Coordination and communication across agencies

Key questions:

- How will we take advantage of the recently established interagency focus on space weather, and what new interfaces may be needed for space weather research and fluent service structure?
- What are the new communities that we need to engage in space weather, and what are the mechanisms to involve them?
- What should the education of next-generation space weather scientists and forecasters look like?
- What should engineers in a variety of fields know about space weather?

Moderator: Tuija Pulkkinen, Committee

Jinni Meehan	*NOAA NWS*	*National Space Weather Program Manager*
Dan Moses	*NASA HPD*	*Program Scientist, Heliophysics Division*
Tammy Dickinson	*Science Matters*	*President*
Sage Andorka	*US Space Force*	*Lead Systems Engineer*

Space Weather Operations and Research Infrastructure Workshop: Phase II, Monday April 11, 2022, 1300 ET

Interagency Coordination of Space Weather Activities

NATIONAL WEATHER SERVICE

Dr. Jennifer Meehan

National Space Weather Program Manager, National Weather Service (NOAA)
Designated Federal Officer, Space Weather Advisory Group (SWAG)
Executive Secretary, White House Space Weather Operations, Research, and Mitigation (SWORM) Subcommittee

National Academies Space Weather Operations and Research Infrastructure Workshop: Phase II
April 11, 2022

SWORM Activities

2014 - 2016: White House charters the SWORM

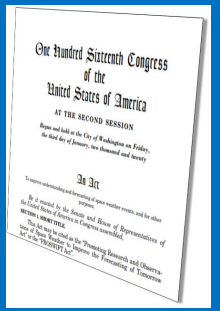
- Coordinates executive branch actions
- 34 Departments, Agencies, and Offices
- EO 13744, Coordinating Efforts to Prepare the Nation for Space Weather Events

2019: White House releases updated Strategy and Action Plan and

- Executive Order 13865, Coordinating National Resilience to Electromagnetic Pulses

2020: PROSWIFT Act codified the SWORM into law

- Directs NOAA to stand up the Space Weather Advisory Group to advise the SWORM


One Hundred Sixteenth Congress
of the
United States of America
AT THE SECOND SESSION

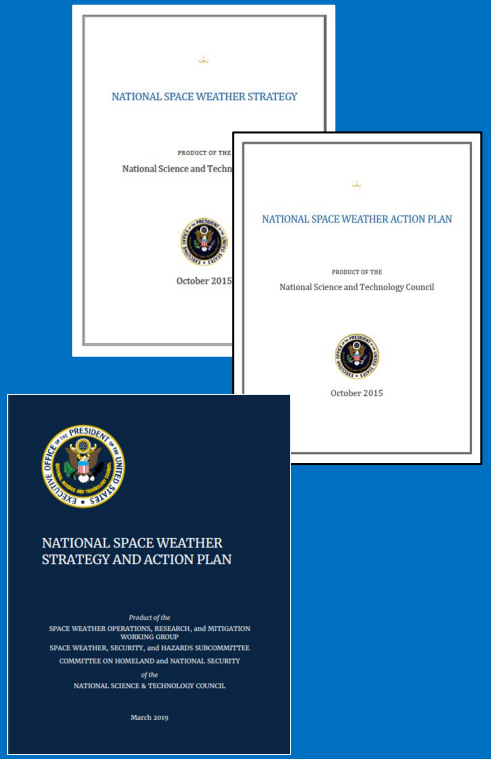
An Act

2022: Update to National Space Weather Strategy and Action Plan begins

SWORM Priorities-

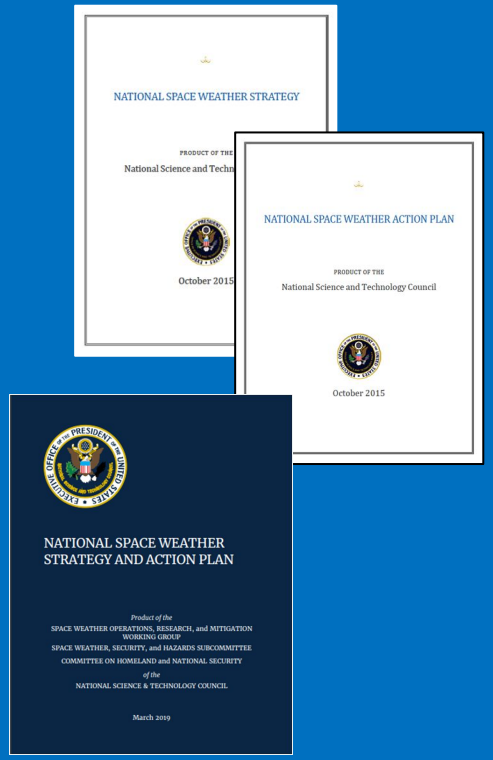
Update to the Strategy and Action Plan

- R2O2R framework for space weather
- Space weather events benchmarks
- U.S. space weather scales
- Space weather hazard mapping of the US
- Observations and forecasting support for human spaceflight
- Space weather observations and modeling to improve space traffic coordination and space situational awareness



