B.6 HELIOPHYSICS LIVING WITH A STAR SCIENCE

NOTICE: Amended December 14, 2018. This amendment presents final text for this program element. Step-1 proposals are due February 14, 2019 and the Step-2 proposals are due March 29, 2019.

The Strategic Capabilities and The Cross-Discipline Infrastructure Building components are not being competed in ROSES-2018.

The requirement to address potential contribution to the Focused Science Team effort was changed in ROSES 2017 (see Section 8.2.2). Please note that the proposer's response to this requirement will be provided in a 4000-character text box on the NSPIRES cover page not in the 15-page main body of the proposal. Section 8.2.3 explains how the evaluation criteria explicitly include assessment of the potential contribution to the Focused Science Team effort.

The Data Use policy for the LWS Science Element in ROSES 2018 is described in Section 1.1

Proposal submission to this program element is by a two-step process, in which a Notice of Intent is replaced by a required Step-1 proposal. See section 8 for details.

Targeted Science Team proposals, whereby a single large proposal covers the entire breadth of a Focused Science Topic, will not be permitted in ROSES-2018.

1. Introduction

The Living With a Star (LWS) Program emphasizes the science necessary to understand those aspects of the Sun and Earth's space environment that affect life and society. A primary goal of the LWS program is to provide scientific understanding, with the potential for prediction, of the Heliosphere as a system. This includes an understanding of the space weather conditions from the Sun to the Earth and throughout the interplanetary medium, as well as the Sun-climate connection.

The LWS program objectives are as follows:

1. Understand how the Sun varies and what drives solar variability.
2. Understand how the Earth and planetary systems respond to dynamic external and internal drivers.
3. Understand how and in what ways dynamic space environments affect human and robotic exploration activities.

The LWS Program seeks to make progress in understanding the complex Heliophysics system, focusing on the fundamental science of the most critical interconnections. Further information on the LWS Program can be found at the updated LWS website (http://lwstrt.gsfc.nasa.gov/). The LWS Science program maintains a strategy with three components, namely, Strategic Capabilities, Targeted Investigations, and Cross-Disciplinary Infrastructure Building programs. Because Strategic Capabilities and Cross-

Disciplinary Infrastructure Building programs are fully subscribed, only the Targeted Investigations will be competed in this announcement.

Further background material concerning relevant research objectives can be found on the LWS website, and in the following documents:

- The LWS TR&T SDT Report (https://lwstrt.gsfc.nasa.gov/images/pdf/TRT_SDT_Report.pdf)
- The LWS *10-Year Vision Beyond 2015 Report* (http://lwstrt.gsfc.nasa.gov/images/pdf/LWS_10YrVision_Oct2015_Final.pdf)
- The National Research Council Decadal Survey Report *Solar and Space Physics: A Science for a Technological Society* (http://www.nap.edu/openbook.php?record_id=13060).

1.1 Data Use in the Living With a Star Program

This program element has policies on the use of data in proposals that expand upon and supersede those given in B.1 Heliophysics Research Program Overview.

For successful completion of the proposed project, proposals to this program may only use data that is in a publicly available archive at least 30 days prior to the Step-2 deadline. This applies to both space-based and ground-based observations, as well as any data products derived from them. This latter point does not exclude data products to be developed as part of a proposed study only those existing in advance of Step-2 submission. Any questions about whether a data set or data product qualifies as publicly available must be submitted to the program element's point of contact at least 10 days before the Step-1 deadline.

After an award is made, projects may incorporate new data that becomes available in a public archive, provided that their use does not alter the goals and objectives of the selected proposal. Any planned changes in the data used must be described in the annual progress report submitted by the Principal Investigator.

While the inclusion of useful ground-based observations is allowed, proposals are expected to incorporate space-based observations so collaboration between space-based and ground-based observers are permitted. Further, the Step-2 evaluation process (see Section 8.2.3) will include the consideration of the presence and importance of space-based or ground-based observations in the proposals. Regardless of the type of data that would be utilized in the proposed study, space-based, ground-based, or some combination, the proposal must clearly demonstrate why the proposed data set or data sets are sufficient to address the proposed goals and objectives.

2. The Strategic Capabilities, Cross-Discipline Infrastructure Building, and Tools and Methods

The Strategic Capabilities and Cross-Discipline Infrastructure Building components of the LWS element are not be competed in ROSES-2018. For Strategic Capabilities, issues regarding topic(s), budgets, and anticipated awards are still being examined and need to be resolved prior to an announcement. It is anticipated that Strategic Capabilities will be competed in ROSES 2019. Cross-Discipline Infrastructure Building is fully subscribed at present. Tools and Methods may be competed as part of ROSES-2019.

