologies, research, instrument and models to address space weather
   - *What advances in capability (infrastructure, research, technology, instrumentation, data science, or modeling) would improve your understanding of space weather **causes**?*
     i. *Are there particular observing or modeling strategies or vantage points that will advance understanding of space weather causes?*
     ii. *Are there particular technologies that should be accelerated to improve understanding of space weather causes?*
   - *What advances in capability (infrastructure, research, technology, instrumentation, data science, or modeling) would improve your understanding of space weather **effects**?*
     i. *Are there particular observing or modeling strategies or vantage points that will advance understanding of space weather effects?*
     ii. *Are there particular technologies that should be accelerated to reduce the risk of space weather effects?*

Research

7. Next generation technologies, research, instrument and models to address space weather (continued)
   - *How should future space weather capabilities be coordinated to reduce duplication of effort and enhance collaboration?*
     i. *How can next-generation capabilities be integrated to rapidly improve numerical models and space weather forecasts?*
     ii. *Should next-generation capabilities be prioritized and, if so, how might that best be accomplished?*
   - *What educational materials or approaches might be employed to improve scientific understanding and participation across the space weather research community?*
   - *What educational materials or approaches might be employed to improve diversity in the space weather research community?*

Proposed User Survey Questions for National Security Sector

Rebecca Bishop and Seth Jonas

Sector Lead

Team Members:

Jenn Gannon, George Ho, Heather Elliott

National Security

Sector	Overlap (Yes/No)
Aviation	Yes
Electric Power Grid	Yes
Emergency Management	Yes
GNSS	Yes
Human Space Flight	Yes
Radio Frequency Applications	Yes
Research	Yes
SSA/STC	Yes
Satellite	Yes

Proposed User Survey Questions for Radio Frequency Sector

Seth Jonas

Sector Lead

Team Members:

Rebecca Bishop, Craig Fugate, Mike Stills

Radio Frequency Applications

Sector	Overlap (Yes/No)
Aviation	Yes
Electric Power Grid	Yes
Emergency Management	Yes
GNSS	Yes
Human Space Flight	Yes
Radio Frequency Applications	Yes
Research	Yes
SSA/STC	Yes
Satellite	Yes

Closing Remarks

Adjourned

Thank you!

Space Weather Advisory Group Meeting 3

June 13-14, 2022
10:00 AM – 2:00 PM EST

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!

Committee Roll Call

SWAG Nongovernmental End-User Representatives

Tamara Dickinson, SWAG Chair
Science Matters Consulting

Mark Olson
North American Electric Reliability Corporation

Michael Stills
United Airlines (retired)

Craig Fugate
One Concern

Rebecca Bishop
Aerospace Corp.

SWAG Commercial Sector Representatives

Jennifer Gannon
Computational Physics, Inc.

Conrad Lautenbacher
GeoOptics, Inc.

Seth Jonas
Lockheed Martin

Kent Tobiska
Space Environment Technologies

Nicole Duncan
Ball Aerospace

SWAG Academic Community Representatives

Tamas Gombosi
University of Michigan, Ann Arbor

Delores Knipp
University of Colorado, Boulder

Scott McIntosh
National Centers for Atmospheric Research

Heather Elliott
Southwest Research Institute

George Ho
Johns Hopkins University Applied Physics Laboratory

Recap of Day 1

- Update on progress since March SWAG meeting
- Briefings by 9 of the Sector Subgroup Leads
- Update from the SWORM

Agenda Day 2

- Welcome and Recap of Day 1
- Sector Subgroups Questions and Process (continued)
- Input from NWS Social, Behavioral, and Economic Sciences Group
- Committee Discussion on Sector Questions and Processes
- Seeking Community Input
- Public Comments
- BREAK 12:15 - 12:45
- Related Activities - Update
- Next SWAG Activity
- Closing Remarks
- Adjourn Day 2

Proposed User Survey Questions for Satellite Sector

Nicole Duncan
Sector Lead

Team Members:

Delores Knipp, Conrad Lautenbacher, George Ho

Satellites

- The Abt report's findings are comprehensive
  - Independent assessment with several additional satellite engineers and operators
  - Report captured overall spacecraft design and operational needs well
- Abt survey group limitations
  - Small survey pool (2 Engineers, 3 Operators)
  - "more sophisticated satellite companies"
  - Not clear if Mission Operations for Exploration were included in survey pool
- Recommendations
  - Re-survey in Tranche 2
  - Include broad range of satellite builders, operators and operational environments: higher and lower-risk, commercial and government contractors, robotic and human missions, cis-Lunar, GEO and Deep Space

NWS Social, Behavioral, and Economic Sciences Program

NWS Social, Behavioral, and Economic Sciences Program Input

Initial Review of Questions Completed

- Majority of edits were rewording to eliminate closed-ended questions

Next Step

- Paperwork Reduction Act (PRA) submission

NWS Social, Behavioral, and Economic Sciences Program Input

The PRA Process

The PRA requires agencies to go through public notice and comment and receive approval from OMB before information is collected.

