B.6 HELIOPHYSICS LIVING WITH A STAR SCIENCE

Amended on February 26, 2013. The Step-1 due date for this program has been delayed from 03/01/2013 until 03/15/2013. Also, a FAQ has been posted under "Other Documents" on the NSPIRES web page for Appendix B.6

The Strategic Capabilities element and the Sun-Climate Theme element will not be competed in ROSES 2013.

Notice: Proposal submission to all calls in Heliophysics will now be done by a two-step process, in which a Notice of Intent is replaced by a required Step-1 proposal. The Title and investigators cannot be changed between the Step-1 and Step-2 proposals. See section 2 for details.

1. Scope of Program

1.1 Overview

The goal of NASA's Living With a Star (LWS) Program is to develop the scientific understanding needed for the United States to effectively address those aspects of Heliophysics science that may affect life and society. LWS Science solicits proposals leading to a physics-based understanding of the integral system linking the Sun to the Solar System, including the impact on the heliosphere, planetary magnetospheres, and ionospheres. The program's objectives can be achieved by data analysis, theory, and modeling, and the development of tools and methods (e.g., software for data handling). LWS Science is a crosscutting initiative that addresses the following LWS strategic goals (in no priority order):

1. Solar energetic particles and galactic cosmic rays pose major radiation hazards for space hardware and astronauts. Penetrating particle radiation adversely affects aircraft avionics and potentially the health of airline crews and passengers on polar flights. Communication and navigation systems are directly affected by impulsive changes in the solar particle and electromagnetic output leading to rerouted polar flights and GPS outages. In support of NASA's vision for space exploration and the national communication, navigation, and transportation infrastructure, the LWS Science program needs to deliver the understanding and modeling required for useful prediction of the variable solar particulate and radiative environment at the Earth, Moon, Mars, and throughout the solar system.

2. One of the major challenges facing humanity is global climate change. In order to gauge the response of the terrestrial climate system to natural and anthropogenic forcings, NASA through the LWS program and the Earth Science Division, in conjunction with other national agencies such as National Oceanic and Atmospheric Administration (NOAA) and National Science Foundation (NSF), needs to deliver the understanding of how and to what degree variations in the solar radiative and particulate output contribute to changes in global and regional climate over a wide range of time scales.

3. National infrastructures are increasingly dependent on satellites orbiting Earth. With increasing miniaturization, these systems are ever more sensitive to variations in the near-Earth space environment. To protect these assets, the LWS program needs to deliver the understanding and modeling required for effective forecasting/specification of magnetospheric radiation and plasma environments.

4. The upper atmosphere and ionosphere is central to a host of space weather effects, including anomalous satellite drag, GPS position error, radio blackouts, radar clutter, and geomagnetically induced currents. In order to mitigate space weather's impact on life and society, NASA through the TR&T program, in conjunction with other national agencies such as NSF and Department of Defense (DoD), needs to deliver understanding and predictive models of upper atmospheric and ionospheric responses to changes in solar electromagnetic radiation and to coupling above and below.

These strategic goals provided the basis for the selection of focused science topics for this solicitation. The primary goal of the LWS Program is to make progress in understanding this complex system, focusing on the most critical interconnections.

The *Final Report of the LWS TR&T Science Definition Team (SDT)* (December 2003), located on the LWS homepage at http://lwstrt.gsfc.nasa.gov/trt_resources.htm, identified Targeted Research & Technology (TR&T) as a systematic, goal-oriented research program. Over the course of the past decade, with the maturation of research topics and the development of the Community Coordinated Modeling Center (CCMC; http://ccmc.gsfc.nasa.gov/) for tools, the former TR&T can be subsumed into "LWS Science." The LWS Science program provides the theory, modeling, and data analysis necessary to enable an integrated system-wide picture of Heliophysics science with emphasis on societal relevance.

Significant progress toward quantitative understanding and predictive capability with respect to these problems will require large-scale, integrated modeling activities. Recognizing the need for activities that would be broader and more sustained than those that can be supported by a traditional NASA grants program, the *Final Report of the LWS TR&T Science Definition Team* recommended that "…large modeling activities that address coupling across traditional science domains in the Sun-Earth chain specifically be included as strategic capabilities." The SDT also recommended the formation of a Steering Committee in order to update periodically the designated strategic capabilities for future solicitations. The most recent report of this Steering Committee is available on the LWS homepage at http://lwstrt.gsfc.nasa.gov.

As a result of these studies and recommendations, the LWS Science program has defined a strategy with three program elements, namely, Strategic Capabilities, Targeted Investigations, and Cross-Disciplinary Infrastructure Building programs.

