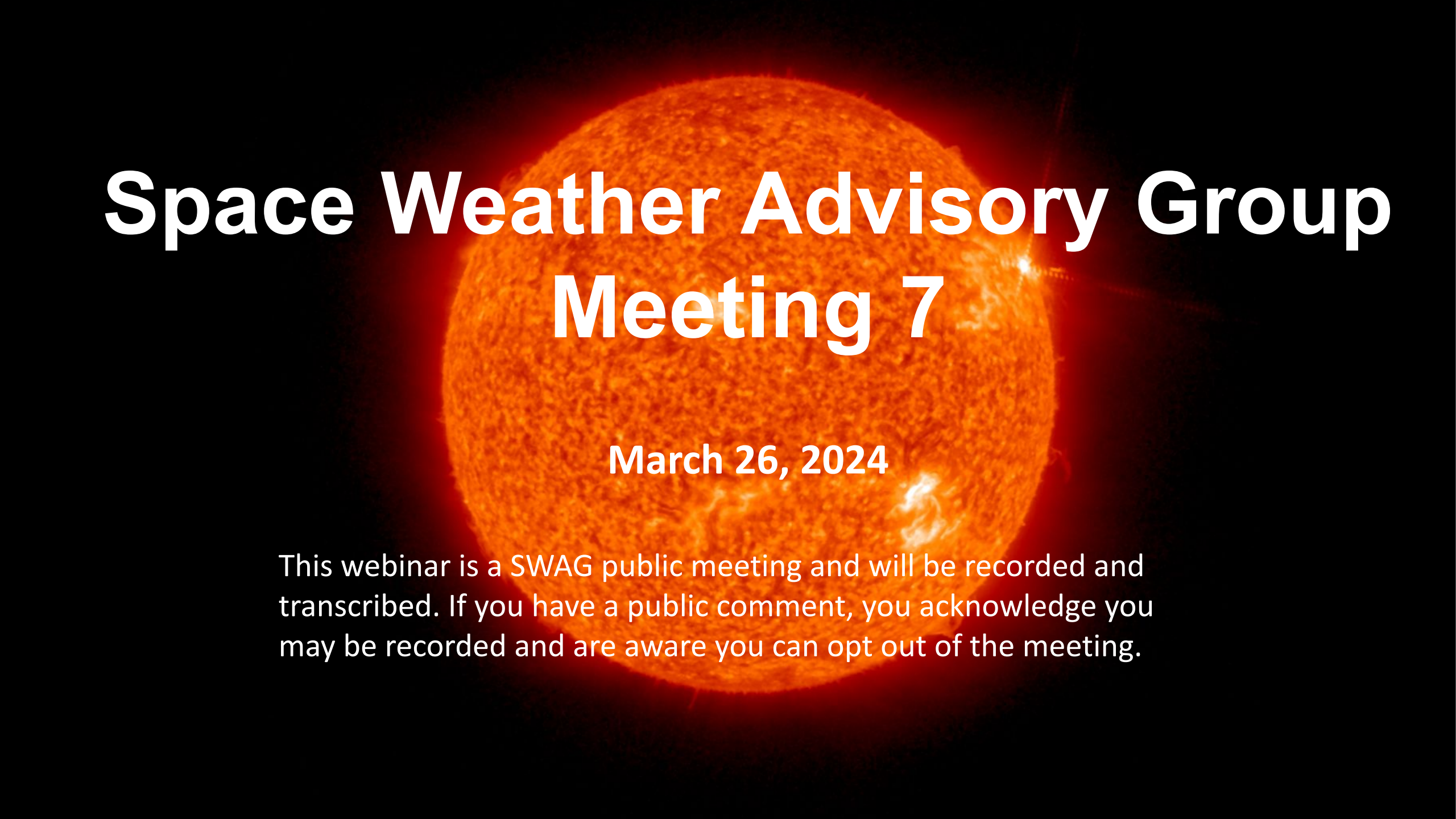


Space Weather Advisory Group Meeting 7

March 26, 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 stakehogonglder 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

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

Tomas Gombosi
University of Michigan, Ann Arbor

George Ho
Southwest Research Institute

Delores Knipp
University of Colorado, Boulder

Scott McIntosh
NSF, National Center for Atmospheric Research, Boulder

Welcoming Remarks from the Chair

Dr. Tamara Dickinson
SWAG Chair
Nongovernmental End User Representative
President, Science Matters Consulting, LLC

Recap of Meeting 5 (March 2022)

- Brief out and discussion of our first report - *Findings and Recommendations to Successfully Implement PROSWIFT and Transform the National Space Weather Enterprise*
- Approved the report

Recap of Meeting 6 (April 2022)

- Update on User-Needs Survey
- Conducting Focus Groups 101
- Mock Focus Group
- Public Comments
- Focus Group 1 - Human Space Flight
- Focus Group 2 - Research
- Focus Group 3 - Space Traffic Management/Coordination
- Lessons Learned from Afternoon Focus Groups

Progress Since Meeting 6

- Release of first report - *Findings and Recommendations to Successfully Implement PROSWIFT and Transform the National Space Weather Enterprise*
  - Space Weather Workshop roll out (April 18) – Tammy Dickinson
  - NASA Space Weather Council (May 10) – Tammy Dickinson
  - SWORM Objective Leads (May 15) – Tammy Dickinson, Seth Jonas, Delores Knipp, and Jenn Gannon
  - NASEM Space Weather Decadal Survey Panel (June 9) – Seth Jonas
  - NASEM Space Weather Roundtable (June 12) – Seth Jonas
  - Space Weather Enterprise Forum (June 22) – Tammy Dickinson, Seth Jonas, Rebecca Bishop, Delores Knipp, and Jenn Gannon
  - CEDAR (June 29) – Rebecca Bishop
  - GMD Workshop (August 15) – Tammy Dickinson
  - House Science staff – (September 5) – Tammy Dickinson and Seth Jonas
  - NOAA Testbed (October 25) – Tammy Dickinson
  - Rethinking Diplomacy Program, Duke Diplomacy Lab (November 7) – Tammy Dickinson, Bill Murtagh and Jinni Meehan
  - NASA Heliophysics Advisory Committee (November 14) – Nicole Duncan
  - Hill Briefing (February 27, 2024) - Tammy Dickinson

Progress Since Meeting 6

- Pivot to User-Needs Survey
  - PRA for User-Needs Survey approved - June 28, 2023
  - Conducted focus groups for all sectors except GNSS
  - Conducted on-line survey for GNSS
  - Presented common themes at AGU and AMS
  - Drafting User-Needs Survey report

Agenda

- Opening Remarks, Progress since and Recap of Meeting 6
- Overview of Today's Meeting
- Update from the SWORM - Jennifer Meehan
- Status of User-Need Survey
- Discussion and Approval of User-Needs Survey Report Findings and Recommendations
- Lunch Break
- Discussion and Approval of User-Needs Survey Report Findings and Recommendations
- Break

Agenda (Continued)

- Discussion and Approval of User-Needs Survey Report Findings and Recommendations
- Public Comment
- Update from Space Weather Round Table - Sara Gibson and Geoff Crowley
- Update from NASA Space Weather Council - Nicole Duncan
- Next Steps and Closing Remarks
- Adjourn

Update from the SWORM

Jinni Meehan
Assistant Director for Space, OSTP
SWORM Co-chair

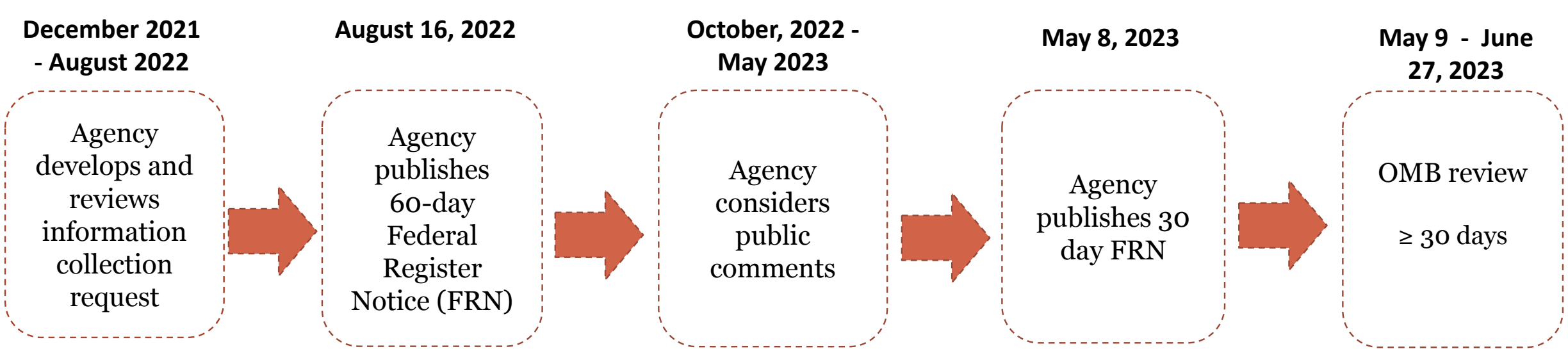
Status of User Needs Survey

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.

Paperwork Reduction Act: Milestones



- The PRA is designed to reduce the amount of paperwork burden imposed by Federal Govt on private business and citizens
- The PRA requires agencies to go through public notice and comment and receive approval from OMB before information is collected

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
  - Chris Cannizzaro, Sharon Williams, Casey Roepke, Asha Balakrishnan, Dan Pechkis
- SWAG members - especially the chairs and co-chairs of the sector working groups

Discussion and Approval of User Needs Survey Report Findings and Recommendations

- Discussion and approval of findings and recommendations to date
  - For presentation at Space Weather Workshop April 16
- Meeting on April 12 to discuss any additional findings and recommendations
- Will be able to revise these if needed as we prepare the full report. Hopefully only minor revision will be needed.
- Full report roll out summer 2024
- 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

Electric Power Sector

Electric Power Sector

Finding 2.1. Validation of GIC models and vulnerability assessments using GIC and magnetic field measurements are a key priority to advance mitigation of the impacts from GIC.

Recommendation 2.1.1. NOAA, (in collaboration with the USGS), should support one or more existing magnetometer arrays and assess priorities for new installations to provide increased public access to geomagnetic field data with adequate coverage, prioritizing areas of higher hazard, to support GIC model validation studies.

Recommendation 2.1.2. NOAA should collaborate with DOE and power industry software providers to integrate geo-electric field maps and estimates into standard power industry software used for GIC studies and GMD vulnerability assessments.

Recommendation 2.1.3. NOAA should invest in infrastructure to ingest magnetic field data from privately-owned sensors into operational geo-electric field models to support industry need for GIC model validation studies.

Electric Power Sector

Finding 2.2. The power industry finds existing space weather alerts and warnings to be useful for triggering preparatory actions prior to onset of a GMD event.

Recommendation 2.2.1. DOE and industry should explore opportunities for developing a new process for direct sharing of real-time GIC data for situational awareness between operators through open access data models and cooperative agreements.