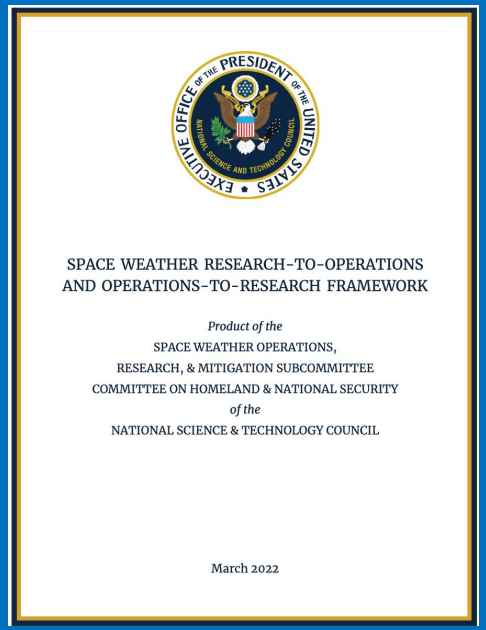
SWORM Priorities-
Update to the Strategy and Action Plan

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



Space Weather R2O2R Framework

PROSWIFT and National Space Weather Strategy: Develop formal mechanisms for R2O2R - include academic, private sector, and international partners



SPACE WEATHER RESEARCH-TO-OPERATIONS AND OPERATIONS-TO-RESEARCH FRAMEWORK

Product of the
SPACE WEATHER OPERATIONS,
RESEARCH, & MITIGATION SUBCOMMITTEE
COMMITTEE ON HOMELAND & NATIONAL SECURITY
of the
NATIONAL SCIENCE & TECHNOLOGY COUNCIL

March 2022

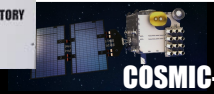
https://www.whitehouse.gov/wp-content/uploads/2022/03/03-2022-Space-Weather-R2O2R-Framework.pdf

Provides a formal interagency structure to ensure an effective space weather R2O2R process.

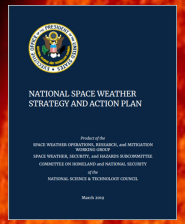
Describes the organizing Framework required to leverage talents and resources of the space weather enterprise to accelerate both the R2O and O2R processes

Space Weather-Ready Nation

A Nation Ready, Responsive, and Resilient to Space Weather



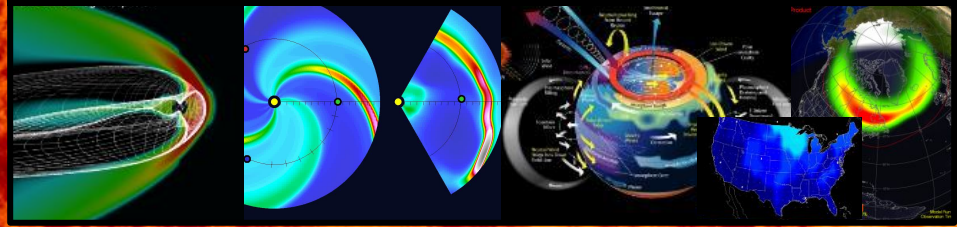
Critical Observations



Partnerships – the entire Space Weather Enterprise working together

SPACE WEATHER PREDICTION TESTBED

Improved understanding with new modeling and R2O2R capabilities



Better information connected to key stakeholders

National Aeronautics and Space Administration

Overview of NASA'S Space Weather Initiatives

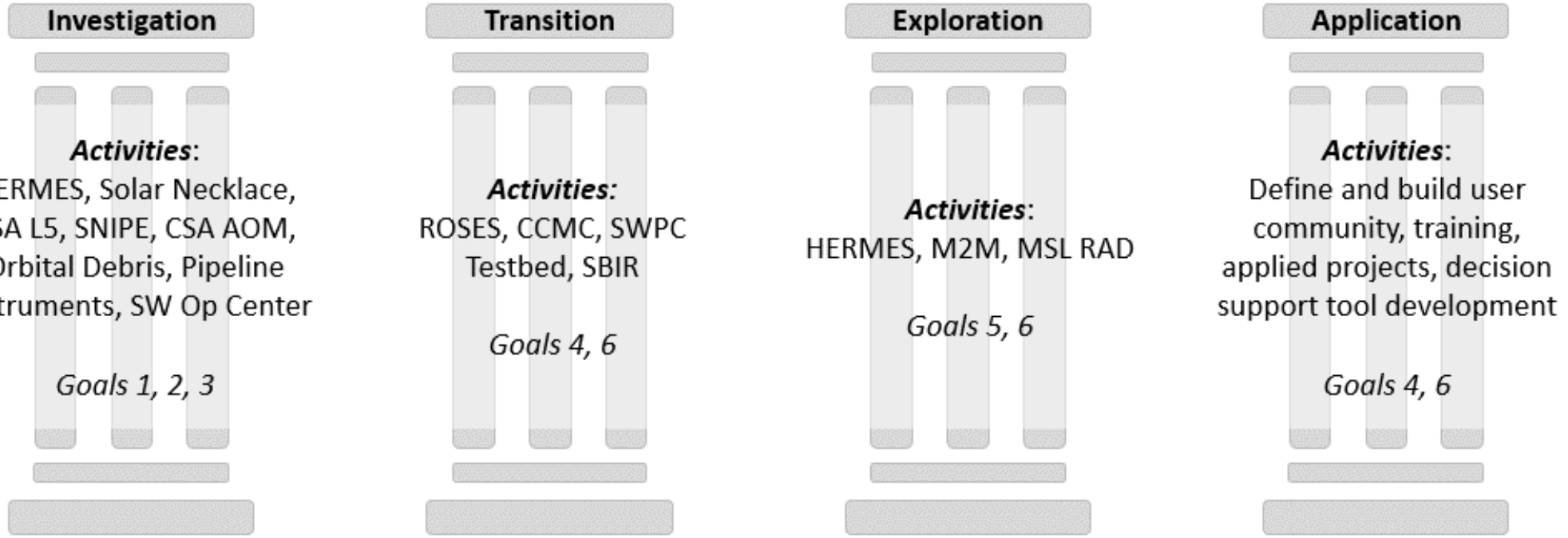
Dr. Dan Moses
HPD Chief Technologist
Space Weather Infrastructure: Phase II
Interagency Partnerships panel
April 11, 2022

NASA Space Weather Program

Space Weather Goal: Advance the science of space weather to empower a technological society safely thriving on Earth and expanding into space.