Further background material concerning relevant research objectives can be found in the following documents:

- The National Academy of Sciences Web tutorial, entitled "*Space Weather: A Research Perspective*" (http://www.nap.edu/catalog.php?record_id=12272);

- The Sun-Earth Connection LWS web site (http://lws.gsfc.nasa.gov/);
- The LWS Science Architecture Team report to SECAS (http://lws.gsfc.nasa.gov/documents/sat/sat_report2.pdf);
- The National Research Council Decadal Survey Report *The Sun to the Earth and Beyond* (http://www.nap.edu/books/0309089727/html/);
- *The Heliophysics Roadmap* (http://sec.gsfc.nasa.gov/sec_roadmap.htm); and
- *The latest TR&T Steering Committee Team Report* (http://lwstrt.gsfc.nasa.gov/trt_steeringcom.htm).

1.2 Strategic Capabilities

Notice: The Strategic Capabilities element will not be competed this year. In its previous guise as "Living With a Star Targeted Research and Technology: NASA/NSF Partnership for Collaborative Space Weather Modeling," it is fully subscribed this year with awards from ROSES-2011 and will not be recompeted until ROSES-2014 at the earliest.

1.3 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 must tackle large-scale problems that cross discipline and technique boundaries (e.g., data analysis, theory, modeling, etc.); and second, the program must identify how this new understanding will have a direct impact on life and society.

The Targeted Investigations element this year consists of: (1) Focused Science Topics (FSTs) and (2) A Special Initiative: Science Analysis for the Solar Dynamics Observatory (SDO).

The maximum duration of these awards are four years and three years respectively. The Sun-Climate Theme of prior years will not be soliciting open proposals this year; instead there is a Sun-Climate centric FST. The implementation of FSTs has been expanded this year as described in section 1.3.1.

Proposals will be judged noncompliant and will not be reviewed if the Compliance Criteria detailed in section 1.3.1 below are not met.

1.3.1. Focused Science Topics

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

(a) Short term solar/atmospheric variability and climate
(b) Magnetic Flux Ropes from the Sun to the Heliosphere
(c) Connection between Solar Interplanetary Structures and the response of Earth's radiation belts

(d) Thermospheric wind dynamics during geomagnetic storms and their influence on the coupled magnetosphere-ionosphere-thermosphere system

Detailed descriptions of each follow on page B.6-5 below.

The maximum duration of these awards is four years. NASA desires a balance of research investigation techniques for each Topic, including theory, modeling, data analysis, observations, and simulations. Any individual proposal does not need to include all techniques. Given the submission of proposals of adequate number and merit, up to eight selections will be made for each Focused Science Topic. Once selected, these investigators will form a team in order to coordinate their research programs. One of the PIs will serve as the Team Leader for the Focused Science Topic for which he/she proposed, and 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 in their proposal describing how they would lead the team effort. Up to one extra page in 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. See Instructions for LWS Focus Team Members and Leaders at (http://lwstrt.gsfc.nasa.gov/trt_focusteams.htm) for full details of responsibilities.

During the past ten years, the focused science topics have brought about a revolution in both LWS science and infrastructure. As a result of previous LWS TR&T efforts, many of the most basic science issues important to LWS have been identified and addressed. Our understanding of a number of LWS science problems has advanced to the point that the remaining issues are ripe for a concerted team effort, where the attributes of the required team can be clearly defined. Furthermore, collaborations between traditionally different subdisciplines have been fostered to the point that we now have a robust interdisciplinary community, which is capable of supporting such predefined science teams. Consequently it is now timely to attack some of the LWS focus science topics with predefined dedicated Teams.

The difference between these Targeted Science Teams (TSTs) and the traditional FSTs is that the TSTs will form *prior* to selection under a single PI and submit a single TST proposal that attacks the TR&T focus science topic. The advantages of this approach are obvious and address some of the major community concerns with regard to the teaming aspects of the present FST program. First, in order to be selected, the TST will necessarily have all the expertise required to attack the specified Science Target rather than rely on random chance to form a complete Team. Second, the Team Leader, the PI, will again be preselected and will necessarily be a likely, effective leader in order for the proposal to be selected rather than again rely on "the luck of the draw."

A key aspect of the TST approach is that the expertise required for a particular Target will be specified in advance by the LWS program as part of the Target description. One of the main criteria for evaluating TST proposals will be the extent to which individual members of the Team satisfy the expertise requirement. This will encourage the TSTs to be strongly interdisciplinary and to involve the best people in the field, rather than simply co-located groups.

Proposers are encouraged to propose to FSTs (a) & (b) as a TST. However, proposers may propose to address any of the FSTs listed by means of a TST. A proposal with an annual budget in excess of $300k will implicitly be taken to be a TST proposal and will be evaluated accordingly. All of the FST compliance and relevance requirements are still valid and mandatory when proposing as a TST.

While the primary evaluation criteria remain unchanged (see *ROSES Summary of Solicitation*, Section VI(a), and the *NASA Guidebook for Proposers*, Appendix C.2), the criterion for relevance includes relevance to one of the four Focused Science Topics (see (a)-(d) below) as an essential requirement for selection within this component. As such, NASA has instituted a compliance check as follows:

In order to be compliant to this ROSES element, each proposal submitted must contain a section, which must be entitled "Proposed Contributions to the Focus Team Effort" and identified in the proposal's table of contents. Failure to include this section will result in the proposal being judged noncompliant, and the proposal will be returned.