Recommendation 2.2.2 NOAA should continue to validate and evolve predictive models of the geo-electric field to improve forecasting capabilities and alert lead times.

Recommendation 2.2.3. NOAA should support the development of regional and local alerts through private sector partnerships.

Recommendation 2.2.4. NOAA, in collaboration with power industry (particularly the power grid RCs), should identify and implement ways to minimize alert latencies, for example, through the use of automated tools that reduce human intervention in the communication path.

Electric Power Sector

Finding 2.3. Harmonic studies are an important component of assessing GIC risk. Reliability standard requirements in North America specify that system planners must evaluate harmonic impacts on the transmission system and equipment in their GMD vulnerability assessments.

Recommendation 2.3.1. DOE should lead a collaborative effort with the power industry to develop capabilities, guidance, and tools for incorporating GIC-related harmonics in GMD vulnerability assessments and promote widespread adoption and use through standard system planning tools and best practices.

Electric Power Sector

Finding 2.4. Effective GIC mitigation is an interdisciplinary, cross-sector, and community-wide effort, requiring increased collaboration between DOE, the National Labs, and power industry.

Recommendation 2.4.1. DOE, the National Labs, and power industry should collaborate to update vulnerability assessment tools and capabilities.

Recommendation 2.4.2. NOAA and USGS, in collaboration with the space weather commercial sector, should provide expanded training opportunities for the power industry on current capabilities for warnings, alerts, and geo-electric field estimates, including those from the commercial sector.

Recommendation 2.4.3. DHS and DOE should solicit sector representatives to participate with other infrastructure sectors and emergency managers to understand and mitigate risks from interdependencies.

Discussion

Aviation Sector

Aviation Sector

Finding 3.1. There is a lack of framework, policies, education, and training across the aviation industry.

Recommendation 3.1.1. DOT, FAA, NIST, NOAA should coordinate with agencies or entities, including ICAO, ISO, or WMO, to create industry-wide best practices, guidelines, or standards.

Recommendation 3.1.2. The FAA should develop appropriate policies and regulations that enable the aviation industry to respond safely and effectively to space weather conditions.

Recommendation 3.1.3. SWORM should coordinate with suitable entities, including aviation professional associations, colleges and universities, and commercial organizations, to develop appropriate curricula on the causes of, informational sources for, risks to aviation, and mitigation instructions about space weather and its effects on aviation.

Recommendation 3.1.4. SWPC, in collaboration with aviation industry, academia, and commercial space weather organizations, should establish regular testbed training exercises, including simulations, focused on aviation.

Aviation Sector

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

Recommendation 3.2.1. The DOC and NOAA, in collaboration with NASA, NSF, and FAA, should conduct or acquire ionizing radiation measurements at all relevant aviation altitudes and make them available for use by the aviation community.

Recommendation 3.2.2. The FAA in collaboration with SWPC and NASA should develop public facing educational materials that clearly explain the elements of human exposure to radiation when flying at altitudes normally used by commercial and corporate aviation.

Recommendation 3.2.3. The FAA, NASA and NOAA in concert with academia should expand their data reporting and data collection mechanisms to the aviation community in order to obtain scientific measurements which can validate existing models such as FAA CARI and NASA NAIRAS.

Aviation Sector

Finding 3.2. There is a lack of radiation measurements, reporting, limits, education, mitigation, and standardization across the aviation industry. (CONTINUED)

Recommendation 3.2.4. The FAA in collaboration with qualified organizations such as the NCRP and ICRP should establish practicable limits and regulatory guidance for crew and passenger radiation exposure limits based on scientific measurements and validated modeling.

Recommendation 3.2.5. Relevant SWORM agencies should promulgate internationally recognizable best practices, guidelines, or standards–developed by entities such as ICAO, ISO, and WMO–for radiation exposure procedures for use by the aviation community.

Aviation Sector

Finding 3.3. There is a lack of navigation measurements, modeling, and standardization across the aviation industry.

Recommendation 3.3.1. DOT, FAA, and DOD, in collaboration with DOC, should conduct or acquire measured navigational information, including GNSS uncertainties, from the ground to aviation altitudes and make them available for common use by the aviation community.

Recommendation 3.3.2. The FAA, NASA, and SWPC, in concert with academia and industry, should continue to improve and validate existing ionosphere models, enable new and additional measurements of the ionosphere, and support the development of data assimilative modeling for the navigation environment.

Recommendation 3.3.3. Relevant SWORM agencies should promulgate internationally recognizable best practices, guidelines, or standards–developed by entities such as ICAO, ISO, and WMO–for mitigating navigation interruption hazards for use by aviation operators.

Aviation Sector

Finding 3.4. There is a lack of communication measurement, modeling, and standardization across the aviation industry.

Recommendation 3.4.1. DHS, FCC, NTIA, DOT, and FAA should conduct or acquire measured communication information, including HF propagation and UHF uncertainties, from the ground to aviation altitudes and make them available for common use by the aviation community.

Recommendation 3.4.2. The FAA, NASA, and NOAA SWPC, in concert with academia and industry, should continue to improve and validate existing ionosphere models with more measurements, and support the development of data assimilative modeling for the communication environment.

Recommendation 3.4.3. Relevant SWORM agencies should promulgate internationally recognizable best practices, guidelines, or standards–developed by entities such as ICAO, ISO, and WMO–for mitigating communication interruption hazards for use by aviation operators.

Aviation Sector

Finding 3.5. Aviation industry needs accurate forecasts with longer lead times (beyond 12 hours).

Recommendation 3. 5.1. NOAA Office of Ocean and Atmospheric Research (OAR), NASA, and NSF should oversee expanded scientific data collection in time and space as well as coordinate expanded fundamental and applied research to develop accurate, operational space weather forecasts beyond 12 hours.

Aviation Sector

Finding 3.6. There is a lack of threat awareness, protocols, planning tools, and oversight across the aviation industry.

Recommendation 3.6.1. The FAA, in collaboration with the aviation industry, and NOAA should develop a thorough space weather threat analysis that can become the framework for a SMS (Safety Management System).

Recommendation 3.6.2. The FAA, in collaboration with the aviation industry, DOC NOAA, and NASA, should develop regulations and policies that address mitigation strategies and solutions to space weather related disruptions.

Discussion

Space Traffic Management/Coordination

Space Traffic Management /Coordination

Product Acquisition and Availability

Finding 5.1. A framework is needed to acquiring, validating and sharing inferred ND values.

Recommendation 5.1.1. NOAA, working with the commercial sector, should invest in data-collection and information-sharing that informs estimates of ND.

Recommendation 5.1.2 NOAA Space Weather Observations (SWO) and SWPC, working with the broader Space Weather Enterprise, should develop: new observations, paths for acquiring satellite constellation ND information, and new forecasting capabilities for lower thermosphere (VLEO to LEO).

Space Traffic Management /Coordination

Product Acquisition and Availability

Finding 5.2. Environmental input parameters need to be maintained and archived for ND Models.

Recommendation 5.2.1. NCEI and SWPC should expand and maintain archives of indices and proxies.

Recommendation 5.2.2. NASA and NOAA should improve cross-agency investment for transitioning measurements to operational products.

Space Traffic Management /Coordination

Product Acquisition and Availability

Finding 5.3. Users need availability of quality-defined Neutral Density (ND) model output and product information.

Recommendation 5.3.1. NCEI and SWPC should work with users via focus groups, testbed exercises and workshops to determine format and documentation requirements for ND information.

Recommendation 5.3.2. SWPC, in collaboration with provider and user communities, should include and document uncertainties associated with all ND related products.

Space Traffic Management /Coordination

Product Acquisition and Availability

Finding 5.4. Users need accessible long-term neutral density databases for model validation.

Recommendation 5.4.1 NCEI and SWPC should determine the cause of latency in data and model output availability and develop and implement a plan to address it.

Recommendation 5.4.2 NOAA, NCEI, and SWPC should develop and implement a sustainable plan for archiving ND model output in a database that is stable, accessible, interoperable, machine-readable with modern change- and outage-notification protocols.

Space Traffic Management /Coordination

Development and Validation

Finding 5.5. Users need near-term ND forecast improvements and model development.

Recommendation 5.5.1. SWPC should extend and continue its engagement with the user community to determine developmental needs for forecast cadence and resolution and latitude requirements for ND forecasting, thresholds for alerts and warnings, and need for neutral winds.

Recommendation 5.5.2. As part of the Operations to Research (R2O2R) process, NOAA SWO, SWPC, NASA, NSF, and DOD should work with satellite owners/operators in all altitude regimes to facilitate data acquisition and sharing for improving ND nowcasting and forecasting.

Recommendation 5.5.3. SWPC and academic and commercial model developers should strive for two-way coupling in their models.

Recommendation 5.5.4. NASA, NSF, in collaboration with industry should invest in science and machine learning underpinnings of reduced order models (ROMs) to support on-orbit LEO constellation operations.

Space Traffic Management /Coordination

Development and Validation

Finding 5.6. Users need long-term ND forecast improvements and model development for conjunction assessments.

Recommendation 5.6.1. NASA, NOAA, NSF, and DOD should support research and development for ND forecasts extending from three to seven days to meet the needs of the STM/C community, in particular service providers such as OSC Traffic Coordination System for Space (TraCSS) and commercial product developers.

Recommendation 5.6.2. NASA, NOAA, NSF, and DOD should invest in observational capabilities. Develop and deploy priority operational instrumentation that will enable forecasts for multi-day epochs. International collaborations should be supported.

Recommendation 5.6.3. NOAA and research community should develop ensemble modeling capability that parallels ensemble capabilities in terrestrial weather forecasting. Users generally agreed that ensemble ND modeling is an important long term goal.

Space Traffic Management /Coordination

Development and Validation

Finding 5.7. Users need long-term solar cycle model development for forecast improvements.

Recommendation 5.7.1. NASA and NSF should fund research in solar (cycle?) forecasting that supports long-term mission planning.

Space Traffic Management /Coordination

Development and Validation

Finding 5.8. Users need regularly scheduled ND model validation as a key component of R2O.

Recommendation 5.8.1. NOAA OAR, in collaboration with SWPC, should publish systematic validations of Whole Atmosphere Model-Ionosphere Plasmasphere Electrodynamics (WAM-IPE) as part of a continuing R2O process.

Recommendation 5.8.2. Relevant SWORM agencies should include validation protocols in future federally funded ND modeling intended for R2O.

Space Traffic Management /Coordination

Dissemination and Other STM/C Concerns

Finding 5.9. Users need clarity about notification of ND forecast updates, especially those relating to abrupt changes.

Recommendation 5.9.1. SWPC should expand dissemination of ND alerts and forecast descriptions.

Space Traffic Management /Coordination

Dissemination and Other STM/C Concerns

Finding 5.10. Participants want clarity about how space weather information is being used in the Office of Space Commerce TraCSS.