3. Scope of Program Element - Targeted Investigations

The stated goal of LWS, that of achieving an understanding of those aspects of the Sun-Solar System that have direct impact on life and society, poses two great challenges for the LWS program. First, the program seeks to address large-scale problems that cross discipline and technique boundaries (e.g., data analysis, theory, modeling, etc.); and second, the program will identify how this new understanding has a direct impact on life and society. Over time, the Targeted Investigations have provided advances in scientific understanding that address these challenges.

The Targeted Investigations component this year consists of four Focused Science Topics (FSTs).

3.1 Focused Science Topics

The Focused Science Topics (FST) permitted as the objectives for proposals this year are as follows:

1) Mid-latitude and Equatorial Dynamics of the Ionosphere-Thermosphere System (described in section 4);
2) Origins, Acceleration and Evolution of the Solar Wind (described in section 5);
3) Understanding the Response of Magnetospheric Plasma Populations to Solar Wind Structures (described in section 6);
4) Understanding Global-scale Solar Processes and their Implications for the Solar Interior (described in section 7).

Detailed descriptions of each FST are listed below. NASA desires a balance of research investigation techniques for each topic, including theory, modeling, data analysis, observations, and simulations. In previous ROSES calls, proposals could be individual proposals that would form part of a team or Targeted Science Teams (TSTs) that form prior to submission under a single Principal Investigator (PI) and submit a single TST proposal that attacks the entire breadth of the Focused Science Topic. However, such TSTs will not be permitted this year and the FST teams will be formed from the selected individual proposals based on panel evaluations and programmatic considerations.

Because of the structure of the LWS FST program element, the results of these investigations often times have an applied component where the results may be used for prediction. As a result, understanding the uncertainty associated with these results is an essential part of this program. Consequently, all proposals must address data and model uncertainty (see section 8.2.3).

LWS Science will pursue one of the recommendations in Chapter 10 of the 2013 Heliophysics Decadal Survey that NASA "work toward doubling the size of Individual-Principal-Investigator grants." Given the strategic nature of LWS, and the fact that strategically feasible tasks require sufficient investment, it is anticipated that FST proposals will have annual budgets in the range of $185K - $225K. (This includes fully encumbered Civil Servant labor, where appropriate.) It is left to individual PIs to decide whether a strategically feasible award size could be achieved by increased collaborative efforts, greater FTE of investigators, or a mix of the two. PIs should be cognizant, however, that verification of the level of effort versus the actual work proposed will be part of the review panel process. Given the submission of proposals of adequate number and merit and investigative techniques, NASA anticipates forming teams of ~5-7 selections for each of the four FST topics. The expected duration of FST awards is four years.

3.2 Focused Science Teams

Once selected, these investigators will form a team in order to coordinate their research programs. In order to foster the collaborations required to coordinate these team research efforts, one of the PIs will serve as the Team Leader for the Focused Science Topic for which he/she proposed. This PI will receive supplemental funding, as necessary, to support costs associated with these duties after the selection process is completed. Proposers are encouraged to propose to act as a Team Leader and, if they do so, should include a brief section at the end of their proposal describing how they would lead the team effort. Up to one extra page of the proposal is allowed for this proposed effort.

All proposers for Focused Science Topics should include sufficient travel funds in their proposed budgets to cover two team meetings per year to be held on the U.S. coast furthest from their home institutions. This assumes that one meeting per year will be held in conjunction with a major U.S. scientific meeting. Successful teams will participate in a Kickoff Workshop were the selected team members will meet and develop work plans for the anticipated period of performance, generally 4 years, based on the requirements of the FST and the composition of the selected team. Guidance for the Team Development process will be provided by NASA.

4. FST #1: Mid-latitude and Equatorial Dynamics of the Ionosphere-Thermosphere System

4.1 Target Description

It is well known that during magnetic storms heating occurs first at high latitudes. Energy is transferred from the magnetosphere to the ionosphere-thermosphere (IT) through Joule heating and particle precipitation. Equally well known are the dramatic positive and negative ionospheric storm effects that undoubtedly result from this input and the complex IT interactions. However, we do not understand how this energy and dynamics are transferred to mid- and equatorial latitudes to form the plasma density and total electron content (TEC) distribution observed there as well as irregularities/ scintillation. To date much of what is known about the dynamics of mid-, low- and equatorial latitude electrodynamics is largely based on observations from a few incoherent scatter radars and individual single ground observatories. In very recent years extended ground GPS arrays have offered global scale dynamics from TEC observations and can potentially track the propagation of TIDs. Although much phenomenological insight has been gained into the complex dynamics at those latitudes, the link to physical processes that result in scintillation and TEC dynamics is not understood. It is not surprising that IT responses observed recently by satellites such as C/NOFS and recent ground instrumentation have been unpredictable and unexpected. Specifically, the significant longitudinal variability now seen in multiple IT properties is not at all understood and has become a barrier for the ongoing global density modeling effort that is necessary to improve TEC and scintillation forecasting capabilities.