- NASA plays a vital role in space weather research by providing unique, significant, and exploratory observations and data streams for theory, modeling, and data analysis research, and for operations.
- Various executive (NSW SAP) and legislative (PROSWIFT Act) mandates direct **NASA** to ***address research and application aspects of space weather.***
- NASA Heliophysics works as the research arm of the nation's space weather effort, ***coordinating*** with the U.S. National Oceanic and Atmospheric Administration, the National Science Foundation and the U.S. Geological Survey, and the U.S. Air Force Research Laboratory on the National Space Weather Action Plan.

Space Weather Program Pillars



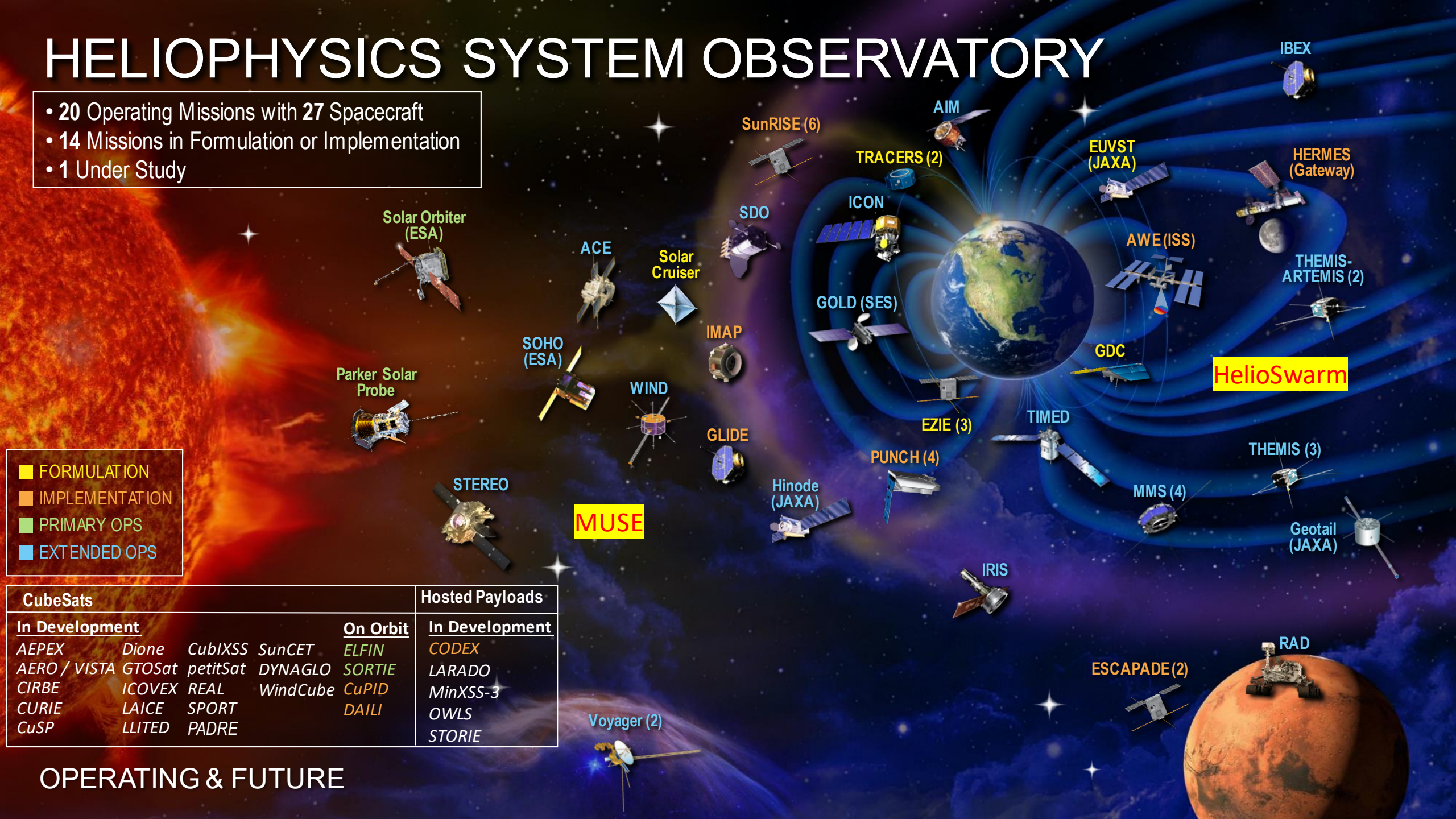
Theme 1:
Coordinate a whole-of-solar-system approach to **observing and modeling** space weather

Theme 2:
Support operational partners by **transitioning** sound and innovative science

Theme 3:
Enable the safe **exploration** – both human & robotic – of the solar system.