Recommendation 5.10.1. NOAA and DOC OSC should clarify to the broad STM/C community how actual and forecast changes in ND will feed into conjunction risk assessment algorithms.

Recommendation 5.10.2. When OSC's TraCSS becomes operational in late 2024, OSC in collaboration with NOAA SWO and SWPC should evaluate and quantify the influence of space weather ND information on the conjunction risk assessments.

Space Traffic Management /Coordination

Dissemination and Other STM/C Concerns

Finding 5.11. Beyond ND information, satellite constellation operators and product developers need data and information about the LEO charging and radiation environment as well as the radio communication environment for current operations and anomaly resolution.

Recommendation 5.11.1 The SWORM should coordinate with users across the National Space Weather Enterprise and invest in information-sharing that supports real-time charging and radiation-environment characterization and prediction across the broad LEO regime.

Recommendation 5.11.2. SWPC, in collaboration with STM/C industry, academia, and commercial space weather organizations, should establish regular testbed training exercises, including simulations, focused on STM/C.

Space Traffic Management /Coordination

Dissemination and Other STM/C Concerns

Finding 5.11. Beyond ND information, satellite constellation operators and product developers need data and information about the LEO charging and radiation environment as well as the radio communication environment for current operations and anomaly resolution. (CONTINUED)

Recommendation 5.11.3 OAR, academia, and commercial developers should collaborate to develop and produce compact charging sensors that would jointly serve on-orbit environment characterization and research needs.

Recommendation 5.11.4 SWPC and relevant agencies within SWORM should collaborate with LEO users to determine if SWPC products that support the ICAO-2018 mandate for aviation communications and radiation advisories can be extended to meet the needs of LEO users.

Space Traffic Management /Coordination

Dissemination and Other STM/C Concerns

Finding 5.12. The user community needs reliable information on GNSS signal disruption associated with space weather.

Recommendation 5.12.1. SWPC should determine if products from the 2020 ICAO aviation space weather advisory system are sufficient to meet STM/C needs.

Recommendation 5.12.2. Relevant SWORM agencies should coordinate with users across the National Space Weather Enterprise to invest in information-sharing that supports real-time radio communications characterization and prediction across the VLEO to LEO regime.

Recommendation 5.12.3. SWAG should continue to investigate GNSS reliability needs in the upcoming GNSS User Needs Survey and Satellite Operations User Needs Survey.

Space Traffic Management /Coordination

SWAG Recommendations

Finding SWAG 5.1. There is a need for implementation of a near-term ND forecast strategy.

Recommendation SWAG 5.1.1. SWORM should update its 2024 Implementation Plan to provide a path forward for observing, modeling and forecasting thermospheric quantities needed 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..

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.

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.

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.

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.

Discussion

LUNCH BREAK
12:00 - 12:30 pm ET

Emergency Management Sector

Emergency Management Sector

Finding 6.1. There is not consistent or sufficiently broad awareness of space weather and its effects across the EM community.

Recommendation 6.1.1. FEMA's Preparing the Nation for Space Weather Events Independent Study Course (IS-0066) should be incorporated into EM required training and education.

Recommendation 6.1.2 Space weather is an event of national security and national economy that has national significance. Therefore, Congress or OMB should consider requiring IS-0066 training to receive EM grants.

Recommendation 6.1.3. FEMA, in collaboration with SWPC, should develop tabletop exercise packages for state, local, and tribal governments. Exercises should address impacts of space weather events.

Recommendation 6.1.4. FEMA, in collaboration with the National Security Council Staff, should incorporate space weather into the FEMA National Exercise Program schedule.

Emergency Management Sector

Finding 6.2. EMs need more information on the impacts of space weather, including cascading impacts, across the broad set of national critical functions and/or infrastructure services.

Recommendation 6.2.1. NOAA should develop forecasts that include the impacts of space weather events on critical infrastructure similar to what they are doing for terrestrial weather events.

Recommendation 6.2.2. NOAA, in collaboration with the commercial sector, should produce visualizations similar to the USGS/NOAA near-real time geoelectric field mapping product.

Emergency Management Sector

Finding 6.3. EMs need space weather forecasts linked to regional space weather effects, including infrastructure, system, and service dependencies.

Recommendation 6.3.1. NOAA and the commercial sector should cooperate to develop regionalized products for EM.

Recommendation 6.3.2. NOAA, in collaboration with the commercial sector, should develop more regionalized forecasts with impact- and geographic-specific space weather information. NOAA may need to involve social science experts to assist in determining what data, models, and research they need to implement this recommendation.

Emergency Management Sector

Finding 6.4. EMs need to be able to better understand what they need to do during the response phase of a space weather event.

Recommendation 6.4.1. FEMA in collaboration with NOAA SWPC should work with state, local, and tribal EMs to evolve EM tool kits to address the impacts of space weather within their community, including coordination of EM functions with infrastructure service providers across their region, and planning and exercising for space weather response and recovery.

Discussion

Research Sector

Research Sector

Planning and Investment

Finding 7.1. The national space weather enterprise needs an integrated and detailed functional implementation plan that enables appropriate research efforts to support the National Space Weather Enterprise.

Recommendation 7.1.1. SWORM should initiate a detailed implementation plan to optimize, prioritize, and sequence actions necessary to advance space weather forecast capability.

Research Sector

Planning and Investment

Finding 7.2. Focusing on the full Research-To-Operations ('R2O') and Operations-to-Research ('O2R') cycle is critical to improving space weather nowcasting, forecasting, and mitigation.

Recommendation 7.2.1. NOAA, NASA, NSF and DOD should improve coordination during the selection and development process throughout the complete R2O-O2R cycle.

Recommendation 7.2.2. NOAA, NASA, NSF, USGS, and DOD should improve the R2O-O2R development process by developing standards and common procedures for testing nowcasting and forecasting capabilities.

Research Sector

Planning and Investment

Finding 7.3. An Observing System Simulation Experiment (OSSE) framework is required to assess the impact of future potential observing systems for forecasts and predictions.

Recommendation 7.3.1. NASA, NOAA, NSF, USGS, and DOD should collaboratively invest, in consultation with the research community, to develop a framework relying on OSSE analysis for prioritizing space weather observations.

Research Sector

Planning and Investment

Finding 7.4. The users repeatedly expressed concern regarding the current inadequate investment in key aspects of space weather observational capabilities and infrastructure required for improving space weather forecasting.

Recommendation 7.4.1. NASA, NOAA, NSF, DOD, and USGS should preserve existing, and develop redundancy for, key long-term historical (multi-decadal) observations.

Research Sector

Planning and Investment

Finding 7.5. The users highlighted the need for next generation computational resources and data analysis techniques for application to space weather research.

Recommendation 7.5.1. NASA, NOAA, and NSF should expand investment in and use of new computing architectures and resources.

Research Sector

Sensor Development

Finding 7.6. The surveyed researchers emphasized the need for improved spatial and temporal observations required to enable research leading to improved space weather forecasting.

Recommendation 7.6.1. NOAA, NASA, NSF, USGS, and DOD, in collaboration with commercial sector, should increase space weather observation capability through in-situ sampling instrumentation, ground- and space-based sensors and associated ground infrastructure in order to increase overall downlink capacity.

Recommendation 7.6.2. To fill observational gaps, NASA, NOAA, NSF, USGS, and DOD, in collaboration with the commercial sector, should develop, test, and deploy new ground, airborne, and space-based instrument designs that use fewer resources (e.g., lower mass and power) informed by OSSE backed analysis.

Recommendation 7.6.3. NASA, NSF and DOD should work with commercial providers and research community to develop robust platforms to reduce risk and cost, and prioritize increased reliability, availability, and spatial sampling of space-based systems.

Research Sector

Product Acquisition and Availability

Finding 7.7. The users strongly stated the need for accessible historical and ongoing critical measurements that are integral for improving, verifying, and validating space weather research and forecast capabilities.

Recommendation 7.7.1. NASA, NOAA, DOD, DOE, national labs, and the commercial sector should work together to include ‘housekeeping’ and metadata as data products for all space-based environmental instrumental datasets.

Recommendation 7.7.2. NASA, NOAA, NSF, and DOD should archive and maintain existing and future space weather, solar, space physics, and geophysical data.

Research Sector

Product Acquisition and Availability

Finding 7.8. The users stated that many long standing observations (e.g. F10.7, Kp, magnetograph flux maps, sunspot number) are critical inputs for testing new nowcasting or forecasting capabilities.

Recommendation 7.8.1. NOAA, NASA, NSF, USGS, and DOD should adequately support the maintenance, validation, and calibration of existing key space weather ground-based, space-based, and airborne network and sensor data.

Recommendation 7.8.2. NOAA, NASA, NSF, USGS, and DOD should augment the facilities' infrastructure and instrumentation capabilities to obtain real time or near real time observations.

Research Sector

SWAG Findings and Recommendations

Finding SWAG 7.1. Non-Keplerian observations are required to improve forecast lead time and accuracy.

Recommendation SWAG 7.1.1. NASA should develop and demonstrate pointing stabilized alternative propulsion methods.

Recommendation SWAG 7.1.2. NASA should develop, demonstrate and deploy compact small-satellite buses to rapidly explore non-Lagrangian points along the Sun-Earth line, off the Sun-Earth line, and out of the ecliptic plane.

Research Sector

SWAG Findings and Recommendations

Finding SWAG 7.2. Key observation types are needed for accurate now-casts and longer-range forecasts and general Sun-Earth System understanding.

Recommendation SWAG 7.2.1. NASA and NSF should develop ground- and space-based imaging and coronagraphic technologies to characterize the magnetic field of the Sun's corona.

Recommendation SWAG 7.2.2. NASA and NSF should develop ground- and space-based spectroscopic imaging technologies to characterize the velocities of the Sun's atmosphere.

Discussion

Human Space Flight Sector

Human Space Flight Sector

Finding 4.1. Radiation measurements, modeling and tools must be a priority for commercial human space flight (HSF).

Recommendation 4.1.1. NASA and NOAA, in collaboration with DOC OSC, DOE, DOD, industry, and academia, should conduct or acquire ionizing radiation measurements, including dose, dose rate changes with high time resolution, at all relevant flight altitudes (suborbital, LEO, deep space, Moon, and Mars).

Recommendation 4.1.2. NASA and NOAA, in collaboration with DOC OSC, FAA, DOE, DOD, industry, and academia, should continue to improve and validate existing U.S. radiation models.

Recommendation 4.1.3. The DOC OSC, NOAA, NASA, FAA, DOE, and DOD, in collaboration with industry and academia, should fund the development of tools that commercial companies can use to specify the local radiation environment based on their specific systems and locations.

Human Space Flight Sector

Finding 4.2. There is a lack of Lunar and Mars-centric space weather tools.

Recommendation 4.2.1. NASA and NOAA, in collaboration with NSF, industry, and academia as well as with advice from the Decadal Survey, should consider acquisition of space weather particles and fields measurements at and near the Moon and Mars as well as other HSF-relevant locations and make them available for common use by the human space flight community.

