



NASA SBIR 2020 Phase I Solicitation

S5.06 Space Weather R2O/O2R Technology Development

Lead Center: GSFC

Participating Center(s): JPL, JSC, LaRC, MSFC

Technology Area: TA11 Modeling, Simulation, Information Technology and Processing

Scope Title

Space Weather R2O/O2R Technology Development

Scope Description

Space weather has the potential to disrupt telecommunications, aircraft and satellite systems, electric power subsystems, and position, navigation, and timing services. Given the importance of these systems to our national well-being, NASA's Heliophysics Division invests in activities to improve the understanding of these phenomena and to enable new monitoring, prediction, and mitigation strategies.

The national direction for this work is organized by the Space Weather Operations, Research, and Mitigation (SWORM) Working Group, which is a Federal interagency coordinating body organized under the Space Weather, Security, and Hazards (SWSH) Subcommittee. The SWSH is a part of the National Science and Technology Council (NSTC) Committee on Homeland and National Security, organized under the Office of Science and Technology Policy (OSTP). The SWORM coordinates Federal Government departments and agencies to meet the goals and objectives specified in the National Space Weather Strategy and Action Plan released in March 2019.

NASA's role under the National Space Weather Strategy and Action Plan is to provide increased understanding of the fundamental physics of the Sun-Earth system through space-based observations and modeling, the development of new space-based space weather technologies and missions, and monitoring of space weather for NASA's space missions. This includes research that advances operational space weather needs.

This subtopic solicits new, enabling space weather technologies as part of NASA's response to these national objectives. While this subtopic will consider all concepts demonstrably related to NASA's Research-to-Operations/Operations-to-Research (R2O/O2R) responsibilities outlined in the Strategy and Action Plan, five areas have been identified for priority development:

(1) Space Weather Forecasting Technologies and Techniques: Innovative technologies and techniques are solicited that explore and enable the transition of tools, models, data, and knowledge from research to operational environments. This includes the preparation and validation of existing science models that may be suitable for transition to operational use. Coordination with existing NASA capabilities, such as the Space Radiation Analysis Group (SRAG) at Johnson Space Center (JSC), the Community Coordinated Modeling Center (CCMC) at GSFC, and the Short-term Prediction Research and Transition (SPoRT) Center at Marshall Space Flight Center (MSFC), is appropriate. Areas of special interest include, but are not limited to:

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- Lunar space environment characterization tools that can be employed by NASA to enhance protection of crewed and uncrewed missions to cis-lunar and lunar surface missions;
 - Specifications and/or forecasts of the energetic particle and plasma conditions encountered by spacecraft within Earth's magnetosphere, as well as products that directly aid in spacecraft anomaly resolution, and end-users such as spacecraft operators;
 - Approaches that potentially lead to a 2-3 days forecasting of atmospheric drag effects on satellites and improvement in the quantification of orbital uncertainties in LEO altitude ranges (up to ~2000 km);
 - Techniques that enable the characterization and prediction of ionospheric variability that induces scintillations, which impact communication and global navigation and positioning systems;
 - Longer-range (2-3 days) forecasting of SPEs (Solar Particle Events) and an improved all-clear SPE forecasting capability.

(2) Space Weather Advanced Data-Driven Discovery Techniques: A particular challenge is to combine the sparse, vastly distributed data sources available with realistic models of the near-Earth space environment. Data assimilation and other cutting-edge data-driven discovery innovations are solicited that enable tools and protocols for the operational space weather community. Priority will be given to proposals that:

- Develop data assimilation space weather applications or technologies desired by established space weather operational organizations;
- Integrate data from assets that typically do not share similar time series, utilize different measurement techniques (e.g., imaging vs in-situ particles and fields), or are distributed throughout the heliosphere;
- Provide new data driven operational forecasting tools that can be straightforwardly validated by the CCMC or another equally robust validation methodology; and/or,
- Integrate underutilized resources (e.g. space-based radio occultation for ionospheric specification or U.S. Geological Survey (USGS) ground conductivity measurements related to geomagnetically induced currents).

(3) Space Weather Benchmarks: The Heliophysics System Observatory (HSO) data archives include a vast array of spacecraft observations suitable for the development of space weather benchmarks, which are the set of characteristics against which space weather events are measured. This includes refining the Phase 1 Benchmarks that were released by the National Science and Technology Council in 2018 for induced geo-electric fields, ionizing radiation, ionospheric disturbance, solar radio bursts, and upper atmospheric expansion. These benchmarks should be in a form useful to the owners and operators of systems and assets that contribute to critical national functions. Innovations to produce and/or further refine these benchmarks are solicited, as are concepts for future creative approaches utilizing new data types or models that could become available.

(4) Space Weather Mitigation Technologies: The 2019 National Space Weather Strategy and Action Plan specifically calls out the need to test, evaluate, and deploy technologies and devices to mitigate the effects of space weather on communication systems, geomagnetic disturbances on the electrical power grid, or radiation events on satellites. It also includes the development of processes to improve the transition of research approaches to operations.