There has been significant speculation on the possible causes of longitudinal electrodynamics variability, which includes: (a) the disturbance dynamo, which is the large-scale neutral wind system responsible for transferring energy from high to low latitudes and across the equator, and/or large scale atmospheric and ionospheric waves (TADs and TIDs) (b) the longitudinal difference in the neutral wind magnitude and direction, (c) the coupling between lower atmosphere and ionosphere (possibly source for non-migrating tides and localized gravity wave activity), (d) the longitudinal difference in the magnetic field orientation and magnitude at low latitudes. However, due to the uneven distribution of suitable ground-based instrumentation, and lack of consistent low-inclination missions, these speculations have not been validated or confirmed. The longitudinal distributions of ground-based instruments (GPS, ground magnetometers, imagers, radars, ionosondes, lidars, etc) are now getting better and can be utilized both for the low latitude longitudinal electrodynamics observations as well as for latitudinal transport of waves and energy from high latitudes to equatorial latitudes.

Understanding the latitudinal energy transport between higher and lower latitudes as well as the longitudinal variability of mid-, low-, and equatorial latitude electrodynamics is essential to the following LWS strategic science areas (SSA): SSA-4 Physics-based TEC Forecasting Capability, and SSA-5 Physics-based Scintillation Forecasting Capability. This topic is timely as it will advance our current state of understanding and capability to forecast scintillation and TEC structure at low latitudes and prepare the research path for multiple upcoming missions (ICON, GOLD, etc.)

4.2 Goals and Measures of Success

The goal of this FST is to understand mid and low latitude plasma density structure that affects scintillation as well as TEC variability and to accurately model the physical sources that drive it. Up-to-date simulation results should be compared with pertinent observations to quantify both our success level and the gaps in our understanding. Measures of success include, but are not limited to:

- The accurate determination of the longitudinal structure of low and equatorial latitudes of plasma density and plasma drifts.
- The determination of the details of vertical plasma motions.
- Specification and quantification of the effect of energy transport (TIDs/TADs) to this longitudinal structure.
- Quantification of a relationship between the longitudinal structure and scintillation effects

4.3 Types of Investigations

We seek investigations that will take advantage of historical, ongoing and future observations from space (e.g., C/NOFS, GRACE, TIMED, etc.) and supporting observations from the growing deployment of mid-, low-, and equatorial latitude ground instrumentation of all kinds, and in combination with empirical and physics based models. Data assimilation techniques are also encouraged. Scientific questions addressed by selected investigations should include, but are not limited to, the following:

- What is the mid-, low-, and equatorial latitude structure of plasma density, particularly during geomagnetically active periods, and how does the magnetic field longitudinal orientation and magnitude affect it?
- How does the disturbance dynamo contribute to transferring energy from high to low latitudes and across the equator?
- What is the role of TIDs and TADs?
- How does the longitudinal difference in the neutral wind magnitude and direction affect longitudinal structure and scintillation?
- How does the coupling between lower atmosphere and ionosphere (possibly source for non-migrating tides and localized gravity wave activity) contribute and affect TEC and scintillation?

4.4 Predictability, Interaction with User Communities, and Uncertainty:

Given the potential relevance of this FST with the upcoming GOLD and ICON missions, proposers should consider potential overlap of the FST and the anticipated observations of those two missions. Given the data policy in Section 1.1, however, proposals must not require the use of data from these two missions to address and achieve closure their science questions. Rather, the impact of the potential future observations from these missions may be considered as a possible source of future data.

All studies must consider data and model uncertainty and how sources of error impact the results (see Section 8.2.3).

5. FST #2: Origins, Acceleration and Evolution of the Solar Wind

5.1 Target Description

The supersonic, super-Alfvenic solar wind arises from the million-Kelvin solar corona, where the heating processes generating these temperatures and the role of small-scale waves, turbulence and field dynamics are far from being understood. In-situ solar wind turbulence observations show a dissipation range, which is direct evidence of ongoing turbulent heating believed to operate throughout the heliosphere, from the low corona out to the heliosheath. Subsurface solar convection powers all its mass loss, generates magnetic fields, excites solar flares through magnetic reconnection, and drives coronal mass ejections, Alfvénic waves, ion–cyclotron waves, and the various turbulent processes that evolve throughout the heliosphere. Understanding the origin, acceleration and evolution of the solar wind is critical for predicting virtually all forms of space weather. This FST directly relates to SSA-0, which focuses on physics-based understanding of the variability of solar magnetic fields and particles.

This FST covers the array of physical processes involved in the solar wind's origin and evolution: the sources of different solar wind types and their connection to different coronal structures; the micro-physics of particle velocity distribution functions, their anisotropies and nonthermal characteristics; the role of turbulence and wave-particle interactions in heating and acceleration; and the energization driven by structures, such as shocks, current sheets and/or magnetic reconnection.