This section must include the following three items:

- The relevance of the proposal to the scientific objectives of the Focused Topic
- The potential contributions (e.g., data sets, simulation results, understanding of physical mechanisms, etc.) from the proposed effort to the Focused Science Team's effort
- Metrics and milestones for determining the successful progress and outcome of the proposed research.

Since each Focused Science Team has to produce a joint statement of work specifying its deliverables, success criteria, and milestones, the mandatory section described here can serve as a starting point for this SOW.

The *NASA Guidebook for Proposers* states, "NASA strongly encourages PIs to specify only the most critically important personnel to aid in the execution of their proposals." LWS further emphasizes that for Focused Science Teams which will be formed from individual proposals selected in a Focus Topic, the individual proposals do not need to tackle the whole problem, but can instead seek to solve a piece of the problem.

1.3.1.(a) Short term solar/atmospheric variability and climate

Target Description:

Both observations and models demonstrate that short-term solar variations can produce significant effects in Earth's upper, middle, and lower atmosphere. Impulsive solar events, such as x-ray flares and solar energetic particles, occur on times scales of minutes to days that is very short compared to climatological time scales. Despite their short duration, these phenomena produce intensity changes at short wavelengths and in the energetic particle populations of several orders of magnitude, leading to dramatic changes in atmospheric response, often localized in space, time, or both.

As elucidated in "The Effects of Solar Variability on Earth's Climate: A Workshop Report" (NAP press, publication 13519, ISBN-10: 0-309-26564-9), a key question remains, namely, where does the role of short-term solar variability (both at short wavelength and in energetic particle populations) fit into the larger effort to understand the influence of the Sun on climate? Although total solar irradiance is the main solar driver of climate variability, whether, and by what mechanisms shorter-time-scale variations have an impact on climate are presently unclear.

The goal of this Focused Science Topic is to develop understanding of the complex response of the atmosphere to these short-term solar variations in order to know how these effects translate into the historical records of solar variability and their long-term impacts on climate. We presently have unprecedented observations of these nonvisible elements of solar variability (short wavelength solar photons and solar energetic particles) and of the atmosphere, which responds to these highly-variable solar drivers. We also now have modeling capabilities to explore the complex interactions and responses throughout the affected portions of the atmosphere to the inputs. If we can quantify these short-term responses through combined model development and data validation, then this knowledge can be used to address the more subtle, but potentially important, slow variation of these same drivers, and the atmosphere's response occurring on climatological timescales.

Goals and Measures of Success:

The goal of this Focused Science Team is to advance our understanding of the short-term responses of the atmosphere to impulsive solar events, such as flares and solar particles by:

- Progress in quantifying the range and sensitivity of the atmosphere's complex response to rapid inputs of energy in the form of x-ray flares and solar particles.

- Progress in understanding what aspects of the flares and solar energetic particles (intensity, duration, spectral shape, etc.) control the atmosphere's response and what other factors might control the response (such as prior condition of the atmosphere).

- Use of modern observations to validate and calibrate models, which in turn can be used to explore recent historical trends of these drivers and their predicted responses.

- Progress on how to extend our knowledge on the short-time scale, to address the slower variability of these same mechanisms occurring on climatological time scales.

Types of Investigations:

- Numerical models of atmospheric responses to a full range of impulsive solar energetic particles and flare photon inputs.

- Integration of observations of actual impulsive inputs and atmospheric models, combined with models, to establish the complex response function and its sensitivity to input and boundary parameters.

- Validated models to explore and to quantify whether longer-term variations in these rapid-timescale phenomena contribute to climate variability.

1.3.1.(b) Magnetic Flux Ropes from the Sun to the Heliosphere

Target Description:

Magnetic flux ropes are widely believed to play a central role in space weather. Essentially all models for the magnetic field that emerges from below the photosphere to form active regions assume a flux rope structure. Observations of coronal cavities, prominences and active region sigmoids suggest a flux rope structure for the preeruption field, and coronagraph observations invariably show a flux rope for the eruption itself. Furthermore, many models for the preeruption coronal magnetic field of CMEs/eruptive flares invoke a twisted flux rope topology, and all CME models predict a highly twisted flux rope for the eruption, irrespective of the preeruption structure. Ground truth is provided by in situ measurements of the field in the heliosphere. These generally show a twisted flux rope. Hence, flux ropes are a unifying theme across Heliophysics, and understanding the mechanisms of their formation, evolution, and propagation is critical to predicting space weather.

Despite their central importance to space weather, many basic questions on flux ropes remain. For example, where, when, and how flux ropes are formed on the Sun remains highly controversial. Some observations and models support emergence of fully or partially formed flux ropes from the convection zone, while others support local formation in the corona due to magnetic reconnection preceding or during eruptions. We also do not understood how a flux rope, once formed, evolves and eventually erupts. Finally, the posteruption transport and evolution of flux ropes through the heliosphere remain unclear. Even though all current eruption and propagation models predict a flux rope at 1 AU, *in situ* measurements frequently appear to show a nonrope structure for ICMEs. We are also far from understanding how the observed fields at the Sun determine the IMF at Earth, which is critical to space weather prediction.