Requirement: 60 day notice in the Federal Register, consultation with members of the public and affected agencies and provide all of the above to OMB and facilitate second public review period (30 days)

NWS Social, Behavioral, and Economic Sciences Program Input

Items Needed from Each Sector for 60-Day Federal Register Notice (FRN)

- Collection Method(s)
- Number of Respondents
- Estimated Time per Response

Items Needed Later

- Collection guides: Survey questionnaires and Interview questions

Committee Discussion

Committee Discussion

- Discussion of Sector Questions and Processes
- Discussion of SWORM input
- Discussion of NWS SBSG Input
- Approval of Sector Questions and Processes
- Next Steps

Seeking Community Input

Seeking Community Input

- AGU (Dec 2022) Townhall requested
  - Rebecca, Jen
- AMS (Jan 2023) Session requested
  - Val, Jen
- What other venues should we be speaking in?
  - SEASONS
  - Aviation Safety Infoshare (held 2X/year, maybe Oct)
  - Airline Dispatcher Federation
  - Flight Safety Foundation
  - NBAA (Biz Jets)
  - NSF/NASA/NOAA Geomagnetically Induced Currents Ideas Lab
  - NERC
  - CEDAR/GEM
  - SWW
  - Commercial Space Flight Org (annual meeting) - Kent/Delores
- ION, IEEE - Rebecca
- International Association of EM
- National Homeland Security Conference
- Space Symposium
- Small Sat Conference
- ISO - Orbital Debris Conference (US Tech Advisory Group)
- Triennial Earth-Sun Summit
- Space Weather Enterprise Forum
- Advanced Maui Optical and Space Surveillance Technologies (AMOS) - Kent, Delores
- American Physical Society (APS) meetings and publications
- AAAS

BREAK

11:54 - 12:00 pm ET

Public Remarks

jennifer.meehan@noaa.gov

BREAK

12:15 - 12:45 pm ET

Related Activities

Related Activities - Update

- National Academies of Science, Engineering, and Medicine Space Studies Board
  - National Academies Space Weather Roundtable (https://www.nationalacademies.org/our-work/space-weather-roundtable)
  - Heliophysics Decadal Survey
  - Committee on Solar and Space Physics

NASA

  - Space Weather Council of the Heliophysics Advisory Committee

Related Activities - Update

Space Weather Roundtable

- Called for in PROSWIFT
- Government-University-Commercial Roundtable on Space Weather

Space Weather Council

- Reports to NASA Heliophysics Advisory Committee
- Community-based, interdisciplinary forum for soliciting and coordinating community analysis and input and providing advice

Space Weather Advisory Group

- Called for in PROSWIFT
- Advises the SWORM
- End Users - Commercial Sector - Academic representatives

Space Weather Roundtable

- **Geoffrey Crowley, Orion Space Solutions, Co-Chair**
- **Sarah E. Gibson, NCAR, Co-Chair**
- Hazel Bain, Cooperative Institute for Research in Environmental Sciences/Univ. of Colorado, Boulder
- Anthea J. Coster, MIT Haystack Observatory
- Jennifer L. Gannon, Computational Physics Inc.
- Janet C. Green, Space Hazards Inc.
- Justin C. Kasper, BWX Technologies and University of Michigan
- Delores Knipp, University of Colorado, Boulder
- Louis J. Lanzerotti, NAE, New Jersey Institute of Technology
- Mark H. MacAlester, Dept. of Homeland Security/CISA
- M. Granger Morgan, NAS, Carnegie Mellon University
- Geoffrey D. Reeves, Los Alamos National Laboratory
- Michael Starks, Air Force Research Laboratory
- Leonard Strachan, Jr., Naval Research Laboratory
- Drew Turner, Johns Hopkins Univ.-Applied Physics Laboratory
- Louis W. Uccellini, NOAA National Weather Service (ret.)
- Shasha Zou, University of Michigan

SWAG and Roundtable

SWAG

Members: academic, commercial, nongovernment end users

Advise SWORM on:

- Facilitating advances in the space weather enterprise of the US
- Enabling the coordination and facilitation of R2O2R
- Improving the ability of the US to prepare for, mitigate, respond to, and recover from space weather phenomena
- Developing and implementing integrated strategy