(5) Space Weather Instrumentation: Heliophysics science relies on a wide variety of instrumentation for its research and often makes its data available in near-real-time for space weather forecasting purposes. Concepts are solicited for instrumentation concepts, flight architectures, and reporting systems that enable enhanced, more informative, robust, and effective measurements for space weather monitoring and forecasting systems. Opportunities for improving measurements include increased spatial and temporal resolution, fidelity, promptness, and measurement system reliability. This includes the miniaturization of existing systems and/or technologies deployable as an array of CubeSats. In order to be considered for investment, SBIR technologies should demonstrate comparable, or better, precision and accuracy when compared to the current state-of-the-art. Further, SBIR instrument designs should avoid duplicating current NASA research spacecraft arrays or detector systems including those currently in formulation or development (e.g. Interstellar Mapping and Acceleration Probe (IMAP), Geospace Dynamics Constellation (GDC), Medici, Explorer concepts, etc.).

Proposals must demonstrate an understanding of the current state-of-the-art, describe how the proposed innovation is superior, and provide a feasible plan to develop the technology and infuse into a specific activity listed

within the National Space Weather Strategy and Action Plan.

References

Executive Order 13744-- Coordinating Efforts to Prepare the Nation for Space Weather Events:

<https://www.federalregister.gov/documents/2016/10/18/2016-25290/coordinating-efforts-to-prepare-the-nation-for-space-weather-events>

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The White House Executive Office of Science and Technology Policy released the National Space Weather Strategy and Action Plan on March 26th, 2019, during the National Space Council meeting in Huntsville, Alabama. The announcement was made by the Office of Science and Technology Policy Director, Kelvin K. Droegemeier. This strategy and action plan is an update to the original National Space Weather National Space Weather Strategy and Space Weather Action Plan, released in October 2015. See: <https://www.whitehouse.gov/wp-content/uploads/2019/03/National-Space-Weather-Strategy-and-Action-Plan-2019.pdf>

Space Weather Phase 1 Benchmarks:

<https://www.sworm.gov/publications/2018/Space-Weather-Phase-1-Benchmarks-Report.pdf>

An Executive Order (EO) on Coordinating National Resilience to Electromagnetic Pulses (EMP) was released by the White House on March 26, 2019. The EO identifies the disruptive impacts an EMP has on technology and critical infrastructure systems, whether the EMP is human-made or naturally occurring. The EO outlines how the Federal Government will prepare for and mitigate the effects of EMPs by an efficient and cost-effective approach.

See: <https://www.whitehouse.gov/presidential-actions/executive-order-coordinating-national-resilience-electromagnetic-pulses/>

Expected TRL or TRL range at completion of the project 3 to 8

Desired Deliverables of Phase II

Prototype, Hardware, Software

Desired Deliverables Description

Space weather is a broad umbrella encompassing science, engineering, applications and operations. The ultimate goal of this SBIR is to generate products or services ("deliverables") that enable end-user action. The deliverables can be applied, for example, to space weather hazard assessments, real-time situational awareness, or to plan protective mitigation actions. Deliverables can be in the form of new data, new techniques new instrumentation, or predictive models that are prepared/validated for transition into operations.

State of the Art and Critical Gaps

We do not yet know how to predict what needs to be predicted; we do not yet know how quantitatively good/bad our operational capabilities are (metrics); mechanisms do not yet exist to enable a broad range of the community to participate in the improvement of operational models; the research environment advances understanding rather than the improvement of operational products.

Space weather poses a constant threat to the Nation's critical infrastructure, our satellites in orbit, and our crewed and uncrewed space activities. Extreme space weather events can cause substantial harm to our Nation's security and economic vitality. Preparing for space weather events is an important aspect of American resilience that bolsters national and homeland security and facilitates continued U.S. leadership in space A robust space weather program and its associated forecasting capabilities are essential for NASA's future exploration success.

Relevance / Science Traceability

This SBIR subtopic enables NASA to demonstrate progress against NASA Goal 1.4: Understand the Sun and its interactions with Earth and the solar system, including space weather.

These applied research projects directly address NASA's role within the Space Weather Operations, Research, and Mitigation (SWORM) Working Group, which is a Federal interagency coordinating body organized under the Space Weather, Security, and Hazards (SWSH) Subcommittee. The SWSH is a part of the National Science and Technology Council (NSTC) Committee on Homeland and National Security, organized under the Office of Science and Technology Policy (OSTP). The SWORM coordinates Federal Government departments and agencies to meet the goals and objectives specified in the National Space Weather Strategy and Action Plan released in March 2019.

The Heliophysics Space Weather Science and Applications (SWxSA) Program establishes an expanded role for NASA in space weather science under single element. It is consistent with the recommendation of the NRC Decadal Survey and the OSTP/SWORM 2019 National Space Weather Strategy and Action Plan. It competes ideas and products, leverages existing agency capabilities, collaborates with other agencies, and fosters partnership with user communities. The SWxSA program is distinguishable from other heliophysics research elements in that it is specifically focused on investigations that significantly advance understanding of space weather and then apply this progress to enable more accurate characterization and predictions with longer lead time. The Heliophysics Living with a Star (LWS) Program has established a path forward to meet the NASA's obligations to the research relevant to space weather and is a significant source of input to SWxSA.

Further involvement by the emerging Heliophysics space weather commercial community has the potential to significantly advance the space weather application obligations portion of the mandate.

Astronauts are not protected by the Earth's atmosphere and are exposed to space radiation such as galactic cosmic rays and solar energetic particles. A robust space weather program and associated forecasting capabilities is essential for NASA's future exploration success.