It is timely to undertake investigations that unify the observation of flux ropes at the Sun by SDO and Hinode, as well as propagation in the heliosphere by LASCO and STEREO, and their *in situ* measurement by ACE, Wind, and STEREO. In addition, a growing network of ground-based instrumentation, including interplanetary scintillation arrays, muon detectors, and low-frequency radio telescopes, has been deployed that has the potential to detect the propagation of heliospheric structures as they travel through interplanetary space. As flux-rope related activity increases over the current solar cycle, we now have new observational, numerical, and theoretical capabilities with the potential to make great progress. For example, SDO and Hinode have provided unprecedented high-resolution (spatial and temporal) observations of coronal cavities, prominences/filaments, and sigmoids and early development of CMEs in active regions. SDO/HMI and Hinode/SOT also provide vector magnetic field observations that are critical to determining the magnetic roots of flux ropes in the photosphere. Such observations, in combination with those from STEREO and ACE, can now monitor flux ropes continuously from the Sun to the heliosphere. Meanwhile, 3D MHD models covering a wide domain ranging from the convection zone to the corona and heliosphere can now simulate flux ropes that can be directly compared with new observations. These numerical efforts are being complemented by parallel theoretical/analytical modeling of relevant elementary processes, such as those leading to prominence formation in flux ropes.

Goals and measures of success:

The overall objective of this Focused Science Team is to advance our observation and understanding of the "life cycle" of a magnetic flux rope, from its birth in the Sun, through its evolution and growth phase in the corona, to its eruption and transport through the heliosphere. Measures of success will, in all cases, be sought to reconcile observations/measurements and predictions with model-based simulations and/or theoretical investigations, as well as the elimination of theoretical ideas demonstrably not supported by observations. The primary goals are fourfold:

- Identify the formation mechanisms of flux ropes in the solar atmosphere
- Understand the evolutionary processes leading to eruptions
- Understand the evolution of flux ropes in the interplanetary medium, and in particular, relate the flux rope IMF at 1 AU to solar observations
- Determine the role of flux rope eruptions in the magnetic flux budget of the heliosphere

Types of solicited investigations:

This FST seeks broad interdisciplinary studies that tie together the heliospheric and solar observations. Possible studies include:

- Observational studies of flux rope formation and evolution, such as vector field data from SDO or from the ground and high-resolution coronal imaging/spectroscopy from SDO, Hinode, and STEREO
- Observational studies of flux rope propagation through the heliosphere, such as those from coronagraphs, heliospheric imagers, and ground-based networks
- Studies of *in situ* measurements of flux rope magnetic and plasma structure, especially plasma properties that can be related to the solar observations, such those from STEREO, ACE, and Wind
- Theoretical/modeling studies of flux rope formation/emergence, evolution and propagation in the heliosphere

1.3.1.(c) Connection between Solar Interplanetary Structures and the response of Earth's radiation belts

Target Description:

We have learned over the last two decades that the response of Earth's hazardous MeV-class outer Radiation Belts to such interplanetary structures as Coronal Mass Ejections (CME's), Corotating Interactions Regions (CIR's), high-speed streams and other structures, is highly unpredictable. An interdisciplinary team is needed to resolve the outstanding issues. There has been much discussion in the literature about the controlling parameters, whether they are pressure, density, velocity, magnetic field magnitude and orientation, and energetic particles that can find their ways into the magnetosphere. But the response to interplanetary structures clearly also depends on the space-time structures of these interplanetary features and the consequential hysteresis of responses of the magnetosphere to those structures. Mechanisms that might communicate the influences of interplanetary structures on the radiation belts could include: 1) ULF waves (that drive RB radial diffusion) generated by external variations and magnetopause K-H wave generation; 2) The relative stimulations of storms and substorms as each has their respective roles in the dynamics of the radiation belts; 3) Global magnetospheric response to external pressure disturbances; 4) Past history (hysteresis, seeding, existing boundary structures) and the consequences on wave generation (e. g. whistlers). Our objective is to sort out the factors associated with the interplanetary structures on the radiation belts and to move towards an understanding of the mechanisms by which those factors exert their influences.

Goals and Measures of Success:

The goal of this Focus Science Team topic is to determine and quantify the relationships between specific solar and interplanetary structures, Coronal Mass Ejections (CME's), Corotating Interaction Regions (CIR's) and other structures, and the dynamic responses of hazardous radiation conditions near and inside the geosynchronous orbit. Success will be achieved when we: 1) Understand the phenomenological connections between the different space-time parametric structures of interplanetary events and the responses of the >MeV outer radiation belt: whether the intensities increase or decrease, whether they move inward or outward, whether they lose their outer layers; 2) Demonstrate the ability to correlate interplanetary structure characteristics and radiation belt responses and develop a scheme for characterizing radiation belt responses; 3) Identify the most important mechanisms by which these interplanetary states regulate the radiation belt responses: generation of storms and substorms, generation of ULF waves; role of seeding, past history, and existing boundaries; global magnetospheric responses to pressure disturbances; and 4) Move towards an understanding about how these mechanisms influence and regulate the >MeV radiation belts.