This FST addresses a range of science questions, including: What specific observables can be derived from and used to test solar wind models? What existing observations can be used to validate solar wind models, ranging from the kinetic to the AU scales? Furthermore, in preparation for the next decade of exploration of the inner heliosphere and corona with Solar Orbiter and Solar Probe Plus, how can the anticipated observations drive theoretical developments?

5.2 Goals and Measures of Success:

The primary goal of this FST is to advance our understanding of the origin, acceleration and evolution of the solar wind for future predictive models.

A key component of this FST will be the inter-comparison and testing of competing solar wind models, better constraining them using an array of solar wind in-situ and remote sensing observations, and the development of observational metrics to evaluate their strengths and limitations. The outcome will improve solar wind modeling capabilities. Direct observations across a range of temporal and/or spatial scales may be used to determine how large-scale features evolve in the origins of solar wind. Measures of success include, but are not limited to the:

- Determination of how magnetic scales couple to enable the release of material that form the wind
- Clarification of how plasma turbulence evolves and dissipates to heat and accelerate solar wind plasma
- Evaluation of how energy propagates across different regions of the corona and through the transition region
- Determination of the relationship between charge-states and elemental abundances and how they are set
- Understanding of nano-flares and magnetic reconnection and how stored electromagnetic energy is transfer to particles
- Evaluation of processes that heat and accelerate the solar wind plasma in the low corona

It is anticipated that future observations may transform our understanding of the origins and acceleration of the solar wind. In preparation, models need to be defined and tested and to establish specific metrics that can be used for validation. This will allow future predictive models to be developed and tested efficiently as new observations of the solar wind emerge.

5.3 Types of Investigations

The nature of this research effort requires the interdisciplinary combination of observational, theoretical, and numerical studies, including the following subtopics:

- waves, turbulence, and/or structures and their role in the heating of the solar wind plasma
- reconnection as an energy source that drives and/or heats the solar wind
- electron transport and heat conduction

- minor ions and their role in the origin and the evolution of the solar wind
- non-Maxwellian velocity distribution functions and their role in non-equilibrium solar wind thermodynamics
- small-scale energy release processes (nano-flares, etc.) and their role in the origin of the solar wind
- solar wind source models based on charge state and elemental composition
- mass flux, solar wind power, and their relationship to the large-scale magnetic field and small-scale dynamics
- differential studies of the spectrum of solar wind types that arise from different global-scale magnetic topologies
- evolution of solar wind properties through the solar cycle

Studies within this program will combine theoretical, numerical, and observational methods. The successful outcome of each research effort will rely on high-quality data analyses from past and present missions – such as Helios 1 and 2, Wind, ACE, Ulysses, STEREO, SOHO, SDO, IRIS, DSCOVR, etc. – to facilitate the robust comparison and constrain models with measurements. The effort could also rely on high-performance computing to facilitate multi-scale modeling activities.

5.4 Predictability, Interaction with User Communities, and Uncertainty:

One motivation of this FST is to advance our understanding of the origins, acceleration and evolution of the solar wind with a goal to identify observational metrics that test solar wind models and to develop the understanding needed to advance predictive solar wind models. The FST should demonstrate how the expected advances will be relevant for prediction of solar wind properties.

Given the potential relevance of this FST with the Parker Solar Probe and upcoming Solar Orbiter missions, proposers should consider potential overlap of the FST and the anticipated observations of those two missions. Given the data policy in Section 1.1, however, proposals must not require the use of data from these two missions to address their science questions. Rather, the impact of the potential future observations from these missions may be considered as a possible source of future data.

All studies must consider data and model uncertainty and how sources of error impact the results (see Section 8.2.3).

6.0 FST #3: Understanding the Response of Magnetospheric Plasma Populations to Solar Wind Structures

6.1 Target Description:

Plasma populations govern space weather conditions within the Earth's magnetosphere. Energetic particles cause single-event upsets and deep dielectric charging in spacecraft electronics and may be harmful to humans in space. While we understand that magnetospheric dynamics is driven by the solar wind, we only understand the first order responses of the magnetospheric populations. Their nonlinear response to different driving conditions, involving coupling and feedback between populations, magnetosphere and ionosphere, wave particle interactions is still poorly quantified.

Many aspects of current geospace modeling efforts rely on simple parameterizations and do not take into account the complexities of different solar wind drivers, or even more the timescales for geoeffective coupling, or the combined effect of multiple driving parameters that can result in dramatically different responses from those to individual drivers. Solar wind can change the locations of the magnetopause and plasmapause, can change the configuration of the global magnetic and electric fields and can drive the generation of Ultra Low Frequency, Very Low Frequency, and Extremely Low Frequency waves that can interact with particles. Understanding and predicting when and where radiation effects related to space weather may occur requires detailed knowledge of the how particle radiation is driven by the solar wind. This topic is well suited to make significant advances in our understanding of low-to-high energy particle dynamics, and hence will lead to next-generation modeling and forecasting models - important for effective mitigation of geomagnetic storms.