Recommendation 4.2.2. NASA and NOAA, in collaboration with NSF, industry, and academia, should continue to improve and validate existing models of Moon and Mars radiation environments.

Recommendation 4.2.3. NOAA and NASA, in collaboration with the commercial sector, should support the development of real-time, automated flare location products and CME solar system forecasts.

Recommendation 4.2.4. NOAA should develop space weather indices for human space flight relevant environments.

Human Space Flight Sector

Finding 4.3. There is a lack of measurements and models for design.

Recommendation 4.3.1. The DOC OSC, NOAA, NASA, FAA, DOE and DOD, in collaboration with industry and academia, should improve accuracy of radiation dose measurements for astronauts and private mission crews through improved monitoring and modeling of dynamic regions such as the South Atlantic Anomaly.

Recommendation 4.3.2. The DOC OSC, NOAA, NASA, DOE, and DOD should support development of on-board sensor suites of particles and fields detectors in support of both public and private sector missions.

Recommendation 4.3.3. NOAA, NASA, and NSF should consider the support of existing ground-based neutron monitor networks in its prioritization of ground-based measurements.

Human Space Flight Sector

Finding 4.3. There is a lack of measurements and models for design. (CONTINUED)

Recommendation 4.3.4. NOAA SWPC, in collaboration with DOC OSC and NASA, should support the collection, validation, and timely distribution of space weather measurements, including those by the commercial sector, and support the development of models in the academic and commercial sectors.

Recommendation 4.3.5. NOAA, NSF, and NASA should fund the development of models and tools that improve the accuracy of forecasting and predictions for a launch date plus 3 days and for flight readiness reviews at least 2 weeks out.

Recommendation 4.3.6. NOAA, in collaboration with NSF, NASA, industry, and academia, should develop climatology models specific to Mars and Lunar environments, to enable long-term planning and mission design.

Human Space Flight Sector

Finding 4.4. There is a lack of regulatory oversight.

Recommendation 4.4.1. The SWORM with inputs from FAA, NASA, DOC OSC, NIOSH, and OSHA, in collaboration with industry and academia, should improve the language of CFR PART 460—HUMAN SPACE FLIGHT REQUIREMENTS.

Recommendation 4.4.2. The SWORM should determine an appropriate method for establishing policy and regulatory guidance for limiting crew and passenger radiation exposure.

Human Space Flight Sector

SWAG RECOMMENDATIONS

Finding SWAG 4.1. There is a need for a gap analysis.

Recommendation SWAG 4.1.1. NASA should fund a gap analysis study across agencies, academia, and industry to ensure all facets of the human space flight sector are able to identify mitigation strategies and provide actionable solutions for space weather related disruptions.

Human Space Flight Sector

SWAG RECOMMENDATIONS

Finding SWAG 4.2. There is a need for continuing space weather enterprise engagement.

Recommendation SWAG 4.2.1. The SWORM should create a suitable process across agencies, academia, and industry that ensures all facets of how space weather affects the human space flight sector can be utilized to provide fundamental knowledge, quality measurements, validated models, and actionable solutions through user-friendly tools for space weather related disruptions.

Human Space Flight Sector

SWAG RECOMMENDATIONS

Finding SWAG 4.3. There is a lack of micrometeoroid and debris measurements and modeling.

Recommendation SWAG 4.3.1. NASA and NOAA, in collaboration with DOC OSC, DOE, DOD, industry, and academia, should conduct or acquire measurements of Micrometeoroids and Orbital Debris (MMOD) in the millimeter to centimeter size range at LEO flight altitudes and make them available for use by the human space flight community.

Recommendation SWAG 4.3.2. NASA and NOAA, in collaboration with DOC, OSC, FAA, DOE, DOD, industry, and academia, should continue to improve and validate existing U.S. MMOD models for LEO that extend in time out to 25 years or two solar cycles.

Recommendation SWAG 4.3.3. NASA and NOAA, in collaboration with NSF, industry, and academia, should continue to improve and validate existing models of Moon and Mars dust environments.

Discussion

GNSS Sector

GNSS Sector

- Extremely large sector with many types of users and technologies relying on integrated GNSS data and systems
  - Sector broken into two focus areas based on dependency:
    - Precise Timing
    - Position/Navigation
- Each area broken into “community groups”

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

GNSS Sector

Fundamental questions to be addressed:

1. *What is the threshold of GNSS outage or degradation that will adversely affect an individual community/application?*
2. *Can space weather events exceed that threshold?*

- Sector survey to be conducted over 2 years.
- Combination of web survey and small panel in-depth interviews
- Year 1 Communities Surveyed:
    - **Communications Networks** (e.g., wireless access services, satellite access services, and internet connection, routing, and access services)
    - **Manufacturing** (e.g., robotics, chemical production, fuel refining and processing)
    - **Distribution** (e.g., pipeline transport, water distribution, electricity distribution)
    - **Land Usage** (e.g., construction, land survey, mining & drilling exploration, agriculture)
    - **Public Safety & Services** (e.g., cyber incident management, fire protection, hazardous material management, law enforcement)

GNSS Sector

- Online survey opened in November 2023
  - 44 total responses
  - Survey completion: 18 responses >75%, 7 responses 19-74%
- Preliminary impression:
  - Lack of understanding among general end users of either GPS technology, basic Space Weather, or both.
- Next Steps:
  - Organize panel survey sessions with at least 2 members of each community.

Community	Survey %
Communication	23
Land Usage	14
Public Safety	9
Distribution	7
Manufacturing	0
Not Specified	48

Discussion

Overarching

- Forecast regionalization and impacts
- Education (training) and Testbeds (including funding for testbed)
- Expansion of data including data archives, resolution, and accessibility
- Reduce latency on alerts
- Uncertainty Quantification
  - Validation - data, models, instrumentation
- Public Private Partnerships
- Industry to industry data sharing - progress from sharing to govt to sharing among companies
- Funding - as in report 1 (Tamas Interstellar probe issue)
- Automation of information dissemination

Overarching (2)

- Model validation (goes with data expansion)

Prioritization

Energy -

Mag data close to power system. validation

Aviation -

Defining aviation workers as rad workers SWG 3.3

STM/C -

ND data

HSF -

automation and data types needed

Research -

Data availability from the overarching list. Increase in coverage

EM -

regionalized forecasted impact

Transformative

- Non-Keplerian orbits (research)
- Utilize proliferated constellations to obtain ND coverage (STM/C)
- Aviation crew working in high rad env. (aviation)
- Develop next gen ground infrastructure for increased telemetry capacity (Research) (add relay)
- New technologies to observe solar wind before it arrives at destination
- Understanding the EM system
- Interdisciplinary workforce (research) maybe the education piece

Low-Hanging Fruit

- Make data we do have accessible and in an archive
- Data buys or ingest commercial and academic instrumentation/data
- Make more current data available? ODR (Kent)
- R2O2R - models and products that are ready to ingest data (seth)
- Testbeds - create regular testbed activity (seth)

BREAK
2:45 - 3:00 pm ET

Public Comments
3:45 - 4:00 pm ET

Space Weather Roundtable Update

Geoff Crowley and Sarah Gibson,

Co-Chairs of NASEM Space Weather Roundtable

NATIONAL ACADEMIES Sciences Engineering Medicine

The National Academies Space Weather Roundtable

Geoff Crowley, Ph.D. (Co-Chair)
Sarah Gibson, Ph.D. (Co-Chair)
Art Charo, Ph.D. Space Studies Board

Space Weather Roundtable

Formed in response to the Promoting Research and Observations of Space Weather to Improve the Forecasting of Tomorrow Act (PROSWIFT Act → "Government-University-Commercial Roundtable on Space Weather"; 2020)

- Charged with facilitating communication and knowledge transfer among Government participants in the Space Weather Operations, Research, and Mitigation (SWORM) Interagency Working Group, the academic community, and the commercial space weather sector.

- Discuss activities to:
  - facilitate advances in space weather forecasting
  - increase coordination of space weather research-to-operations and operations-to-research
  - improve preparedness for space weather events.

- Meetings:
  - Monthly telecons
  - 3rd In-person Meeting January 17-18, 2024

	Art Charo
	Geoffrey Crowley Sarah Gibson
1	Hazel M. Bain
2	Anthea J. Coster
3	Jennifer L. Gannon
4	Janet C. Green
5	Justin C. Kasper
6	Delores Knipp
7	Louis J. Lanzerotti
8	Mark H. MacAlester
9	M. Granger Morgan
10	Omar A. Nava
11	Geoffrey D. Reeves
12	Michael Starks
13	Leonard Strachan Jr.
14	Drew L. Turner
15	Louis W. Uccellini
16	Shasha Zou
	Mangala Sharma (NSF)
	Genene Fisher (NASA)
	James Spann (NOAA)

Roundtable in Relation to Other Space Weather Committees

Space Weather Advisory Group (SWAG): Also created by PROSWIFT, formally advises SWORM.

Space Weather Council (SWC): Advises NASA's Heliophysics Advisory Committee.

Unlike SWAG and SWC, Roundtable is not FACA and does not make recommendations. Allows for frank, deep dive discussions of orphan issues.

Overlapping membership. Frequent communication between leadership of SWAP, SWC, and Roundtable

US Space Weather Committees and their Members

SWAG (15 members)

Craig Fugate (FEMA, ret)	Tammy Dickinson (Sci. Matt.) *CHAIR*						
Michael Stills (FAA, ret)	Tomas Gombosi (U. Mich.)	Delores Knipp (CU)					
Rebecca Bishop (Aero)	Seth Jonas (LMCO)	Jennifer Gannon (CPI)					
George Ho (APL)	Conrad Lautenbacher (GeoOptics)						
Scott McIntosh (NCAR)	Kent Tobiska (SET)	Nicole Duncan (Ball) *CHAIR →*					
Mark Olson (NERC)	Heather Elliott (SWRI)						

Roundtable (18 members)

			Mark MacAlester (CISA)	Leonard Strachan, Jr (NRL)	Michael Starks (AFRL)	Omar Nava (USAF)	Lou Uccellini (UMD)
			Shasha Zou (U. Mich.)	Anthea Coster (MIT)	Granger Morgan (CMU)	Hazel Bain (CIRES)	Lou Lanzerotti (NJIT)
			Justin Kasper (BWXT)	Geoff Crowley (Orion) *Co-CHAIR*	Sarah Gibson (NCAR) *Co-CHAIR*	Geoff Reeves (LANL)	Drew Turner (APL)
			Janet Green (Spa. Haz.)				
			Dan Baker (CU/LASP)	Piyush Mehta (WVU)	TBD	TBD	Paul O'Brien (Aero)
			Ron Turner (Anser)	Michele Cash (NOAA)	Alexa Halford (NASA)	Sage Andorka (USSF)	Angelos Vourlidas (APL)

SWC (12 members)

INSTITUTION TYPES

- 11 Academia
- 8 For-Profit
- 8 FFRDC/UARC
- 4 Individual / Consultant
- 4 DoD Civil Servant
- 3 USG Civil Servant
- 3 Non-Profit