Types of investigations:

The FST participants will address the structure and evolution of interplanetary structures, and the interaction of such structures with the dynamics of Earth's radiation belts. Possible investigations include:

• Observational studies correlating characterize the detailed space-time structures of interplanetary features impinging on Earth's magnetosphere (CME's CIR's, high speed streams, etc.) with observations (e. g. SAMPEX and RBSP, etc.) of the response of the radiation belts.
• Global simulations of the magnetospheric response to Solar Wind structures that provide the plasma and fields in the inner magnetosphere. These results will be compared to the *in situ* observations of RB probes, and provide the context for wave studies.
• Observational and theoretical studies of wave generation and damping (ULF, Chorus, EMIC, etc.), and the resulting wave-particle scattering.

1.3.1.(d) Thermospheric wind dynamics during geomagnetic storms and their influence on the coupled magnetosphere-ionosphere-thermosphere system

Target Description:

The role of winds in modifying the ionosphere during geomagnetic disturbances, and how this varies with disturbance magnitude, remains an important unsolved problem in upper atmosphere science. An improved understanding of the global thermospheric wind system and the sources of its variability is essential for improving our ability to develop useful predictive models of satellite drag and ionospheric electron density variations during geomagnetic storms. Thermospheric winds, both horizontal and vertical, are excited in complex ways by magnetospheric energy and momentum inputs at high latitudes, affecting global circulation patterns and electrodynamics. The winds modify thermospheric density and composition, and strongly impact the ionosphere both directly, through ion transport, and indirectly, through influences on the production and loss of plasma and the generation of dynamo electric fields.

Recent observations and modeling developments now permit substantial progress on this question. New global observations from GPS-equipped satellites such as the COSMIC/FORMOSAT-3 constellation, CHAMP and GRACE, from CINDI observations onboard C/NOFS, and expanding ground-based networks, are providing unprecedented global coverage needed to understand the role of neutral wind dynamics. Recent developments in modeling, such as first-principles and empirically based disturbance time wind models, and the development of assimilative models that can derive winds, are useful new resources that permit substantial progress.

Goals and Measures of Success:

The primary goals of this focused science topic are to improve modeling and characterization of thermospheric wind processes during disturbed periods and to improve understanding of the role of winds in ionospheric storm time dynamics. Measures of success include improved predictive capability of thermospheric winds based on solar wind inputs; development and application of new direct and indirect wind observations that measure storm-time wind dynamics on global scales; new coordinated data sets of ionospheric electron density, electric fields, and thermospheric properties; and new insights into the spatial/temporal scales of storm-time thermospheric variations that affect terrestrial space weather.

Types of Investigations:

Substantial progress on this Focused Science Topic is possible with the following investigations:
• New observation and characterization of global wind field dynamics using direct and indirect measurements from ground and satellite
• New methods for obtaining global wind fields using data assimilative techniques
• Analyses of thermospheric wind responses to solar and magnetospheric energy inputs
• Analyses that elucidate the role of thermospheric dynamics in ionospheric storm-time variability, taking into account transport, electrodynamics, and thermospheric composition

• Developing and/or using first-principles and empirical models to characterize winds and the relationship between winds and ionospheric storm time response
• Theoretical and modeling studies that elucidate the role of winds in causing thermospheric and ionospheric variability
• Improved use of past data sets in light of current understanding.

1.3.2 Science Analysis for the Solar Dynamics Observatory (SDO) Initiative

This topic challenges proposers to use the data from the Solar Dynamics Observatory (SDO) to characterize the properties, evolution, and terrestrial consequences of the solar magnetic field. SDO produces images of the Sun at wavelengths from the visible to the extreme ultraviolet and soft X-ray, full-disk Dopplergrams, as well as full-disk vector magnetograms at an unprecedented cadence and spatial resolution that span scales from the arcsecond resolution to the full diameter of the Sun. Data during the initial part of the SDO mission has shown the Sun during the rise to the maximum of Solar Cycle 24 has many interesting phenomena that require additional analysis to understand. Fast wave-like processes, distant interactions between solar regions, the thermal fine structure of the corona, and the sources of irradiance variations over a wide range of X-ray and (E)UV wavelengths are now routinely made. These observations can tell us more about the origins of solar variability and space weather. Below are some topics of interest.

Types of investigations:

- Investigate the linkage of subsurface structures (e.g. winds, magnetic fields) with magnetic fields above the surface;
- Determine the cross-scale coupling of events by taking advantage of SDO's unique high-resolution full disk capabilities;
- Determine energy balance in dynamic phenomena;
- Improve our understanding of the processes responsible for EUV irradiance variations through accurate modeling of the magnetic field,
- Use of SDO observations to predict future solar activity, from short timescales to forecast of the properties of Solar Cycle 25.