Theme 4:
Deliver societal benefit through the **application** of space weather decision support

HELIOPHYSICS SYSTEM OBSERVATORY



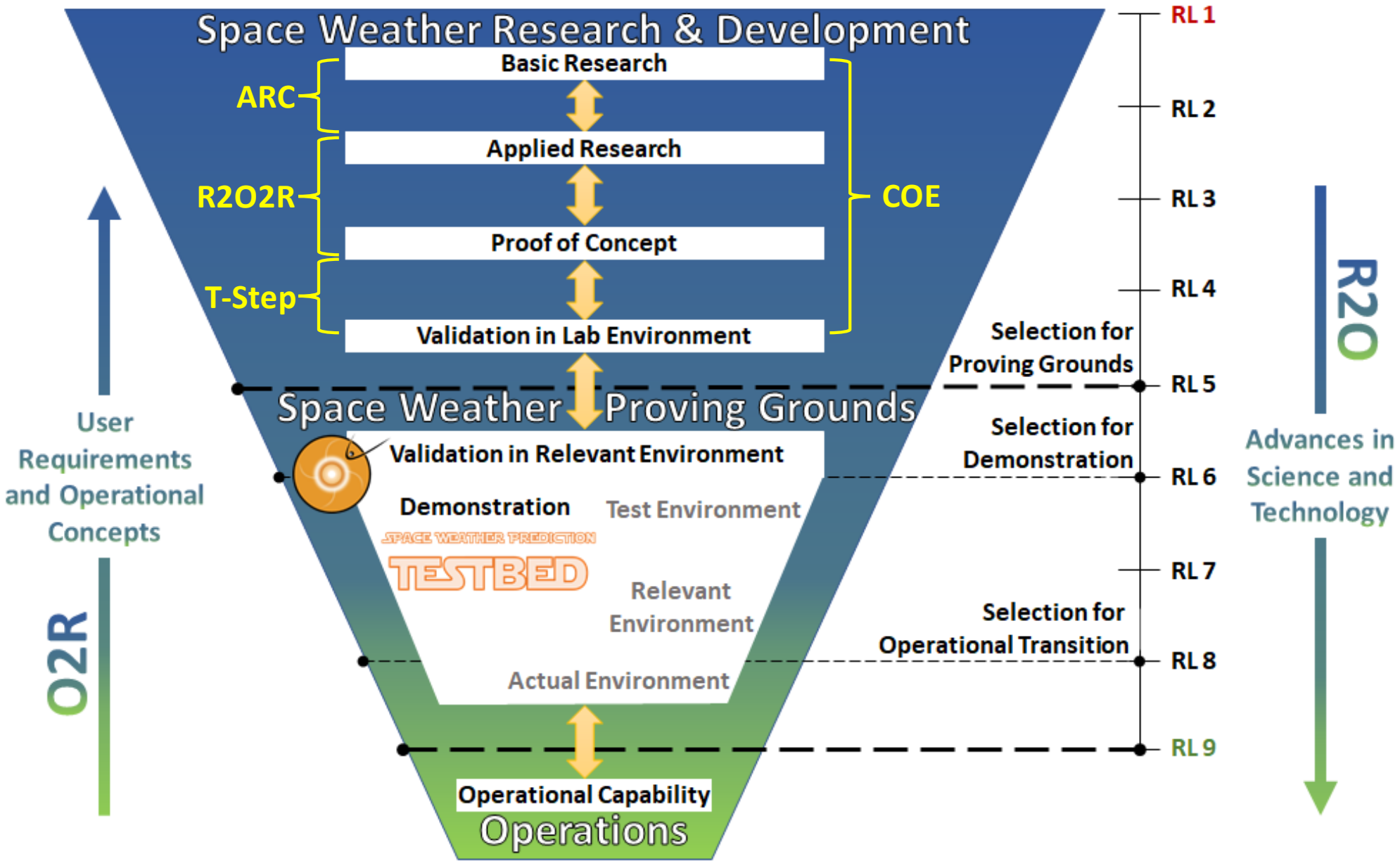
- **20** Operating Missions with **27** Spacecraft
- **14** Missions in Formulation or Implementation
- **1** Under Study

- FORMULATION
- IMPLEMENTATION
- PRIMARY OPS
- EXTENDED OPS

CubeSats					Hosted Payloads
In Development				**On Orbit**	**In Development**
AEPEX	*Dione*	*CubIXSS*	*SunCET*	*ELFIN*	*CODEX*
AERO / VISTA	*GTOSat*	*petitSat*	*DYNAGLO*	*SORTIE*	*LARADO*
CIRBE	*ICOVEX*	*REAL*	*WindCube*	*CuPID*	*MinXSS-3*
CURIE	*LAICE*	*SPORT*		*DAILI*	*OWLS*
CuSP	*LLITED*	*PADRE*			*STORIE*

OPERATING & FUTURE

The R2O/O2R Process

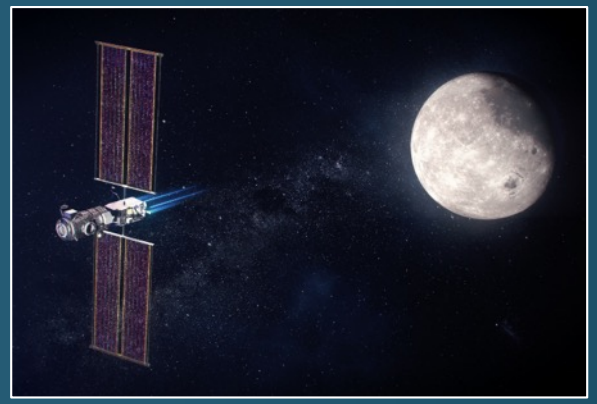


Recent CubeSat Selections

In November 2021, HPD announced the selection of four Cubsats within the HFORT 2019 ROSES element, and a further four selections from HFORT 2020. The four listed below focus on space weather research.