Conduct user needs survey

Roundtable

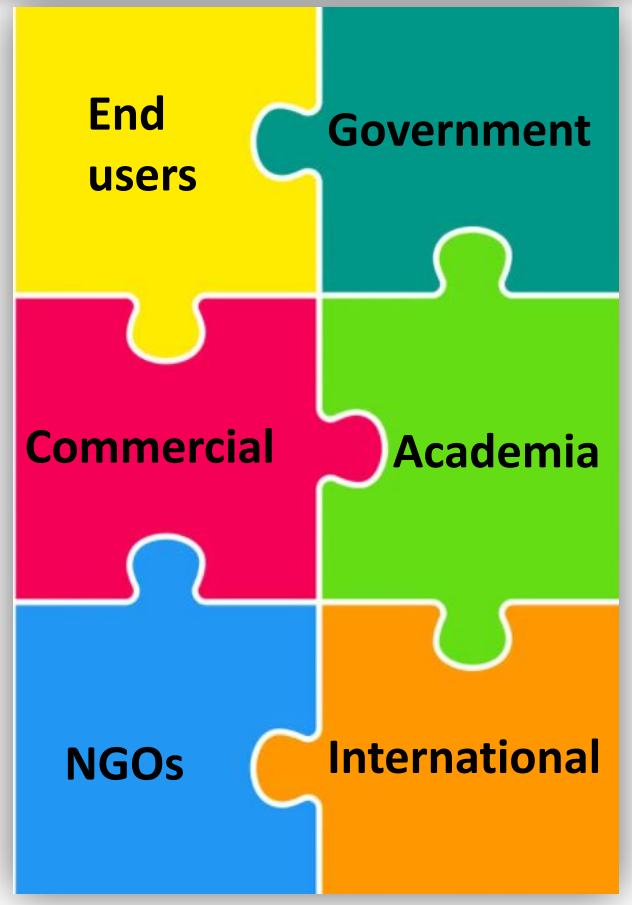
Members: academic, commercial, government (SWORM)

Facilitate communication and knowledge transfer among government (SWORM), academic and commercial space weather communities to:

- Facilitate advances in space weather prediction and forecasting;
- Increase coordination of space weather R2O2R;
- Improve preparedness for potential space weather phenomena

Collaboration

- **<u>Collaboration and coordination will be key</u>**
- Volunteered to speak today and at the NASA Space Weather Council next meeting
- Creating a invite list for SWAG meetings to include Roundtable and SWC chairs and members
- Administrative meetings between SWAG, Roundtable, and SWC chairs and staff



We are all working towards <u>one common goal</u>: to prepare and protect against the social and economic impacts of space weather phenomena.

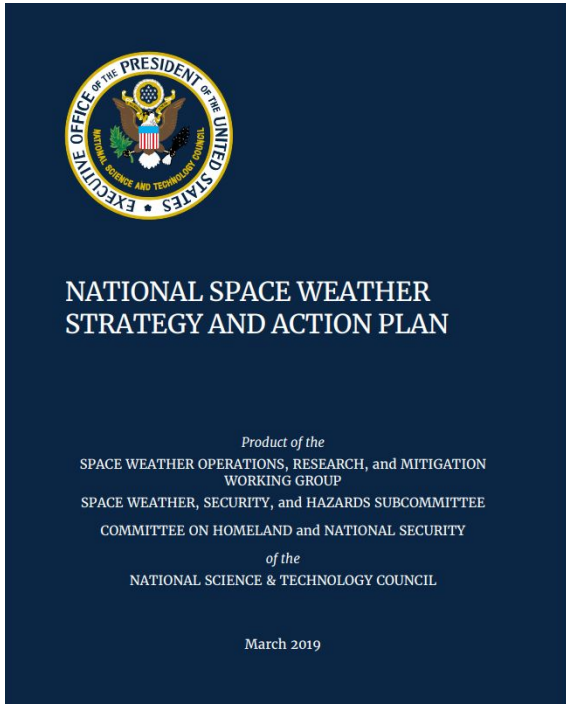
Next SWAG Activity

SWAG Brainstorming

- Advice on new elements and or new emphases on National Space Weather Strategy and Action Plan
  - role of commercial sector
  - government/commercial sector planning
- Articulate the value of space weather observations, forecasting, and services, build constituency base.
- Benchmarks and Space Weather Scales
  - All clear notifications
- R2O2R
  - Security and availability of data
  - Make archived forecasts available for model validation
  - what are the operational requirements that are being hindered by the lack of research and development

Next SWAG Activity - Assessment of 2019 National Space Weather Strategy and Action Plan