This proposal opportunity is open to all interested parties, including Co-Investigators of SDO Science Investigations. A Co-I must show that the proposed research does not overlap with research currently funded by the SDO mission. Also, proposers should get a letter of acknowledgement from the Instrument PI (or PIs)to ensure that the latest data product described in the proposal will be available to them. Since is not an team collaboration for SDO Science Analysis , the maximum duration of these awards are for three years only.

1.4. <u>Cross-Discipline Infrastructure Building Programs</u>

One of the major challenges facing the LWS Program is the development of a research community that can cross traditional discipline boundaries and attack the system-wide problems that are central to understanding and modeling the Sun-Solar System connection. In order to address this challenge, proposals to this LWS TR&T program may include one or more of the following infrastructure-building elements: cross-disciplinary workshops and summer schools. Most of these activities will be supported through formal proposals to the TR&T program as part of the regular proposal cycle. In all cases, two extra pages will be allowed to the page limit for the science/technical/management section of the proposal (see Section 3 below) for each of these activities.

1.4.1 Support of LWS Workshops/Campaigns:

Given the goals of the Infrastructure Building Program, there are several guidelines that successful requests for workshop/campaign support must satisfy:

- The workshop must address a science or technology topic that is both timely and important to the goals of the LWS program.
- Workshops must focus on comparing and validating tools that have already been developed. Examples of possible workshops include 1) predicting all clear forecasting, 2) comparison of helioseismic techniques, and 3) velocity estimation methods.
- Other workshop topics must be cross-disciplinary in nature and bring together researchers from different disciplines encompassed by the LWS program.
- Although there are no restrictions as to where the workshop will be held, preference should be given to locations that are convenient and cost-effective for LWS researchers and students.
- Workshops that encourage the training of new researchers in LWS system science are strongly encouraged.
- Workshops that leverage funding from other institutions and agencies are strongly encouraged.

1.4.2 Directed Topic Workshops:

To address science topics that are both timely and important to the goals of the LWS program, but whose scope is not sufficient for the level of support of an FST, proposals for workshops that will address the following two topics are strongly encouraged:

a. Critical Assessment of Dynamo Models; and
b. Maximizing Science Return from Solar Wind Composition Data.

In addition to describing the location, objectives, and tentative agenda/schedule of the workshops, proposals should provide a list of likely invited participants. In this regard, the Directed Topic Workshops may be viewed as TSTs, bringing together a predefined team to attack the science problem in an interactive, intimate, workshop format. Parallels may be drawn with the ISSI workshops (http://www.issibern.ch/) and the CEDAR/GEM challenges (http://cedarweb.hao.ucar.edu/wiki/index.php/2012_Workshop:CEDAR_ETI_Modeling_Challenge). Proposals should thus include plans for team websites and publication of results in (special issues of) peer-reviewed Journals.

(a) Critical Assessment of Dynamo Models

The origin of solar activity lies below the photosphere in the internal flows that generate the magnetic field and determine the properties of the dynamo. Between these causative flows and the effects in the solar atmosphere and heliosphere lies a chain of physical processes and interfaces that are complex and far from understood. Many such processes have been studied in detail, but the connections between them are largely unexplored. We must advance our understanding of these couplings and incorporate them in improved physics-based models in order to make reliable forecasts of the solar activity cycle.

Subsurface magnetic field can be generated in the tachocline at the base of the convection zone, in the body of the convection zone, near the surface in a shear layer, and by turbulence. In kinematic dynamo models, the interplay between the large-scale internal flows of differential rotation, meridional circulation, kinetic helicity, and turbulent magnetic diffusion results in the transport of magnetic flux and helicity within the convection zone and subsequent concentration of the field to the point that it becomes buoyant and emerges at the surface. Kinematic dynamo models have achieved significant success, but some critical ingredients are poorly constrained below the surface and incompletely understood even at the surface. Questions that need to be investigated include:

• What is the nature of interior flows, and how do they determine the sunspot cycle period?
• Are subsurface flows from helioseismology consistent with observed flows in the photosphere?
• How is magnetic helicity generated and transported throughout the convection zone?
• How does the generation of kinetic and magnetic helicity below the photosphere affect the emergence and evolution of active regions and dynamo itself?
• Do observed poloidal fields arise only from the surface transport of active-region fields?
• Are models of photospheric flux transport measurably improved by including subsurface flows or different models of turbulent magnetic diffusion?
• How do additional mechanisms of flux transport (for example turbulent magnetic pumping) affect the observed properties of the dynamo?
• Can critical elements of the kinematic dynamo picture be constrained through observations of other stars?

The goal of this Directed Workshop is to bring researchers in the various subfields of solar physics together to better understand the coupled magnetic and kinematic processes in the solar interior, photosphere, and corona and to use this knowledge to improve the predictive potential of dynamo models. Metrics of success include improved agreement between observed and modeled surface magnetic flux that better incorporate helioseismically determined subsurface properties and, therefore, have fewer free parameters, and the ability to account for the observed range of cyclic behavior in solar-type stars.