Name	PI	Institute
CubIXSS: The CubeSat Imaging X-ray Solar Spectrometer	Amir Caspi	Southwest Research Institute
Sun Coronal Ejection Tracker (SunCET)	James Mason	Johns Hopkins University/Applied Physics Laboratory
DYNamics Atmosphere GLObal-Connection (DYNAGLO)	Aimee Merkel	The Regents Of The University Of Colorado
WindCube	Scott Sewell	University Corporation for Atmospheric Research

NASA Space Weather



Recent Accomplishments

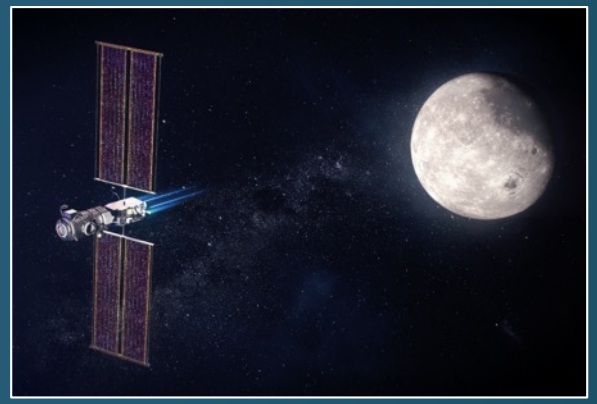
- NASA space weather strategy and implementation plan
- NOAA and DoD Framework to transition NASA research, techniques and technology relevant to space weather operations
- Joint NSF-NASA Space Weather Quantification of Uncertainty (SWQU) grant solicitation

❖ Research to Operations to Research (R2O2R) grant solicitation: ***Additional Transition Step*** for efforts that show promise to use in an operational space weather environment at NOAA or DoD

❖ HERMES instrument package in support of Gateway and Artemis and space weather; HERMES Inter-Disciplinary Scientists (IDSs) were selected in June 2021

❖ ***Completed a Space Weather Science Gap Analysis*** – managed by APL - https://science.nasa.gov/science-pink/s3fs-public/atoms/files/GapAnalysisReport_full_final.pdf

NASA Space Weather



Looking Ahead

- ❖ Develop space weather ***instrument pipeline*** for future opportunities
- Engage international partners on future collaborations (ESA Lagrange, CSA AOM, ESA Daedalus, KASI SNIPE, ISRO Aditya, others?)
- Continue transitioning Radiation Assessment Detector (RAD) instrument on Curiosity rover on Mars from Planetary Science Division to the Heliophysics Division to engage space weather community supporting forecasting research at Mars
- Continued funding R2O2R grants and SWx SBIR efforts - >70 funded efforts with multiagency input (DoD/NOAA/NSF/NASA)
- Preparing solicitation for Space Weather Centers of Excellence – draft released out for community comment
- ❖ PROSWIFT: Actions responding to PROSWIFT Act are well underway

NASA HPD & PROSWIFT

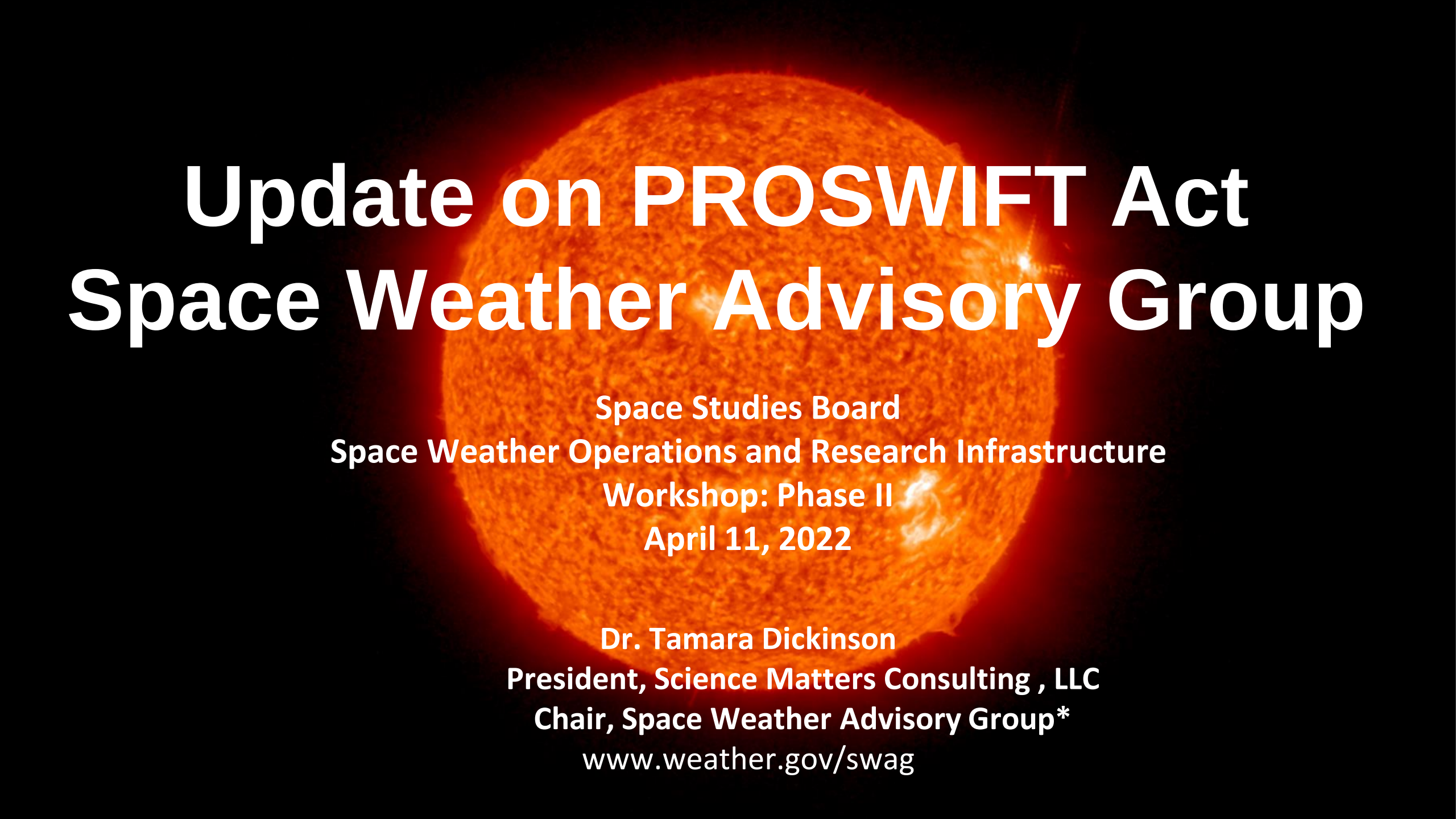
PROSWIFT allows NASA to focus on what NASA does best in space weather: Pushing the limits of our understanding the Sun-Earth system including space weather phenomena and leading the evolution of the space-based network of Heliophysics observatories – and the science behind them – through new missions, technology development, and cutting-edge research and modeling.