POCs

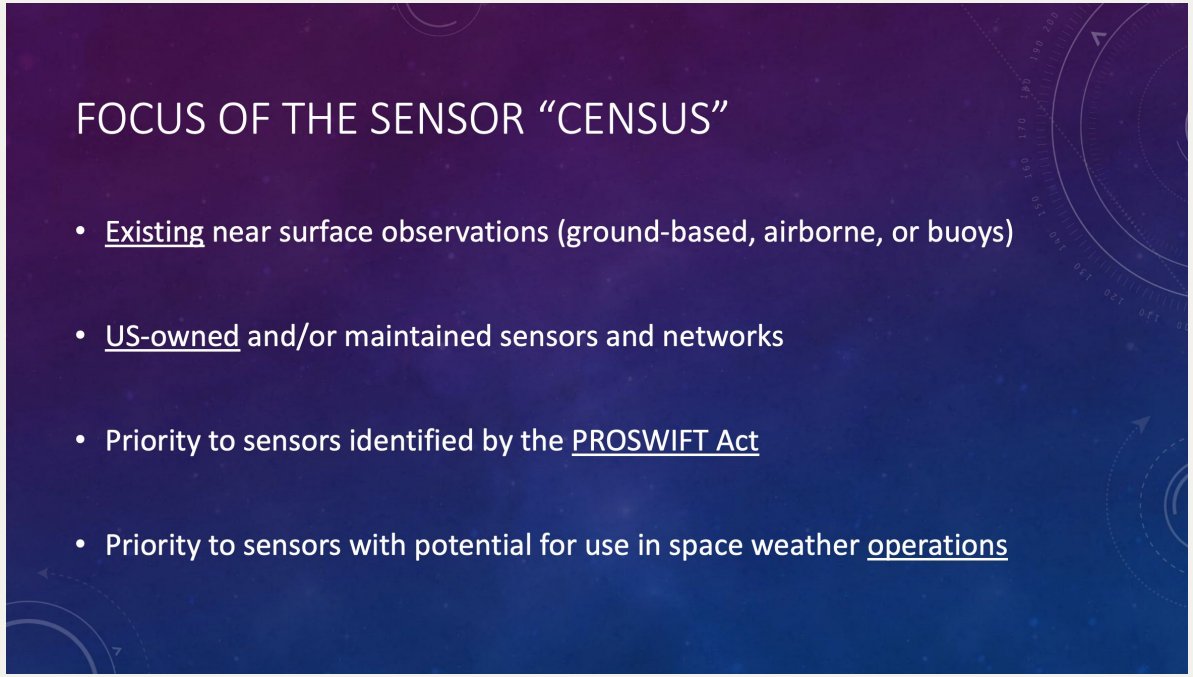
SWAG
Jennifer Meehan
jennifer.meehan@noaa.gov

Roundtable
Arthur Charo
acharo@nas.edu

SWC
Kelly Korreck
kelly.e.korreck@nasa.gov

~Deep-Dive Topics (sub-groups)

- **Ground-based Observations for Space Weather – Jan, Feb, April 2023 monthly telecon discussions, "Closure Session" at in-person meeting in June and final presentation by Gannon in August 2023 telecon**



National Academies Space Weather Roundtable, Past Events, August 22, 2023, Jenn Gannon

- **Space Weather Benchmarks – July, August, September discussions with presentations by G. Reeves and M. MacAlester, and September guest C. Canizerro and S. Jonas**

June 1-2, 2023 In-person Meeting: Sessions

- **Reports from SWAG/SWC** (Seth Jonas, Jinni Meehan, Nicole Duncan)
- **Discussion of Space Weather Benchmarks** (Geoff Reeves, Mark Olson, Bill Murtagh)
  - Goal of establishing unified benchmarks for gov't + industry
- **Research to Operations/Operations to Research (R2O/O2R)** (Genene Fisher, Shea Hess Webber, Humberto Godinez, Janet Green)
  - Functional issues: need for new workforce, new ways of doing business
- **Lessons Learned from Terrestrial R20/O2R** (Nikki Prive, Elsayed Talaat)
  - Observing System Simulation Experiments (OSSEs): where/how they are useful
  - Data Buys: progress, risk mitigation
- **Geospace Dynamics Constellation (GDC)** (Katherine Garcia-Sage, Paul O'Brien, Dan Baker, RT ex-officio)
  - Top recommendation of 2012 Heliophysics DS; explicit Space Weather impact; currently 'on pause`
  - 'A big bright light' on fundamental questions underlying Space Weather science.
- **Ground-based Observing Networks and Space Weather** (Jenn Gannon, Mike Farrar, Mark Engebretson, Asti Bhatt, Mike Hartinger, Anthea Koster, Dave Mencin, Glen Mattioli, Eric Donovan)
  - Orphan area – NSF does research, NASA and NOAA-NESDIS does space-based.
  - Networks are aging, nodes are disappearing, and plans for transition to operations generally unsupported. *SWAG/SWORM recommendations**
  - Lessons learned from terrestrial: multi-agency/commercial 'weird matrix of funding'.

June 1-2, 2023 In-person Meeting: Discussion Themes

- **What does the new R2O-O2R workforce look like?**
  - Researchers trained in operational requirements, user needs
  - Software engineers experienced in transitioning to operational frameworks and with access to computational resources for the transition
  - Liaisons between research and operational communities (opportunity for small businesses?)
  - Operational communities with clear guidelines/procedures for Observing System Simulations Experiments (OSSE) implementation
- **We've trodden this ground before…**
  - The SWAG recommendations are similar to those from the National Space Weather Program 20 years ago, with increasing interest in the operational side
  - Ground-based observing networks were the subject of the NASEM Distributed Array of Small Instruments (DASI) workshop report (2006); an NSF magnetometer facility was recommended in its Geospace Portfolio Review.
- **How can we be more intentional in proritizing/planning/sustaining the space weather enterprise?**
  - Who owns ground-based space weather observations? Should such networks become facilities?
  - The 'pause' on Geospace Dynamics Constellation — with its real time data stream of thermospheric (neutral) densities at a time when satellites in LEO are steadily increasing (and with them the danger of space debris) — is an alarming development.

January 17-18, 2024 In-person Meeting: Sessions

- **Reports on Related Efforts**
  - SWAG User Survey (Tammy Dickinson)
  - SWORM Implementation Plan (Jinni Meehan, Ken Graham)
  - SWC (Janet Green)
- **Discussion:**
  - Benchmarks & Scales; SWORM actions
    - long-term reanalysis, is it orphan?
  - Modeling Gap Analysis (Piyush Mehta, Angelos Vourlidas)
    - is there a need for a deep-dive by RT on this?
- **SWPC Testbed** (Jinni Meehan for Bill Murtagh, Tzu-Wei Fang, Eric Adamson)
  - Scales, New Products, R2O2R Readiness Levels
  - Proving Grounds vs Testbeds? How evaluated? Unfunded mandate?
- **Cislunar and Beyond -- Radiation Environment**
  - ARTEMIS (Yari Collado-Vega)
  - SRAG (Ricky Egeland, Katie Whitman)
  - SWPC (Kim Moreland for Hazel Bain)
  - Spacecraft charging (Linda Parker)
  - NASA Engineering/Safety (Joe Minow)
- **Strengthening the Partnership between DOD and Civil to Advance Space Wx Enterprise**

January 17-18, 2024 In-person Meeting: Discussion Themes

- **How to improve communications between research and operations**
  - Is there a missing forum? How do researchers find out what operators want and vice verse?

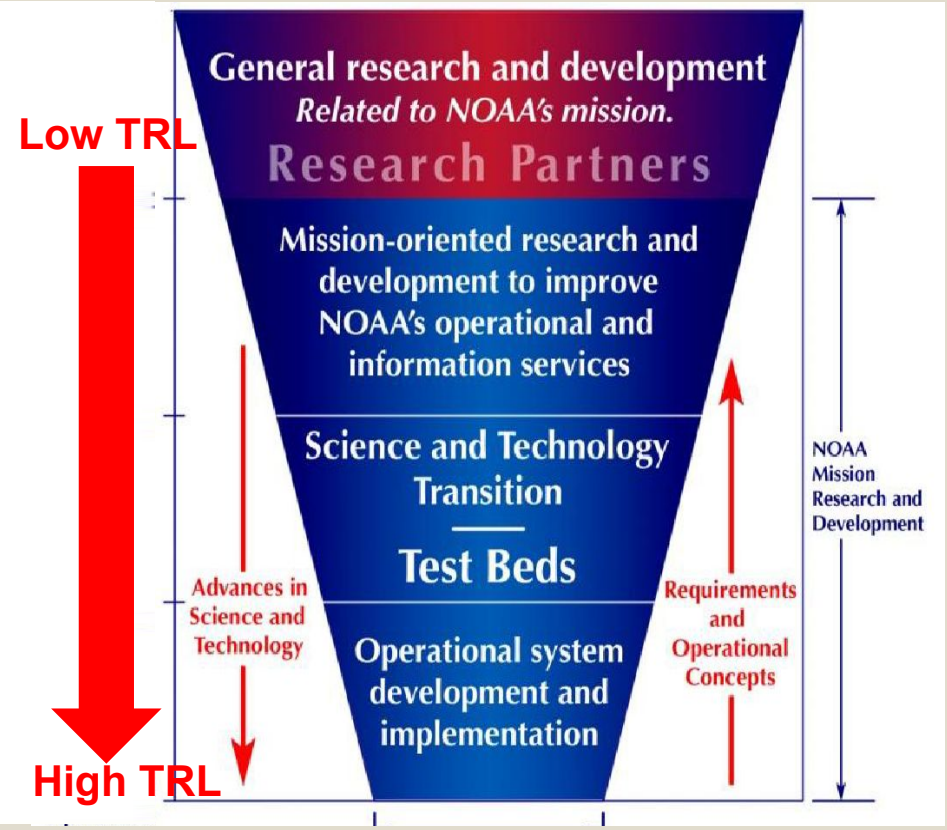
- **R2O2R**
  - A recurring theme at Roundtable
  - Difficulties with transition R2O – different skills than research, and funding (where/who/how)
  - Role of commercial?
  - Effectiveness of readiness levels?
  - Tabletop exercise O2R – outbrief and deep dive? Consequences of not filling gaps…

- **Engaging civil and DOD**
  - Deeper discussion of evaluation, mitigation and response
  - Identifying synergies