The Solar Dynamics Observatory produces a wealth of pertinent data necessary to address this topic; for example, HMI will provide high-degree helioseismology and simultaneous high-cadence vector magnetic field observations in the photosphere. The broad and systemic nature of the proposed research requires a coordinated approach that spans multiple areas of expertise but retains a focus matching observations at and above the photosphere with the picture of an underlying dynamo.

Likely participants to increase the probability of workshop success should offer:

• Studies of the relationship between helioseismic inferences of internal flows and observed vector magnetic fields in the photosphere, including detailed analysis of polar field measurements,
• High resolution MHD models of convective turbulence at various depths in the convection zone, including surface effects such as supergranular flows, to yield better estimates of turbulent magnetic diffusion for inclusion in flux transport models and the generation and transport of magnetic helicity at various depths in the convection zone.
• Global MHD studies of various flux generation and transport mechanisms within the convection zone.
• Kinematic dynamo models that can explore a wide range of parameters using both solar and stellar observations as constraints.
• Stellar observations focused on measurable properties that can constrain the solar kinematic dynamo picture—e.g., cycle period, rotation rate, differential rotation, latitude distribution of activity, and asteroseismic properties.

(b) Maximizing Science Return from Solar Wind Composition Data

The heliosphere is filled with solar wind, with speeds ranging from below 400 km/s to above 700 km/s. The fastest solar wind (>700 km/s) is primarily associated with large regions of predominantly unipolar magnetic field – coronal holes. Near solar minimum the fast solar wind is usually confined to the two polar coronal holes. The slow solar wind (~400 km/s), on the other hand, is usually confined within a band associated with the heliospheric current sheet that separates the two polarities. Fast solar wind is characterized by ionic charge states that are indicative of relatively cool conditions in the corona. The slow wind exhibits ionic charge states indicative of hotter conditions in the corona and also has an elemental composition that is fractionated with respect to the photosphere, favoring ions with low first-ionization-potential (FIP), a phenomenon not strongly observed in the fast wind.

It is timely, given the wide variation in the continuous solar wind composition measurements in the past two solar cycles, and the nonselection of an Ion Composition Experiment for Solar Probe+, to call for a series of Workshops to maximize the science returns from *existing* Solar Wind Composition data: *ACE*/SWICS, *Ulysses*/SWICS, *STEREO*/PLASTIC, *Wind*/SMS, and *SOHO*/CELIAS data, so as to develop a coherent mechanism for fractionation of solar wind composition, heating and acceleration of solar wind ions, and its temporal and spatial variations. To explain the origins of the differentiated solar wind completely, it is key to characterize and understand the bulk flow and elemental/ion composition *simultaneously*. This is a quintessential System Science investigation: given that the energy that heats the corona and drives the wind derives from photospheric motions and is channeled, stored, and dissipated by the magnetic fields that emerge from the photosphere and structure the coronal plasma, changes in solar wind properties must ultimately stem from processes in, or below, the photosphere. Therefore. it is also key to combine observations of different layers of the solar atmosphere that manifest these (sub-)photospheric processes for interpreting and understanding the variations in solar wind composition.

Likely participants to increase the probability of workshop success should offer:

- Self-consistent models of coronal heating, solar wind acceleration, and ion-neutral fractionation that are consistent with solar wind composition data and associated solar observations.
    - Are the fast wind and slow wind driven by radically different processes, or is a continuous range of bulk flow properties possible?
    - To understand the causes for variations in solar wind composition.
- Models and techniques to prepare for, and that will enhance the science return of, the *Solar Orbiter* and *Solar Probe+* missions. Explaining the solar wind ion composition by means of physics-based models of coronal heating and acceleration of the nascent solar wind. For example:
    - Is solar wind acceleration decoupled from coronal heating?
    - What processes/characteristics in the solar atmosphere determine the variations in the solar wind ion composition?
- Explanations of the solar wind elemental composition in the solar wind by means of physics-based models for ion–neutral fractionation.
- Solar observations (e.g. magnetic, spectroscopic, or dynamic properties) or empirical models that can relate to and interpret the spatial or temporal variations in the solar wind composition.
- Explanations of the long-term variations in composition/velocity dependence signatures over the solar cycle, and, in particular, in the recent unusual solar minimum.
- Explanations of the short-term variations in composition over individual solar wind streams (down to flux tubes/instrument cadence limit). This may include *ACE-STEREO* correlation studies.
- Models of solar wind thermal and suprathermal elemental/ion composition properties and ion VDFs in the inner heliosphere, so as to prepare for the upcoming launch of *Solar Orbiter*, and to mitigate the lack of an Ion Composition Experiment on *Solar Probe+*.

2. Submission and Evaluation Process

2.1 Step-1 Proposals

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 *Summary of Solicitation Section IV. (b) vii*).

