

# NASA SBIR/STTR Technologies

T6.02-9986 - Improved Forecasting of Solar Particle Events and their Effects on Space Electronics



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## Identification and Significance of Innovation

Solar Particle Events (SPEs) associated with flares/coronal mass ejections generate energetic particles that constitute a dynamic radiation environment and may adversely affect space missions, and high-altitude and terrestrial systems. It is crucial to forecast SPEs and their effects on systems to plan NASA mission-related tasks and adopt risk mitigation strategies for personnel and equipment. The proposed effort will develop a comprehensive modeling capability, comprising individual modules to address different aspects of the overall problem, for complete event-to-effects analyses.

Innovations: (1) Integrated modeling software with state-of-the-art modules to address issues from SPE4 forecasting to heliospheric transport to geomagnetic/atmospheric interactions; (2) Flexibility to link with various radiation effects calculation codes; (3) Use of empirical/physics-based models and observations for high fidelity; (4) Emphasis on transitioning software to operational use.

Estimated TRL at beginning and end of contract: ( Begin: 3 End: 4 )

## Technical Objectives and Work Plan

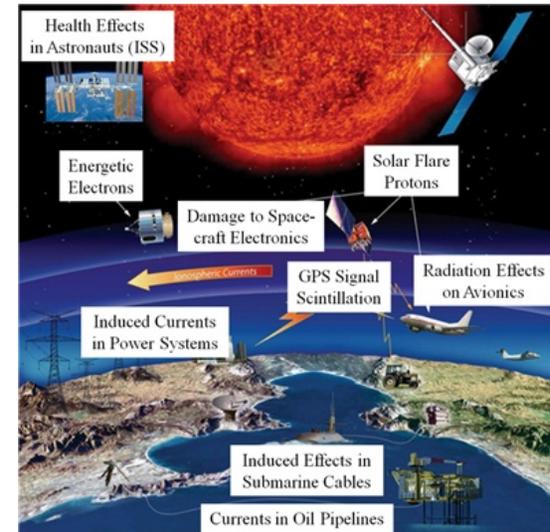
Technical Objective: Develop a capability to accurately forecast solar particle events (both probability of event and all-clear scenarios) and the impact of SPE-generated energetic particles on electronics. We will utilize an integrated approach including high-fidelity computational software and available observations, to achieve this objective.

Phase I Work Plan:

- (1) Install the MAG4 and PATH codes, and the Geant4 toolkit, at CFDRRC.
- (2) Validate performance of each code using test cases from literature/observations.
- (3) Develop interfaces for information transfer between the codes.
- (4) Develop a Python-based framework prototype and demonstrate automated execution of the integrated software (MAG4 to PATH to Geant4)

Phase II Work Plan:

- (1) MAG4 updates: improve flare/CME forecasting based on HMI databases.
- (2) PATH updates: improve calculation procedures, incl. cross-field diffusion
- (3) Develop radiation databases for low-Earth orbits as a function of altitude, particle energy, etc. using parametric Geant4 calculations.
- (4).Link to downstream codes to calculate single-event effects in electronics.
- (5) Demonstrate event-to-effects capability; improve towards operational use.



## NASA Applications

Improved forecasting of SPEs and their effects is aligned with NASA's Living With a Star program, the Human Research Roadmap, and OCT TA06, specifically, Radiation (Space Weather Prediction and Protection Systems). The developed SPE4 software will support mission operational planning (e.g., at SRAG/JSC) by forecasting the occurrence and all-clear periods of SPEs, to plan extra-vehicular activities for astronauts at the ISS, and planned temporary shutdown of systems to avoid catastrophic failure

## Non-NASA Applications

A predictive capability for SPE-induced radiation and resulting effects in electronics can help mission/equipment managers schedule tasks and adopt risk mitigation strategies. Directly relevant to DoD agencies and commercial entities with space-based or high-altitude assets (e.g., satellites), navigation/GPS, radio communications, electrical power transmission systems, oil pipelines.

## Firm Contacts

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NON-PROPRIETARY DATA