This FST is relevant to LWS TR&T Strategic Science Areas (SSAs): SSA-0: Solar electromagnetic, energetic particle, and plasma outputs driving the solar system environment and inputs to Earth's atmosphere; SSA-1: Geomagnetic Variability; and SSA-6: Radiation Environment.

6.2 Goals and Measures of Success

This FST is targeted at improving our understanding of how particular structures in the solar wind affect global fields and particle populations from a whole systems approach. Measures of success include, but are not limited to, studies that provide:

- Improved empirical models for the magnetospheric plasma environment as a function of solar wind and geomagnetic conditions.
- Improved first principle models capable of predicting the time-dependent response of magnetospheric plasma populations to varying solar wind conditions.
- Validation of the models, and specification of intrinsic errors during selected extreme events.

6.3 Types of Investigations

Investigations that address this FST include, but are not limited to:

- The development of the quantitative models for magnetospheric plasma populations.
- Studies which utilize multipoint ground-based and spacecraft observations of magnetospheric and solar wind conditions.
- The examination of how particular structures in the solar wind determine the spatial and temporal evolution of the magnetospheric plasma populations.
- Case studies that utilize empirical models and/or global numerical simulations.
- Investigations involving machine learning, and the development of global simulations capable of assimilating both in situ and remote observations.

6.4 Predictability, Interaction with User Communities, and Uncertainty

Proposals should identify potential Scientific/User Community that would benefit from specific prediction capabilities generated by the proposed work. In addition, the proposal should provide a brief statement on how particular user communities could utilize the results.

All studies must consider data and model uncertainty and how sources of error impact the results (see Section 8.2.3).

7.0 FST #4: Understanding Global-scale Solar Interior Processes and the Implications of Changes in the Solar Interior on the Heliosphere

7.1 Target Description

The particulate and electromagnetic outputs of our star are modulated by the behavior of the Sun's magnetic field. That field, on timescales from seconds to millennia, controls the interaction between the Sun and the heliospheric environment. Unfortunately, the processes that drive the genesis and much of the evolution of global-scale magnetic field are largely hidden from direct observation. As a result, models of solar magnetic flux origins have attempted to explain the generation and evolution of the magnetic field using assumptions about the internal flow fields including temporally varying differential rotation, meridional flows, and zonal flows, as well as estimates of magnetic field emergence, reconnection, and diffusion. Recent observations, however, have highlighted the presence of more complex meridional circulation patterns and significant differences in evolution of the higher latitudes that may play a major role that has not been previously investigated. The assimilation of time-variable, large-scale, internal solar dynamics into models of solar magnetic flux origins is essential for forecasting solar magnetism and activity. These models will support attempts to predict the resulting geomagnetic effects across numerous timescales making this FST relevant to SSA-0, SSA-1, and SSA-2.

This FST should develop a consensus set of observational constraints for the latitudinal and temporal variation of meridional circulation, the solar rotation profile, etc., using state-of-the-art observations and data analysis techniques from historical and contemporary data archives. This FST will bring together observers to provide information on the internal flows, with solar interior modelers to provide the simulations, and data assimilation experts to construct a framework to integrate observations and models.

The overarching goal of this FST is to produce a data-driven model for solar magnetic flux production to enable forecasting of active latitude and longitude regions on time scales ranging from years to decades. Bringing together observers, analysts, modelers, and theorists to work together is a necessary prerequisite to the development of a forecast capability for solar activity across spatial and temporal scales, in readiness for the ~2022-23 maximum of solar cycle 25 in direct support of Parker Solar Probe and Solar Orbiter mission science.

7.2 Goals and Measures of Success

The results of this FST will advance our understanding of the time-variable and large-scale internal solar dynamics, magnetic field creation, and emergence. Success can be measured by the degree to which the team improves the forecasting of solar inputs to heliospheric and terrestrial atmosphere models beyond solar rotational time scales.

The team will develop a "consensus" set of observational constraints of surface and interior flows that extend the present reliance of the modeling community on sunspot archives, including hemispheric and broader latitudinal dependence. The team will demonstrate how to assimilate observations into models of the flows and magnetic dynamo activity of the solar interior. Measures of success are the prediction of the magnitude and timing of the next solar cycle maximum and the prediction of active latitudes during the next solar cycle.

Validation of predictive tools will be addressed through hindcast comparisons with legacy observations.

7.3 Types of Investigations

The following list covers a broad range of topics and activities that could be included in the FST Team. It is not anticipated, however, that this complete set of topics will be included in the selected FST Team.

