C.7 LIVING WITH A STAR (LWS) TARGETED RESEARCH AND TECHNOLOGY

1. Scope of Program

1.1 Overview

The goal of the Living With a Star (LWS) program is to develop the scientific understanding needed for the United States to effectively address those aspects of the connected Sun-Earth system that may affect life and society. The LWS Targeted Research and Technology (TR&T) program element solicits proposals leading to a physics-based understanding of the integral system linking the Sun to the Earth both directly and via the heliosphere, magnetosphere, and ionosphere. The program's objectives can be achieved by data analysis, theory, and modeling, and the development of tools and methods (e.g. software). LWS is a crosscutting initiative whose goals and objectives relate to NASA's Exploration Initiative, as well as NASA's Strategic Enterprises, namely (and in no priority order):

- Aeronautics – LWS characterizes those aspects of the Earth's radiation belt environment needed to design reliable electronic subsystems for use in air and space transportation systems;

- Biological and Physical Research – LWS defines the radiation environment beyond the Earth's magnetosphere to enable exploration of interplanetary space by humans;

- Earth Science – LWS improves our understanding of the effects of solar variability and disturbances on terrestrial climate change;

- Exploration Systems, and Space Flight – LWS develops the knowledge needed to predict solar energetic particle events that affect the safety of humans and technology in space; and

- Space Science – LWS quantifies the physics, dynamics, and behavior of the Sun-Earth system over the 11-year solar cycle.

The *LWS TR&T Science Definition Team (SDT) Report, 2003*, located at URL http://lws-trt.gsfc.nasa.gov/trt_news.htm identified particular scientific topics to be addressed using measurements by the LWS space flight missions, as well as data from other missions, and also by employing theory and modeling efforts. Among these topics are: the role of solar variability in climate and in stratospheric chemistry; ionospheric perturbations and scintillations; neutral thermosphere composition and density; geomagnetically-induced currents; energetic particles in the magnetosphere and atmosphere; and radiation associated with explosive events on the sun. The hazards to and effects on society, space-based systems, and human space flight are of particular importance to this program.

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 *TR&T Science Definition Team Report* recommended that "*…large modeling activities that address coupling across traditional science domains in the Sun-Earth chain specifically be included as strategic capabilities*." The TR&T SDT also recommended the formation of a TR&T Steering Committee in order to update periodically the designated strategic capabilities for future NRAs. The report of this Steering Committee is available at the Web site given above.

The TR&T SDT defined a strategy with three program elements, namely, Strategic Capabilities, Targeted Investigations, and Cross-Disciplinary Infrastructure Building programs. This current NRA solicits proposals only for the last two of these program elements as discussed in the following subsections.

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://www7.nationalacademies.org/ssb/SSB_Space_weather97.pdf) ;
- The report on the Solar Influences Workshop (http://www.ispe.arizona.edu/research/sunclimate/);
- The Sun Earth Connection LWS WWW site (http://lws.gsfc.nasa.gov/);
- The LWS Science Architecture Team report to SECAS (http://lws.gsfc.nasa.gov/docs/LWSSAT_SECASreport_30Aug01.pdf);
- The Sun-Earth Connection Roadmap report (http://sec.gsfc.nasa.gov/sec_2002_roadmap.pdf);
- The Geospace Mission Definition Team Report (http://lws.gsfc.nasa.gov/docs/Geospace/GMDTReportforWeb.pdf); and
- The NRC Decadal Survey Report (http://www.nap.edu/books/0309089727/html/)
- The TR&T Science Definition Team Report (http://lws-trt.gsfc.nasa.gov/TRT_SDT_Report.pdf)
- The TR&T Steering Committee Team Report (http://lws-trt.gsfc.nasa.gov/trt_news.htm)