- **Still concerned about GDC**

- **Looking forward to Decadal Survey….**

Space Weather Roundtable: R2O2R

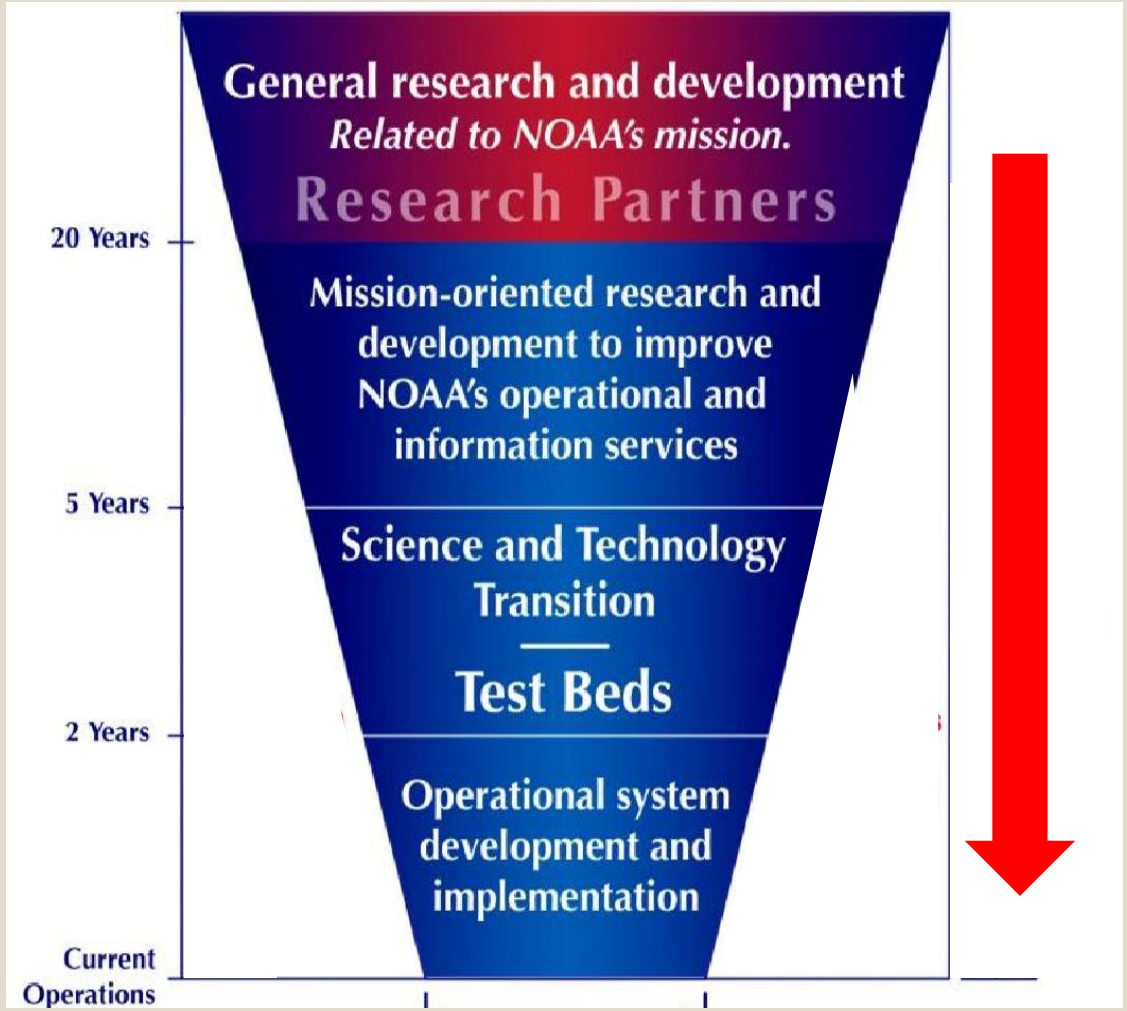


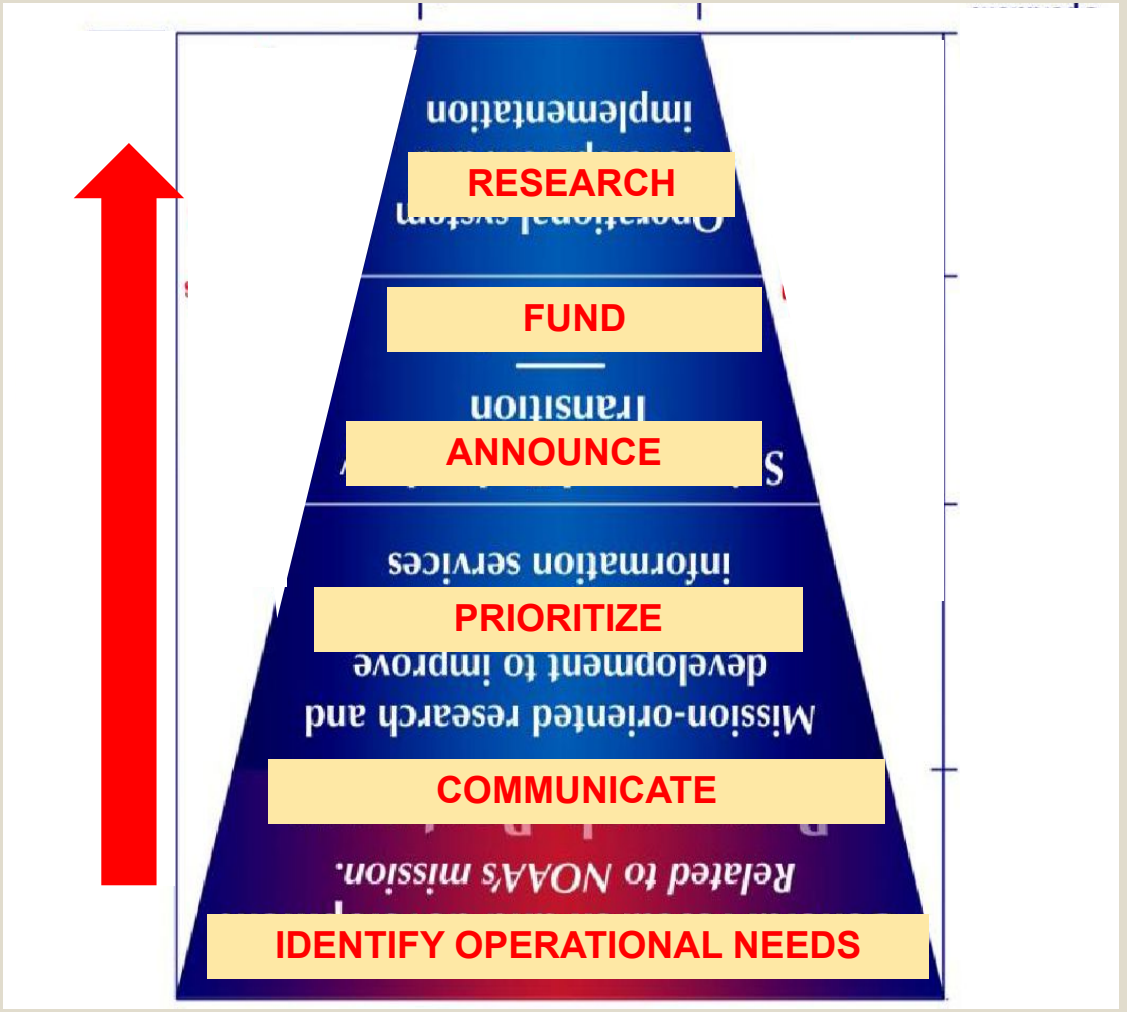
How to Cross the Valley of Death?

- There is a large body of Research being performed
- Much of it is fundamental research (low TRL)
- How do we transition these capabilities?
- Skill-sets required to transition data and models is different than fundamental research
- What skills are needed? (Kubernetes, Containerization)
- Who pays for the transition to operations?

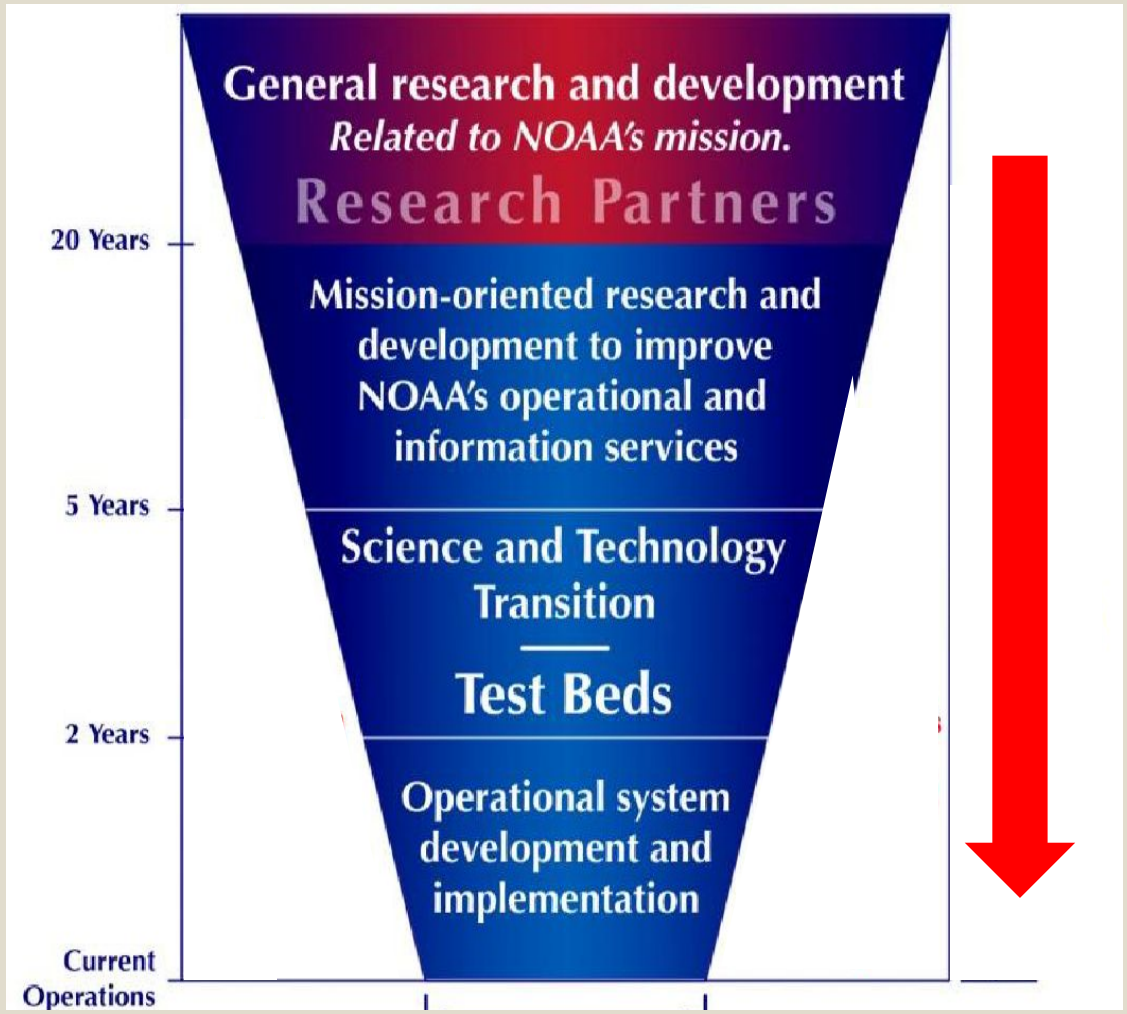
This raises another less obvious question:
What is needed for Operations?