- Theory and modeling of large-scale flows and generation of magnetic fields in the solar interior.
- Novel data analysis techniques: Methods tailored to measure large-scale flows in the photosphere and solar interior 1) with appropriate spatial resolution 2) that reach to high latitudes. These can be combined with observational and numerical studies to identify monthly to decadal timescale variations in internal flows, and studies of how these affect internal dynamo action.
- Inversion techniques: Development of new helioseismic methods for pushing the range of validity in latitude and in depth (shallowness) of the various diagnostics, including the use of multiple-line techniques with different sensitivities to the presence of magnetism. Use of feature-finding algorithms: Investigations that explore existing community resources (e.g., the Heliophysics Events Knowledgebase; HEK) and develop methodologies for identifying and tracking features in magnetograms and solar imaging in contemporary and legacy data to derive further information about global-scale flows.
- Use of ancillary observations as additional constraints: Investigations that explore the relationships and differences between global-scale evolution observed in the low and high latitudes using data of the photosphere, chromosphere and corona in addition to archived measures of the solar wind and sun-as-a-star radiative properties.
- Observational studies of the spatial structure of internal and surface solar flows, and numerical studies of how these affect internal dynamo processes and flux emergence latitudes. This includes diagnostic intercomparisons and validation, with observational investigations including helioseismology (based on observations or numerical simulations), the nature of super-granulation, giant cells, etc.
- Studies to develop assimilative methods required to incorporate observed solar flows into flux evolution and dynamo models. This includes data assimilation into predictive tools for near-real-time updating, which is encouraged. The investigations must emphasize how development enables predictive capabilities.

7.4 Predictability, Interaction with User Communities, and Uncertainty

Given the potential relevance of this FST with the Parker Solar Probe and upcoming Solar Orbiter missions, proposers should consider potential overlap of the FST and the observations of those two missions. Given the data policy in Section 1.1, however, proposals must not require the use of data from either of these two missions to address their science questions. Rather, the impact of the potential future observations from these missions may be considered as a possible source of data or application of FST Team results. In addition, NASA science and human exploration programs rely on understanding the strength and timing of future solar variability for planning through the use of numerous models of solar activity and the terrestrial response.

All studies must consider data and model uncertainty and how sources of error impact the results (see Section 8.2.3).

8. Submission and Evaluation Process

To streamline the proposal process (submission, evaluation, and administration), this program uses a two-step proposal submission process (see the overall description of a two-step process in the ROSES *Summary of Solicitation* Section IV(b)vii).

In addition to the general requirements and restrictions (e.g., in Table 1 of the *ROSES Summary of Solicitation* and in B.1 Heliophysics Research Program Overview) this program element has specific compliance constraints for both format (e.g., Sections 8.1.1 and 8.2.1) and content, e.g., involving data (see Sections 1.1 and 8.2.3). These compliance rules ensure fairness and are enforced strictly by the Heliophysics Division. Proposals that are deemed non-compliant will typically be returned without review or, if not caught until during or after the review, will typically be declined despite any merits that may have been found by peer review.

8.1 Step-1 Proposals

Proposers should refer to the "Instructions for Submitting a Step-1 Proposal" under "Other Documents" on the NSPIRES page for this program element.

A Step-1 proposal is required and must be submitted electronically by the Step-1 due date given in Tables 2 and 3 of ROSES-2018. The Step-1 proposal must be submitted by the organization's Authorized Organizational Representative (AOR). No budget or other uploaded files are required. Only proposers who submit a Step-1 proposal are eligible to submit a Step-2 proposal. Step-1 proposals will be checked for compliance, but they will not be evaluated. The Step-1 proposal title, science goals and objectives, and investigators (Principal Investigator, Co-Investigators, Collaborators, Consultants, and Other Professionals) cannot be changed between the Step-1 and Step-2 proposals. The expected format and evaluation criteria are described below. Submission of the Step-1 proposal does not obligate the offerors to submit a Step-2 (full) proposal.

8.1.1 *Step-1 Proposal Format*

The Step-1 proposal is restricted to the 4000-character Proposal Summary text box on the NSPIRES web interface cover pages. It should include the following information:

- A description of the science goals and objectives to be addressed by the proposal.
- A brief description of the methodology to be used to address the goals and objectives.
- A brief description of "Proposed Contributions to the Focused Science Team Effort" (see Section 8.2.2 for the material to be summarized).

The NSPIRES system for proposal submission requires that Step-1 proposals include a summary (i.e., abstract) describing the proposed work as outlined above. The proposal summary is entered directly into a text field in NSPIRES. No PDF attachment is required or permitted for Step-1 proposal submission. All information for the proposal summary will be entered within the 4000-character Proposal Summary text box on the NSPIRES web interface cover pages. Proposers will be notified by email when they are able to submit their Step-2 proposals.