In this sense, NASA Heliophysics:

- **Pioneers new techniques, technology, observations,** and advances knowledge relevant to space weather.
- **Launches space investigations** that solve scientific questions to remove barriers to improved space weather forecasting.
- **Funds research** that uses observations and advances models to predict and understand the variability of the space environment.
- **Transitions techniques, technology, models, and knowledge** to operations.
- **Collaborates with other agencies and international partners** to advance space weather knowledge and operations to meet national and societal needs

The NASA Space Weather Council

- The *Space Weather Council* (SWC) was established 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.



Update on PROSWIFT Act Space Weather Advisory Group

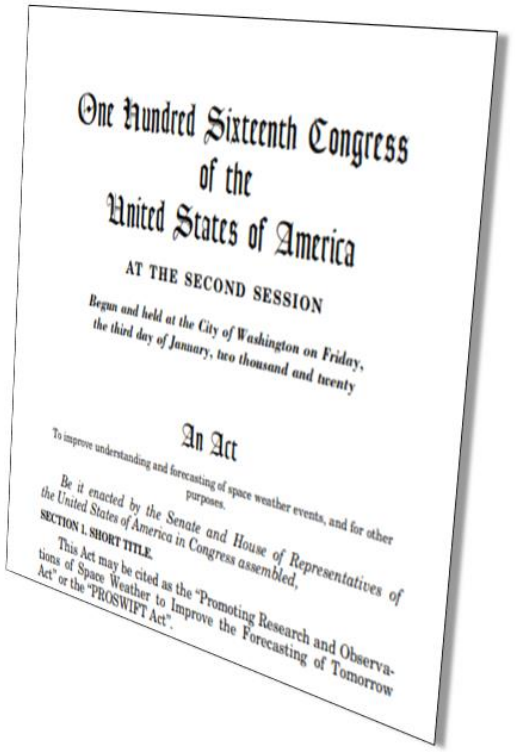
Space Studies Board
Space Weather Operations and Research Infrastructure
Workshop: Phase II
April 11, 2022

Dr. Tamara Dickinson
President, Science Matters Consulting , LLC
Chair, Space Weather Advisory Group*
www.weather.gov/swag

PROSWIFT Act - Overview

Basic Elements

- 60601 Space weather
  - Role of Federal Agencies
  - Interagency Working Group (SWORM)
  - Interagency Agreements
  - **Space Weather Advisory Group (SWAG)**
- 60602 Integrated strategy
- 60603 Sustaining and advancing critical observation
- 60604 Research activities
- 60605 Space weather data
- 60606 Knowledge transfer and information exchange (NASEM Roundtable)
- 60607 Pilot program commercial sector
- 60608 Benchmarks



One Hundred Sixteenth Congress
of the
United States of America

AT THE SECOND SESSION

Begun and held at the City of Washington on Friday, the third day of January, two thousand and twenty

An Act

To improve understanding and forecasting of space weather events, and for other purposes.

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled,

SECTION 1. SHORT TITLE.

This Act may be cited as the "Promoting Research and Observations of Space Weather to Improve the Forecasting of Tomorrow Act" or the "PROSWIFT Act".

PROSWIFT Act - SWAG

ESTABLISHED - **NOAA Administrator** … informs the interests and work of **SWORM**

COMPOSITION - **appointed by SWORM** , 5 *representatives* of **academic** , **commercial** space weather, **end user** communities

TERM LIMITS - 3 years terms , no more than 2 consecutive terms

CHAIR – chosen by NOAA Administrator, no more than 2 terms, regardless of whether the terms are consecutive

Committee Members

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 (former FEMA Adm)

Rebecca Bishop
Aerospace Corp.