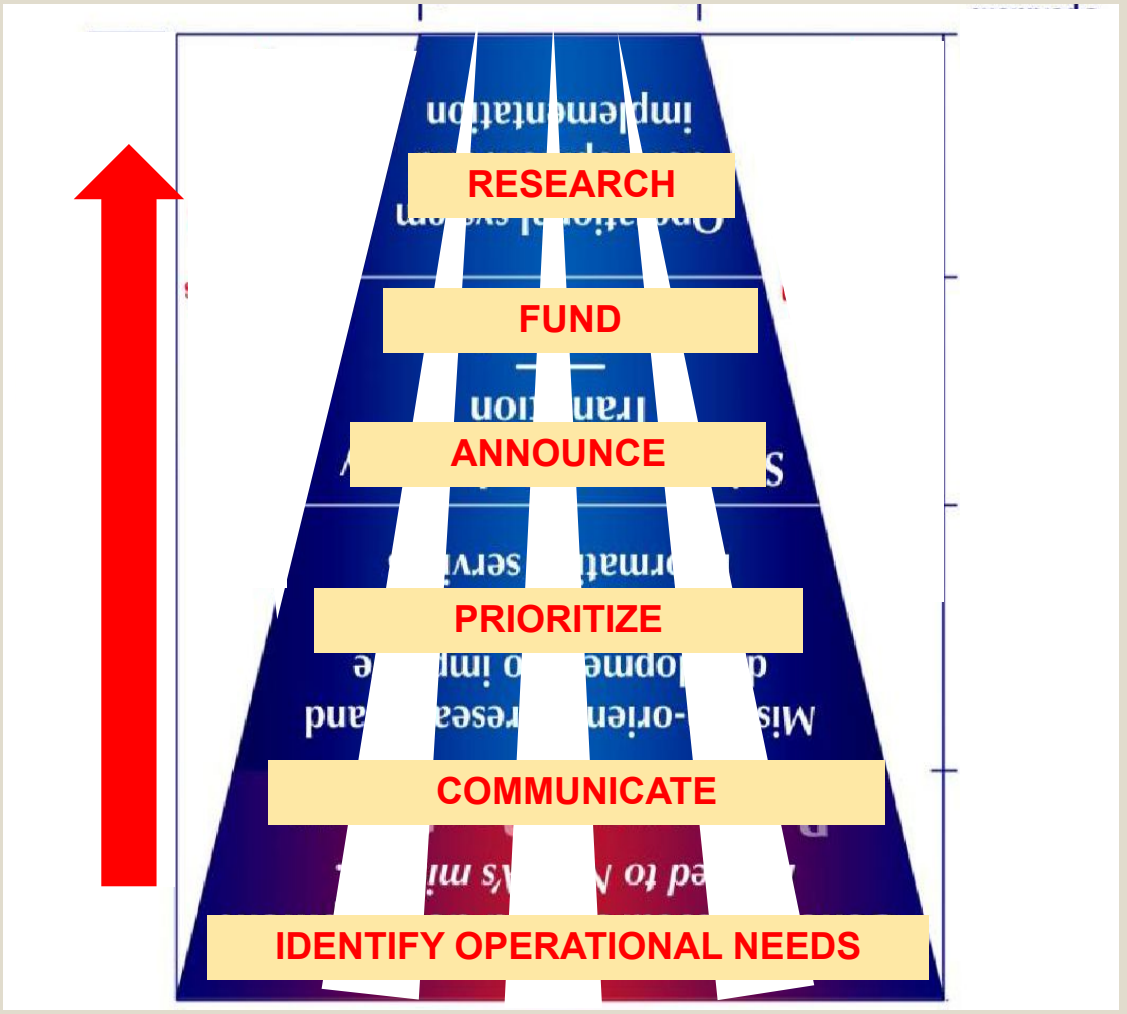
R2O - O2R


General research and development
Related to NOAA's mission.
Research Partners
Mission-oriented research and development to improve NOAA's operational and information services
Science and Technology Transition
Test Beds
Operational system development and implementation
20 Years
5 Years
2 Years
Current Operations


RESEARCH
FUND
ANNOUNCE
PRIORITIZE
COMMUNICATE
IDENTIFY OPERATIONAL NEEDS

R2O - O2R





Is the O2R process going well?

Roundtable Successes (Related to R2O2R)

- R2O2R has been a recurring theme at Roundtable
- Recognition that its difficult to transition R2O
- Not enough funds to transition all research
- R2O transition uses different skills vs. Research
- Change is required in how we think about R2O2R
- **Success**: Roundtable provided a Forum for discussion
- **Success**: Our concern about R2O2R has been communicated to SWAG & SWORM (agencies)
- **Success:** Picked up by SWAG & SWORM
  Quad MOA, Space Weather Action Plan (SWAP)
- **Still near the beginning:** 2nd Innings of the conversation about R2O2R

R2O2R - Where Can the Commercial Providers Contribute?

- **Actions that could be taken to benefit from Commercial participation**
  - Recognize that commercial companies have useful capabilities (inclusion)
  - Make people aware of commercial capabilities (inclusion, ACSWA)
  - Refer Users to commercial companies that can help them (inclusion, ACSWA)
  - Transition the products of SBIR development to operations: Ph-IIE, Ph-3
    - *Recognize that SBIR products can be sole-sourced for transition to operations*
  - Data Buys: Include ground-based (& ocean-based) data in data buys
  - Government should not develop products that are commercially available
  - Government should not be competing with commercial companies (hardware, models, data)
  - Create special funding 'avenues' to take advantage of commercial capabilities (CWDP, etc) – currently easier for Govt to give money to UARCs or FFRDCs, or build it internally

Roundtable can convene Workshops!

Potential Workshop Topics

- DOD-Civil Partnership Follow-On
- Tabletop Follow-up – research gap analysis
- ???

Roundtable moving forward

Roundtable funded for initial 5 year period

- Appointments
  - 3 year term with option to extend for up to 2 years
  - Staggered terms

- Ex-officio members come/go at discretion of NASA/NOAA/NSF

Connection to other committees

Communication is key, and has been good in both directions

- Deep-dive topics inspired by other groups
- RT discussions can shine light on topic and provide material for other groups

NASA Space Weather Council

Nicole Duncan

Chair NASA Space Weather Council

Space Weather Council

Nicole Duncan, SWC Chair

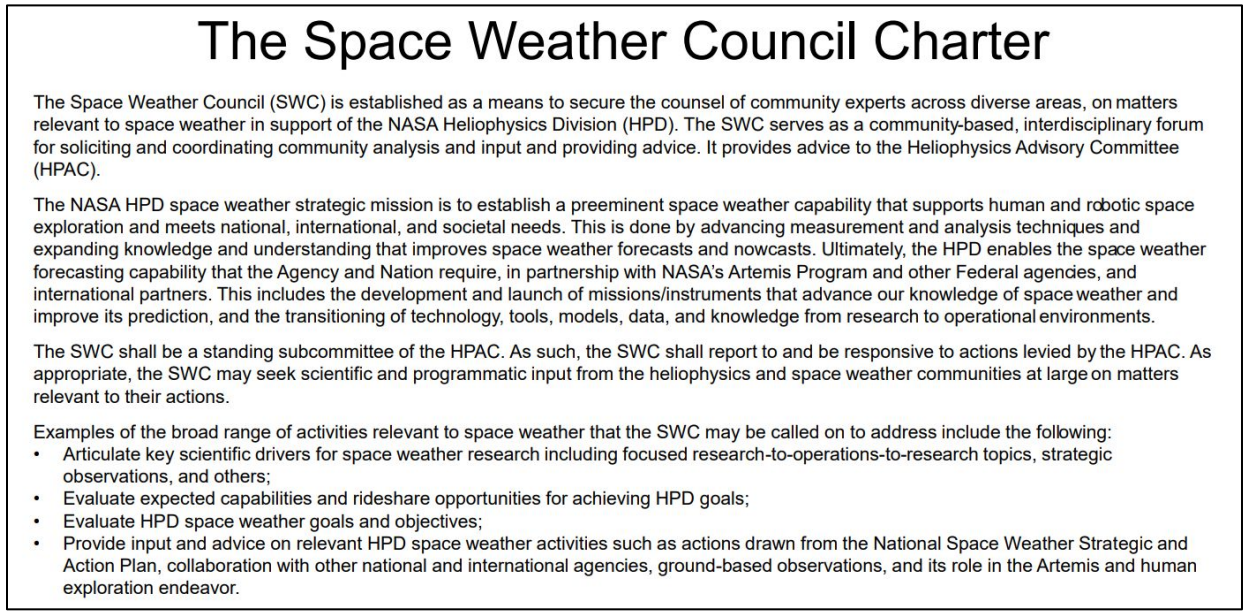
Nicole.Duncan@ballaerospace.com

*** All opinions expressed are my own

3-26-2024

Space Weather Council (SWC)

- **Established by NASA, reports though HPAC**
- **Community-based forum to coordinate input and provide advice**
  - Chair: Nicole Duncan
  - DFO: Kelly Korreck
  - Members: Janet Green, Michele Cash, Angelos Vourlidas, Piyush Mehta, Ron Turner, Alexa Halford, Paul O'Brien, Dan Baker and Sage Andorka
  - **NEW Members**: Harlan Spence and Dan Welling
- May 2023 report available on SWC website
  - Feb 2024 report pending HPAC approval (marked in green)
- **Last Meeting: February 22 – 23;** Next meeting TBD



The Space Weather Council Charter

The Space Weather Council (SWC) is 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 NASA HPD space weather strategic mission is to establish a preeminent space weather capability that supports human and robotic space exploration and meets national, international, and societal needs. This is done by advancing measurement and analysis techniques and expanding knowledge and understanding that improves space weather forecasts and nowcasts. Ultimately, the HPD enables the space weather forecasting capability that the Agency and Nation require, in partnership with NASA's Artemis Program and other Federal agencies, and international partners. This includes the development and launch of missions/instruments that advance our knowledge of space weather and improve its prediction, and the transitioning of technology, tools, models, data, and knowledge from research to operational environments.

The SWC shall be a standing subcommittee of the HPAC. As such, the SWC shall report to and be 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.

Examples of the broad range of activities relevant to space weather that the SWC may be called on to address include the following:

- Articulate key scientific drivers for space weather research including focused research-to-operations-to-research topics, strategic observations, and others;
- Evaluate expected capabilities and rideshare opportunities for achieving HPD goals;
- Evaluate HPD space weather goals and objectives;
- Provide input and advice on relevant HPD space weather activities such as actions drawn from the National Space Weather Strategic and Action Plan, collaboration with other national and international agencies, ground-based observations, and its role in the Artemis and human exploration endeavor.