8.2 Step-2 Proposals

Proposers should refer to the "Instructions for Submitting a Step-2 Proposal" under "Other Documents" on the NSPIRES page for this program element. A Step-2 (full) proposal must be submitted electronically by the Step-2 due date (see below and Tables 2 and 3 of ROSES). The Step-2 proposal must be submitted by the organization Authorized Organizational Representative (AOR). A budget and other specified information is required. The Step-2 proposal title, science goals and objectives, and investigators (Principal Investigator, Co-Investigators, Collaborators, Consultants, and Other Professionals) must be the same as those in the Step-1 proposal.

Proposers must have submitted a Step-1 proposal to be eligible to submit a Step-2 proposal. Proposers that have received a noncompliance letter are not eligible to submit a Step-2 proposal.

Proposers may be expected to provide mail-in reviews for one to three proposals in this competition. Much of the science expertise lies in the PI/Co-I community, because, increasingly, nearly the entire Heliophysics community proposes. In order to maintain a high caliber review process, it is important to get the additional mail-in reviews to cover all proposals fairly.

8.2.1 *Step-2 Proposal Format*

All proposals submitted to ROSES must strictly conform to the formatting rules. Proposals that violate the rules may be rejected without review or declined following review if violations are detected during the evaluation process.

- The Scientific/Technical/Management section must not exceed the length specified in this Program Element (see Section 9 below).
- Margins: No less than 1 inch on all sides.
- Page size: The PDF must be set for a standard US letter page size of 8.5 × 11 inches.
- Font: Times New Roman, 12-point or larger. If an alternate font is used, it must meet the requirement of having, on average, no more than 15 characters per horizontal inch, including spaces. Proposers may not adjust the character spacing or otherwise condense a font from its default appearance.
- Line spacing: Font and line spacing settings must produce text that contains, on average, no more than 5.5 lines per vertical inch. Proposers may not adjust line spacing settings for a selected font below single spaced.
- Figure captions*:* Captions must follow the same font and spacing rules as the main text*.*

- Figures and tables: For text in figures and tables, font and spacing rules listed above do not apply, but all text must be judged to be legible to reviewers without magnification above 100%. Expository text necessary for the proposal may not be located solely in figures or tables, or their captions.

General agency guidelines for proposals are specified in the *NASA Guidebook for Proposers* but the requirements in this program element supersede those found in the Guidebook (see Section I(g) of the *ROSES-2018 Summary of Solicitation*). Instructions for the mechanics of submitting Step-2 full proposals will be downloadable as a PDF file entitled "How to create and submit a Step-2 Proposal (PDF)" under "Other documents" on the NSPIRES page for this program element after Step-1 submissions are complete.

8.2.2 *Required Additional Section in Step-2 Proposal Front Pages: Proposed Contribution to the Focused Science Team Effort*

Proposals to this program element must address the proposed contribution to the Focused Science Team effort in a 4000-character plain text box on the NSPIRES cover pages and this will be peer reviewed as part of the evaluation of relevance (see Section 8.2.3). Since it is no longer included in the main body of the proposal, this text does not count against the 15-page limit for the Scientific/Technical/Management section. Proposals that fail to address the proposed contribution to the Focused Science Team effort will be declared noncompliant and will typically be returned without review or, if not caught until during or after the review, will typically be declined despite any merits that may have been found by peer review.

This section must summarize the following three topics:

- The relevance of the proposed study to the scientific objectives (Goals and Measures of Success) of the Focused Science Topic outlined in Sections 4.2, 5.2, 6.2, or 7.2,
- The potential contributions of the proposed study (Type of Investigation) to the Focused Science Team's effort outlined in Sections 4.3, 5.3, 6.3, or 7.3, and
- Metrics and milestones for determining the successful progress and outcome of the proposed research.

This summary must describe the goals of the proposed project and why they are aligned with the FST goals outlined in Sections 4.2, 5.2, 6.2 or 7.2. For proposals that address a Type of Investigation that is listed in Sections 4.3, 5.3, 6.3, or 7.3, this summary must also describe briefly how the proposed investigation addresses one or several of those investigations. For proposals that address a Type of Investigation that is NOT listed in the FST description, the summary must briefly describe the proposed Type of Investigation and how the proposed investigation will meet the Focused Science Topic Goals and Measures of Success. In addition, all proposers are expected to provide a set of metrics that they will use to identify progress toward their proposed goals. Finally, a set of milestones should indicate the anticipated timing of the major achievements during the course of the proposed study. These metrics and milestones may change once the FST Team is formed so the proposed metrics and milestones should be based on the proposed study as a stand-alone effort. The review panel will only consider material in this section when the "Proposed Contribution to the Focused Science Team Effort" portion of the proposal is evaluated.