SWAG Commercial Sector Representatives

Jennifer Gannon
Computational Physics, Inc.

Conrad Lautenbacher
GeoOptics, Inc. (former NOAA Adm)

Seth Jonas
Lockheed Martin

Kent Tobiska
Space Environment Technologies

Nicole Duncan
Ball Aerospace

SWAG Academic Community Representatives

Tomas 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

PROSWIFT Act - SWAG Duties

Advise White House SWORM Subcommittee on:

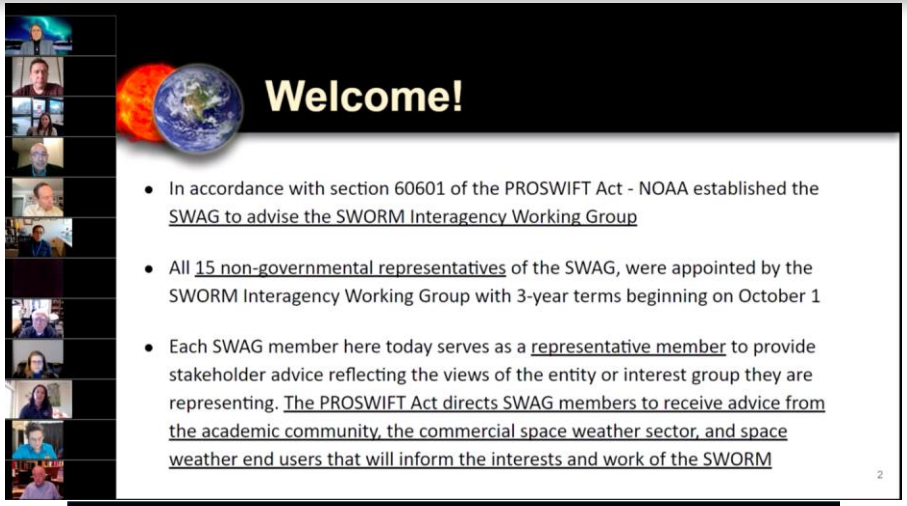
- Facilitating advances in the space weather enterprise of the US
- Improving the ability of the US to prepare for, mitigate, respond to, and recover from space weather phenomena
- Enabling the coordination and facilitation of R2O2R
- Developing and implementing the integrated strategy for coordinated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

Conduct a comprehensive user needs survey of space weather products

SWAG Meetings

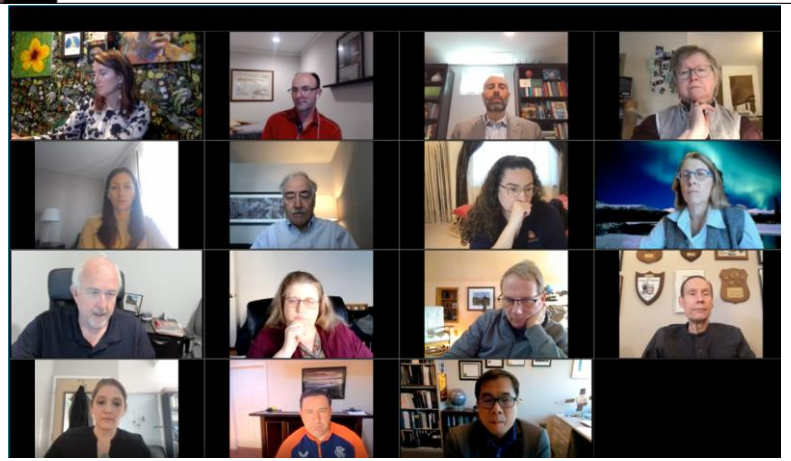
December 1, 2021 (virtual)

- Briefings by SWORM Co-Chairs (OSTP, NWS, DHS)
- PROSWIFT Act overview of SWAG duties
- Kicked off discussion of the user needs survey



March 17-18, 2022 (virtual)

- Briefing by SWORM
- Defined user needs survey process and sectors
- Related activities - SW Roundtable and NASA SWC
- Brainstormed other topics to address



(Future) Late May or June, 2022 (virtual)

For meeting information please visit: www.weather.gov/swag

Concurred on Survey Process Overview

1. Use one or more **space 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. **Space weather sectors to survey**
   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 **one or more products**

Concurred Sectors

Abt Associates Report Sectors

- Electric Power Grid
- Satellite
- GNSS
- Aviation
- Emergency Management

Additional Sectors

- Space Situational Awareness, Space Traffic Coordination
- Radio Frequency Application (comms and Radar)
- Human space flight
- National Security
- Research