A Step-1 proposal is required and must be submitted electronically by the Step-1 due date (see below and Tables 2 and 3 in the *ROSES Summary of Solicitation*). The Step-1 proposal must be submitted by the organization Authorized Organizational Representative (AOR). No budget or other elements are required. Only proposers who submit a Step-1 proposal are eligible to submit a full Step-2 proposal. Full proposals must contain the same scientific goals proposed in the Step-1 proposal. The Step-1 proposal title, Principal Investigator, and all co-investigators, collaborators and consultants cannot be adjusted between the Step-1 and Step-2 proposals. The expected format is described below. Submission of the Step-1 proposal does not obligate the offerors to submit a Step-2 (full) proposal later, but all Step-1 proposals are eligible to submit Step-2 proposals.

2.1.1 Step-1 Proposal Format

The Step-1 proposal is restricted to one page in length. It should include the following information:

- A description of the goals and objectives to be addressed by the proposal.
- A brief description of the methodology to be used to address the goals and objectives.

The NSPIRES system for proposal submission requires a very brief summary to be entered into the "Proposal Summary" field AND it requires a "Proposal Attachment" which should be the Step-1 proposal. Proposals will be checked that the text is compliant with the program element indicated (i.e., relevant to one of the four specified FSTs, the SDO Data Analysis Initiative, or appropriate for Cross-Discipline Infrastructure Building).

2.2. Step-2 Proposals

A Step-2 (full) proposal must be submitted electronically by the Step-2 due date (see below and Tables 2 and 3 in the ROSES Summary of Solicitation). The Step-2 proposal must be submitted via NSPIRES by the organization Authorized Organizational Representative (AOR). A budget and other specified information is required. The Step-2 proposal title, Principal Investigator, and all team members must be the same as those in the Step-1 proposal. Step-2 proposals must contain the same goals proposed 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 noncompliant letter are not eligible to submit a Step-2 proposal.

2.2.1 Step-2 Proposal Format

Guidelines for submitting Step-2 full proposals are specified in the *NASA Guidebook for Proposers*.

2.2.2 Step-2 Evaluation Criteria

Step-2 proposals that are not compliant with format requirements in Section IV (b) ii of the *ROSES Summary of Solicitation* and the *NASA Guidebook for Proposers* may be rejected without review.

Compliant proposals will be evaluated according to the criteria specified in section C.2 of the *NASA Guidebook for Proposers*. These criteria are intrinsic scientific and technical merit, relevance to the NASA's objectives and those of the FST, which includes cost realism/reasonableness.

For Focus Science Topics (only) described in section 1.3.1, in addition to the factors given in the *NASA Guidebook for Proposers*, the evaluation criterion for relevance specifically includes the following factor:

Each proposal submitted *must* contain a section, entitled "Proposed Contributions to the Focus Team Effort" and it *must* be identified in the proposal's table of contents. Failure to include this section will result in the proposal being judged noncompliant, and the proposal will not be reviewed. See section 1.3.1 for more details.

Relevance is dependent on the particular Focus Science Topic. Each proposal must demonstrate that the investigation is appropriate for the FST selected.

For the Cross-Discipline Infrastructure Building Program described in section 1.4, there are no additional evaluation criteria, other than those given in the *NASA Guidebook for Proposers*.

3. Summary of Key Information

Expected annual program budget for new awards	~ $3.5 M
Number of new awards pending adequate proposals of merit	~ 30
Maximum duration of awards	Focused Science Topics: 4 years Science Analysis for SDO: 3 years Cross-Discipline Infrastructure: 1-5 years
Step-1 Proposal Due Date	**03/15/2013 [amended 2/26/2013]**
Step-2 Proposal Due Date	See Tables 2 and 3 in the *ROSES Summary of Solicitation*.
Date for start of investigation	No earlier than October 1, 2013.
Page limit for the central Science-Technical-Management section of proposal	15 pp; extra page permitted for proposals to be Team Leader of Focused Science and two extra pages permitted for proposals for Cross-Discipline Infrastructure Building; see also Chapter 2 of the *NASA Guidebook for Proposers*
File size limit for the proposal	10MB; this limit applies to the combined size of all PDF files that are uploaded for a single proposal.
Relevance	This program is relevant to the Heliophysics strategic goals and subgoals in NASA's *Strategic Plan*; see Table 1 of ROSES and the reference therein. Proposals that are relevant to this program are, by definition, relevant to NASA.
General information and overview of this solicitation	See the *ROSES 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 required or permitted. See also Section IV of the *ROSES*

	Summary of Solicitation and Section 3.3 of the *NASA Guidebook for Proposers*.
Web site for submission of Step 1 and Step 2 proposal via NSPIRES	http://nspires.nasaprs.com/ (help desk available at nspires-help@nasaprs.com or (202) 479-9376)
Web site for submission of Step 1 proposal via Grants.gov	http://grants.gov (help desk available at support@grants.gov or (800) 518-4726)
Web site for submission of Step 2 proposal via Grants.gov	Option not Available
Funding opportunity number for downloading an application package from Grants.gov	NNH13ZDA001N-LWS
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