8.2.3 *Step-2 Evaluation Criteria*

Compliant proposals will be evaluated according to three main criteria: (1) Intrinsic Merit, (2) Potential Contribution to the Focused Science Team Effort (Relevance), and (3) Cost Reasonableness. The data management plan, described in ROSES, will also be evaluated. The Intrinsic Merit and Cost criteria will be evaluated primarily as specified in the *ROSES-2018 Summary of Solicitation* and the *NASA Guidebook for Proposers*, but Relevance is handled differently, see below.

The evaluation of Intrinsic Merit will consider only information contained within the 15-page main body of the proposal (the Scientific/Technical/Management section). Most proposals are expected to describe a complete scientific study (i.e., clearly identified science questions and a project that achieves closure on those questions); however, this program element also accepts proposals that lack a complete scientific study but do describe a project that would enable or enhance the FST's activities (e.g. develop a data set or implement a model for use by the FST Team). Regardless of the project, all proposals must identify science questions responsive to the FST's goals that are addressed by the proposed work.

As mentioned above (sections 4.4, 5.4, 6.4, or 7.4), all proposals must address data and model uncertainty. This is described in section 3.13 of the Guidebook for Proposers which indicates that all proposals must address "Sources of error and uncertainties and what effect they may have on the robustness of potential results and conclusions." The treatment of uncertainty will be evaluated by the review panel as a methodology issue (intrinsic merit) and will be assigned a strength or weakness based on the treatment presented in the proposal. Proposers are free to choose any appropriate method of uncertainty analysis but it must be clearly addressed in the body of the proposal. Proposals that fail to address uncertainty will be assigned a Major Weakness in the evaluation and may be considered unselectable.

The evaluation of the Potential Contribution to the Focused Science Team (Section 8.2.2) will serve as the Relevance evaluation. Please note that the review panel will consider only the response to this NSPIRES cover page question (described in Section 8.2.2) in the evaluation of this criterion.

Evaluation of Cost Reasonableness will compare the scope of the proposed study and the proposed resources (personnel-time allocated, necessary computer resources, etc.).

Also, as part of the review process, the evaluation will include the determination of whether the proposal violates the restrictions in Section 1.1, including the use of data not in a publicly available archive 30 days before the Step-2 deadline. If possible, proposers should include a link or links to the data set(s) to be used in the proposed study. Non-compliant proposals may be returned without review.

9. Award Types

The Heliophysics LWS Science program will primarily award funds through three vehicles: (1) grants, (2) interagency transfers, and (3) awards to NASA centers. This call will not award contracts, as it is not appropriate for the nature of the work. Please also see the *ROSES-2018 Summary of Solicitation*, Section II a.

10. Summary of Key Information

Expected annual program budget for new awards	~$4.8 M
Number of new awards pending adequate proposals of merit	~ 21 – 26
Maximum duration of awards	4 years
Due date for Step-1 proposals	See Tables 2 and 3 of ROSES
Due date for Step-2 proposals	See Tables 2 and 3 of ROSES
Planning date for start of investigation	No earlier than 6 months after the Step-2 proposal due date.
Page limit for the central Science-Technical-Management section of proposal	15 pp; one extra page permitted for proposals to be Team Leader of a Focused Science Topic; see also Table 1 of ROSES and the *NASA Guidebook for Proposers*
Relevance	This program is relevant to the Heliophysics questions and goals in the NASA Science Plan. Proposals that are relevant to the FSTs in this program element are, by definition, relevant to NASA. See Section 8.2.3 regarding evaluation criteria.
General information and overview of this solicitation	See the *ROSES-2018 Summary of Solicitation*.
Detailed instructions for the preparation and submission of proposals	See the *NASA Guidebook for Proposers* at http://www.hq.nasa.gov/office/procurement/nraguidebook/.
Submission medium	Electronic proposal submission is required; no hard copy is permitted.
Web site for submission of proposals via NSPIRES	http://nspires.nasaprs.com/ (help desk available at nspires-help@nasaprs.com or (202) 479-9376)
Web site for submission of proposals via Grants.gov	http://grants.gov (help desk available at support@grants.gov or (800) 518-4726)
Funding opportunity number for downloading an application package from Grants.gov	NNH18ZDA001N-LWS

NASA points of contact concerning this program	Jeff Morrill Heliophysics Division Science Mission Directorate National Aeronautics and Space Administration Washington, DC 20546-0001 Telephone: (202) 358-3744 Email: jeff.s.morrill@nasa.gov Janet Kozyra Heliophysics Division Science Mission Directorate National Aeronautics and Space Administration Washington, DC 20546-0001 Telephone: (202) 358-1258 Email: janet.kozyra@nasa.gov Simon Plunkett Heliophysics Division Science Mission Directorate National Aeronautics and Space Administration Washington, DC 20546-0001 Telephone: (202) 358-2034 Email: simon.p.plunkett@nasa.gov