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

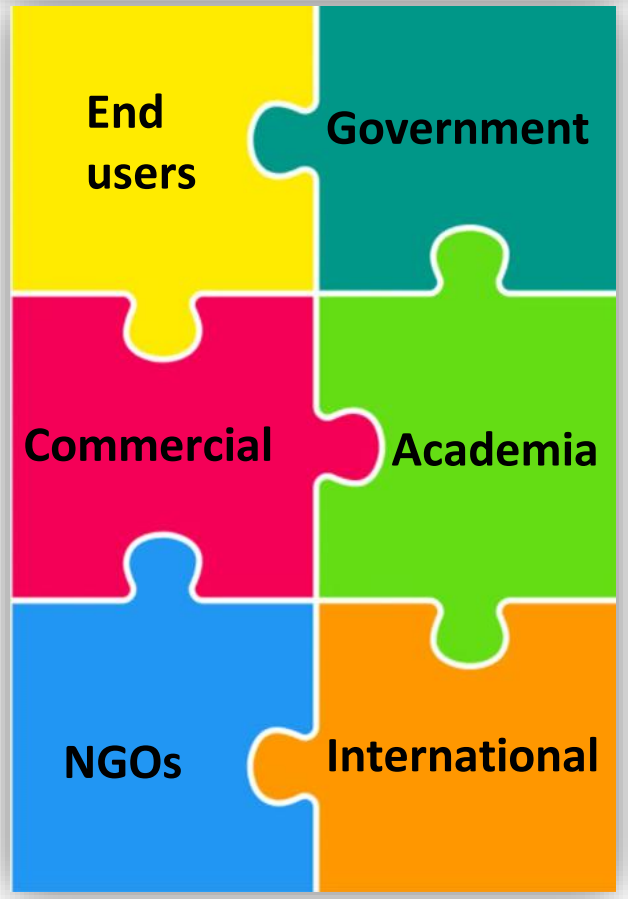
Members: academic, commercial, government (SWORM)

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>**
- Spoke at recent CSSP meeting, speaking here today, and volunteered to speak at next NASA Space Weather Council meeting
- Creating invite list for SWAG meetings to include Roundtable and SWC chair/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.

SWAG Brainstorming

- Build constituency base/strong voice for observations and forecasting
- Expert review of SWORM products
- Benchmarks and Space Weather Scales
- All clear notification after an event has past (or forecasted)
- Resilience and preparedness
- What is role of commercial sector?
- Data output format and curation
  - Security and availability of data for R2O2R
  - Make archived forecasts available for model validation
- Space traffic coordination

THANKS!

dickinson.tamara@yahoo.com

www.weather.gov/SWAG

Interagency Partnerships panel: United States Space Force

11 April 2022

Sage Andorka
Lead Systems Engineer
Space System Center
Space Domain Awareness Division
Advanced SDA Modeling
(SSC/ECZGA)

Semper Supra

SET4D Overview

Space Domain Awareness (SDA) Environmental Toolkit for Defense (SET4D)

- An integrated software suite of space environment data, models, and applications to provide mission impacts and SDA for DoD warfighters and IC operations
- Space is warfighting domain w/ near-peer adversaries operating in a contested environment and congested spectrum
  - Direct to operators (vs. web pull)
  - Focused on impacts (vs. environment)
  - Tailored to specific ops (vs. generic global)
  - Awareness/assessments on-demand (vs. scheduled)
  - Data archived for AI/ML analytics (vs. only stored for 30 days)
  - Open architecture designed for component reuse & rapid R2O (vs. monolithic codebase in sustainment w/ duplication & stove-pipes)
  - Include weather impacts on space services (vs. space weather only)
- End to End Cloud Development Deployment Environment

USSF Interagency Interaction

Space Force is establishing independent interagency agreements to enhance current missions and support our fellow agency's efforts.

- Share agency data between agencies
- Multiple data stores across organizations
  - How can we securely synchronize data stores/warehouses/lakes without duplicating data?
- Open architectures with APIs
- Smallest component development vs large "tool" design
  - Enables low-cost upgrades by all entities

Interaction with Communities

- More Students!
  - Eager, creative, better versed on new technologies
  - Integrate with our accelerators (AFWERX, JCO, etc.)
- Commercial
  - Data Buys (SDA Marketplace)
  - Sensor network rentals

Pivoting the Approach for New Tools

Modern Technologies

- What's scientifically interesting is not operationally relevant
- Not all weather phenomena effect DOD systems equally
  - New SDA architecture is providing ability to discover near real-time operational metrics vs weather metrics
  - Drive next generation need from environmental modeling and observation systems need/commercial data buys
- Making "bad" data useful
  - Using other RF signals as a sensors – bad data could be an indicator of environment
  - Tend to throw out our own bad observations, but not keep the useful parts

Engineering Challenges

Space Weather will not effect your network equally

- AE - Spacecraft is about location, location, location
  - Unless proton event – everything is impacted
  - GEO – Surface Charging
  - LEO – SAA, Auroral impacts
  - HEO - Everything
- SE - Many of DOD system claim “all weather capability”
  - Electromagnetic Spectrum Impacts
    - EE - Solar Radio Burst, Ionospheric refraction, Scintillation, x-ray ionization
    - ME/EE- Terrestrial issues (hail causes attenuation (approx. 100 MHz) but still impacts all frequencies – esp. to the ground system), rain rate, ATM ducting

Utilizing Science Pathfinders

Always been a “tough nut to crack”

- Legacy policy was not to create operational dependencies on short-lived scientific missions
  - No guarantee of follow-on, leaving a gap
  - Software engineering to exploit data took long to integrate
  - Latent data – okay for post-facto metrics, but not useful for real-time ops
- Potential fixes
  - No guarantee follow-on but… Show benefit if:
  - Cloud migration allows for rapid integration following standardized data formats and open architectures – what if it’s “bad”?
  - Improved over modern technologies – AWS outposts, local zones, cloud processing

Look Forward

Opportunity for new innovations

- "Reject Foolish Consistency" – *Patton on Leadership: Strategic Lessons for Corporate Warfare* by Alan Axelrod
- Let's develop new ways to do science leveraging the 21st century technologies/processes

Interagency Partnerships panel: United States Space Force

11 April 2022

Sage Andorka
Lead Systems Engineer
Space System Center
Space Domain Awareness Division
Advanced SDA Modeling
(SSC/ECZGA)

Semper Supra