Space Weather Council - NASA Science

Task 1: Advisory Group Coordination

- Coordination is successful –
  - Cross-membership
  - Regular chair tag-ups
  - Sticking to charter
  - Sharing information
- Co-author advisory group white paper to mitigate continued community confusion on R&R
- Coordinate community input across NASA directorates (STMD, ESMD, SOMD)

SWORM SWAG

Tammy Dickinson (Sci. Matt.)
Kent Tobiska (SET)
Mark Olson (NERC)
Scott McIntosh (NCAR)
Seth Jonas (LMCO)
Tomas Gombosi (U. Mich.)
Craig Fugate (FEMA, ret)
George Ho (APL)
Rebecca Bishop (Aero)
Conrad Lautenbacher (GeoOptics)
Michael Stills (FAA, ret)

A gavel in the corner indicates chair or co-chair of the group in that quadrant

Nicole Duncan (Ball)

NASA SWC

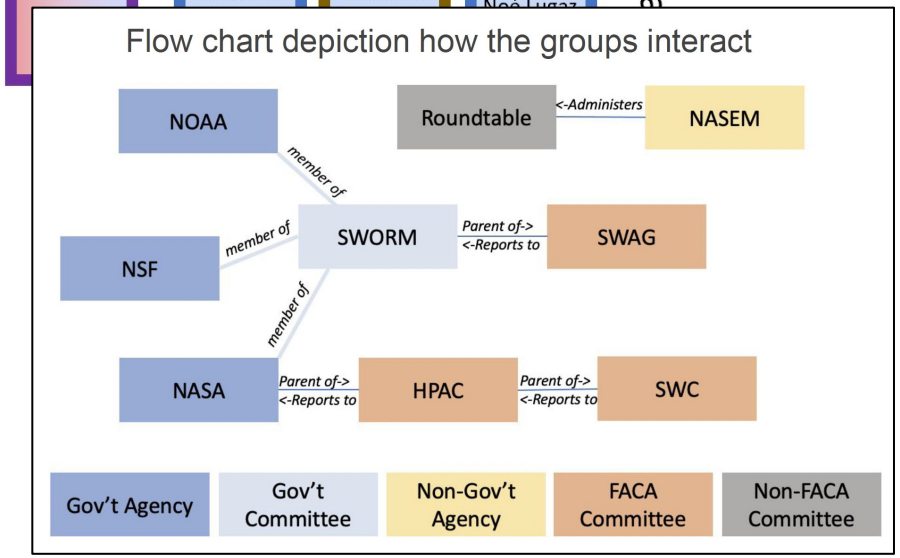
Ron Turner (Anser)
Angelos Vourlidas (APL)
Piyush Mehta (WVU)
Sage Andorka (USSF)
Dan Baker (CU-LASP)
Open
Michele Cash (NOAA)
Alexa Halford (NASA)
Open

NAS Roundtable

Delores Knipp (CU)
Leonard Strachan, Jr (NRL)
Michael Starks (AFRL)
Geoff Crowley (OSS)
Sarah Gibson (NCAR)
Jennifer Gannon (CPI)
Anthea Coster (MIT)
Granger Morgan (CMU)
Shasha Zou (U. Mich.)
Lou Lanzerotti (NJIT)
Lou Uccellini (NWS, ret)
Mark MacAlester (FEMA)
Geoff Reeves (LANL)
Justin Kasper (BWXT)
Heather Elliott (SWRI)
Drew Turner (APL)
Hazel Bain (CIRES)
Janet Green (Spa. Haz.)
Christina Cohen (Cal Tech)
Steven Morley (LANL)
Michael Wiltberger (UCAR)
Paul
Thomas
Yaireska

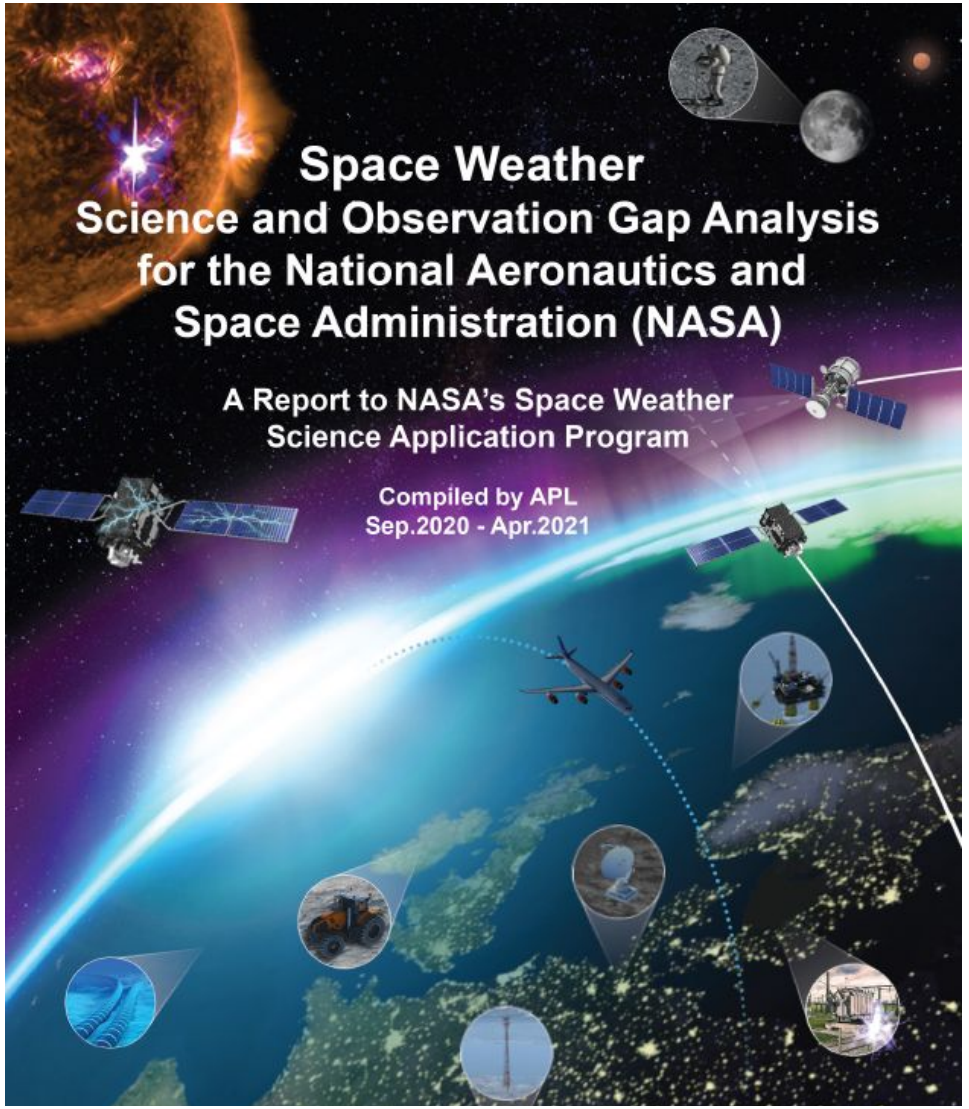
Decada

Flow chart depiction how the groups interact



Task 2: Gap Analyses

- Observational & infrastructure gaps are well understood
- Undertake observational gap filling analysis with return on investment
- Urgent need for SEP gap filling analysis for exploration
- Undertake modeling gap analysis
- Invest in OSE/OSSEs
- Invest in methods to overcome data sparseness, like data-assimilation and synthetic data
- Identify and close gaps related to technical aspects of modeling



Task 3: Artemis & Space Biology

- Encourage mission & modeling teams to support M2M SEO validation efforts
- Coordinate model technical requirements to facilitate integration into CCMC's operational environment
- R2O2R development process is unlikely to address urgent modeling needs – pursue alternate methods
- Develop observational requirements for Earth-independent solar particle forecasting
- Broadly communicate SWx science opportunities from Artemis and M2M

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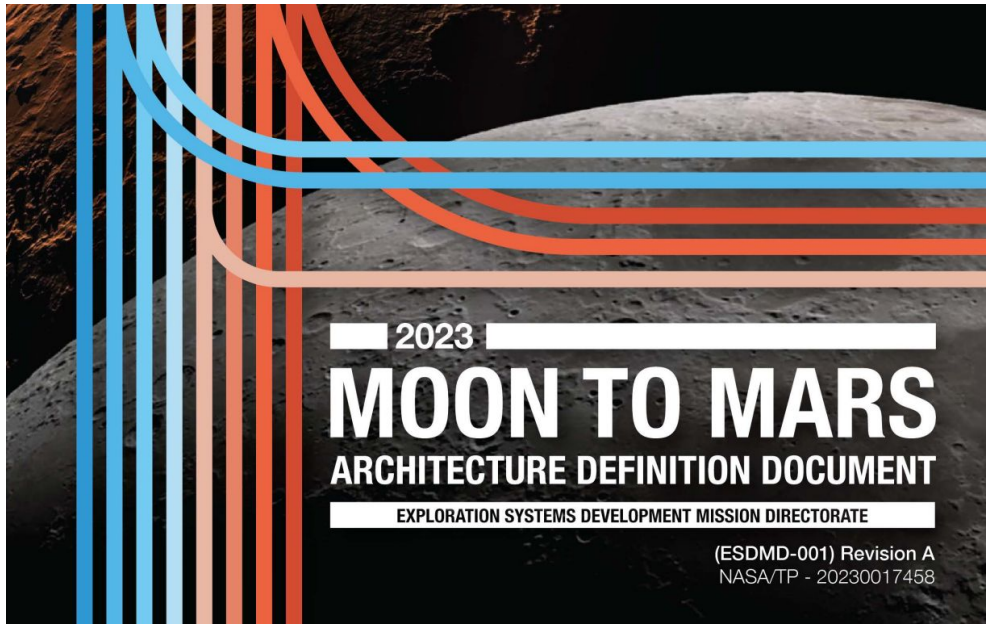
Space Weather Architecture Options to Support Human and Robotic Deep Space Exploration



Task 4: Cooperation

- Space weather data portal
- Connect DoD & Civil gaps
- Establish pre-emptive MOUs
- Enhance collaboration with "One NOAA" framework & OAR
- Consider including applications objectives in science missions, like ES Applied Sciences Program
- Extensive R2O2R discussion
  - Intentionality, transparency, definitions, interfaces, funding, non-gov't role, improving end-user input

Image courtesy of NOAA

Next meeting breaks out R2O2R and cooperation into separate Tasks

Thank you

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Next Steps

- Continue refining findings and recommendations
- Finish developing SWAG recommendations for chapters
- Develop sidebars/text boxes and figures
- Continue editing chapter text. This will require chapter zoom meetings.
- Title
- Next public meeting is April 12 from 10 am to 2 pm ET
  - Will discuss additional findings and recommendations
  - Will discuss any changes to current findings and recommendations
  - Prep for Space Weather Workshop
- Continue editing the document
- Official roll out of full report summer 2024

Closing Remarks

Adjourn