- Coming up on 4-year point (Mar 2023) since release of 2019 National Space Weather Strategy and Action Plan (NSW-SAP)
  - Time to review the NSW-SAP and assess our progress in achieving the stated objectives
- Are the objectives and actions still relevant and aligned with the Administration priorities, and statutory and policy frameworks?
- Are modifications to the existing NSW-SAP necessary? Should new actions be added?
  - SWORM Working Group leads will coordinate with their teams on assessment
  - Consolidate and provide initial assessment next SWORM meeting (July 2022)
- Complete assessments with recommendations due date will be determined 6 July SWORM meeting



The statutory and policy framework to prioritize activities to inform assessment of NSW-SAP

- The Promoting Research and Observations of Space Weather to Improve the Forecasting of Tomorrow (PROSWIFT) Act (2020)
- OSTP Space Weather Administration Priorities (2021)
- National Space Weather Strategy and Action Plan (2019)
- Executive Order 13744 on Coordinating Efforts to Prepare the Nation for Space Weather Events (2016)
- Executive Order 13865 on of March 26, Coordinating National Resilience to Electromagnetic Pulses (2019)
- National Space Priorities Framework (2021)

Discussion

Closing Remarks

Adjourned

Thank you!

Back up slides

Survey Points vs Abt Main Questions

Index	PROSWIFT Area	Primary Topic Area Mapping
i	Federal Government SpWx Goals' Adequacy	3,4,7
ii	Improve advancement of SpWx Goals	3, 4, 5/6
iii	New SpWx data collection opportunities	1, 8
iv	Improve coordination of SpWx R2O and O2R	4, 5/6
v	Next generation technology, research, instrumentation for improving SpWx for end users	9
vi	Future SpWx mitigation techniques and technologies	2, 3, 4, 5

- The Space Weather Council (SWC) was established as a means to secure the counsel of community experts across diverse areas on matters relevant to space weather in support of the NASA Heliophysics Division (HPD).
  - The SWC serves as a community-based, interdisciplinary forum for soliciting and coordinating community analysis and input and providing advice.
  - It provides advice to the Heliophysics Advisory Committee (HPAC).
- The SWC is a standing subcommittee of the HPAC. As such, the SWC reports to and is responsive to actions levied by the HPAC.
  - As appropriate, the SWC may seek scientific and programmatic input from the heliophysics and space weather communities at large on matters relevant to their actions.

Space Weather Council Members

Ms Patricia Doherty
Boston College

Dr Daniel Baker
CU/LASP

Dr Michele Cash
NOAA/SWPC

Dr Angelos Vourlidas
JHU/APL

Dr Janet Green
Space Hazards Inc

Dr Valeriy Tenishev
University of Michigan

Dr Alexa Halford
NASA/GSFC

Dr Piyush Mehta
West Virginia University

Dr Ronald Turner
ANSER

Ms Sage Andorka
USSF

Dr Joachim Raeder
UNH

Dr Paul O'Brien
Aerospace Corp.

From PROSWIFT Act

- The advisory group shall advise the SWORM on the following:
  - Facilitating advances in the space weather enterprise of the United States.
  - Improving the ability of the US to prepare for, mitigate, respond to, and recover from space weather phenomena.
  - Enabling the coordination and facilitation of research to operations and operations to research.
  - Developing and implementing the integrated strategy.
    - The Director of OSTP, in collaboration with the SWORM and upon the advice of the SWAG, shall develop a strategy for coordinated observation of space weather among members of the SWORM

SWAG Brainstorming

- 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 role of commercial sector?
- Build constituency base
- Data output format and curation
- Space traffic coordination

SWAG Brainstorming

- Benchmark related - important sector thresholds
- Best approach for useful information gathering
- Wild west factor - close the gap between government/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 has past (or forecasted)
- Make archived forecasts available for model validation
- Create flow chart for each sector that identifies communication lines from end-user, technology engineers, etc. to SWPC and what sort of info is required at each level. This may be a good way to focus/summarize the survey results as well.

SWORM Input on Potential SWAG Activities

- DOD, including Space Force, and National Security interests should be considered in the SWAG effort
- The SWAG should focus on trying to understand what are the operational requirements that are being hindered by the lack of research and development. If we could utilize the SWAG to bridge that gap and identify that information, we could then use that information 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 Academy's Solar and Space Physics Decadal Survey.

SWORM Input on Potential SWAG Activities

- Advice on new elements and or new emphases on National Space Weather Strategy and Action Plan, whether at beginning, during, and/or end.
- SWAG could independently articulate the value of space weather services and efforts to national security, economic vitality, and STEM advancements - supports American leadership in space initiative.
- SWAG could illustrate various scenarios of space weather impacts and issues - both for extreme events and everyday impacts over time.