Note that to enable NASA Office of Space Science to properly evaluate the relevance of proposals submitted to its programs, as well as track its progress towards achieving its goals as mandated by the Government Performance Review Act (GPRA), all research supported by NASA's programs must now demonstrate its relationship to NASA Goals and Research Focus Area's (RFAs) as stated in the latest version of its Strategic Plan (follow links from the Web site http://spacescience.nasa.gov/); see also the discussion in Section I of the *Summary of Solicitation* of this NRA Therefore, all proposers to this program element are asked to state their perception of this relevance in terms of the Goals, Science Objectives, and RFAs given in Table 3 found in the *Summary of Solicitation*. In particular, this program element is designed to help fulfill all of the Ra's for the Science Objective 1 for both Goals I or II of the Sun-Earth Connection science theme. The appropriate place for this statement of relevancy is in the introduction to the proposal's "Scientific/Technical/Management" section (see Section 2.3.5 in the *Guidebook for Proposers Responding to an NRA*). The index numbers in this table may be used to identify a specific RFA, for example, "Goal I, Sun-Earth Connection Theme, RFA 1(c)" or "Goal II, Astronomical Search for Origins, RFA 3(b)."

1.2 Targeted Investigations

This Targeted Investigations program element is subdivided into the three components described below, and pending the submission of proposals of adequate merit, the approximate portion of resources allocated for each is given in parentheses.

1.2.1 Tools and Methods (10%)

The Tools and Methods component supports studies that, by themselves, may not deliver significant new science understanding, but instead deliver tools and/or methods that enable critically needed science advances. Examples include the development of new empirical methods or analysis techniques, such as local helioseismology, that can be used to forecast solar, interplanetary, and geospace activity, and the development of software tools that can identify, retrieve, assimilate, and/or portray data in order to model results from different sources for LWS research and forecasting objectives.

1.2.2 Independent Investigations (15%)

The Independent Investigations component supports studies that are not appropriate for either the Tools and Methods component above or the Focused Science Targets component discussed in the next section. However, simply failing to address these other two components does not necessarily make a project suitable for this Independent Investigations component. Rather the criteria that determine whether a proposed study should be submitted to this component are its urgency and impact to LWS goals and objectives.

1.2.3. Focused Science Topics (75%)

The stated goal of LWS, that of achieving an understanding of those aspects of the Sun-Earth system that have direct impact on life and society, poses two great challenges for the TR&T program. First, the TR&T must tackle large-scale problems that cross discipline and technique (e.g., data analysis, theory, modeling, etc.) boundaries; and second, the TR&T must identify how this new understanding will have a direct impact on life and society. To address these requirements, a set of six Focused Science Topics as further identified below have been chosen for emphasis in this NRA (for further detail, also see the TR&T Steering Committee Report at http://lws-trt.gsfc.nasa.gov/trt_news.htm). Therefore, while the primary evaluation criteria will be scientific and technical merit as usual, relevance to one of these Science Topics will be essential for selection within this component. In addition, a balance of research investigation techniques will be sought for each Topic, including theory, modeling, data analysis, observations and simulations. 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 (similar to the PIs selected for a NASA hardware mission who form a coordinated science working group). These teams will define a plan for structuring their work into an integrated research program that will hopefully address the Focused Science Topic in a much more complete way than any one investigation could by itself. These teams will also define success measures and deliverables for their integrated program, develop strategies for disseminating their results to the science community and NASA, and prepare an integrated final Team Report at the end of the three-year duration of the selected investigations.

As part of the peer review process, one of the highest rated PIs will be identified to be asked to serve as the Team Coordinator for the Focused Science Topic for which he/she proposed. These Team Coordinators will take the lead role in organizing their team, setting up appropriate meetings and interactions, and generally ensuring the success of the project as a whole. The Coordinators will also serve as the lead liaison with the TR&T Project Office at NASA's Goddard Space Flight Center (GSFC) and LWS Program Office at NASA Headquarters, which together will monitor and assist the progress of each team. The Team Coordinator will receive supplemental funding as necessary to support costs associated with these duties. Proposers are encouraged to volunteer to act as a Team Coordinator 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.

The Focused Science Topics appropriate as the objectives for proposals to this LWS TR&T solicitation are as follows:

a. To quantify the sensitivity of regional and global climate to solar forcing in the full context of the interactive climate system.

Goals and measures of success: Success in this Topic will be measured by the ability of climate models to specify global and regionally-specific impacts of interactive solar and other external and internal forcing of the coupled climate system, and the ability of solar-coupled climate models to replicate global and regional climatic records.

Types of solicited investigations: Proposals that address the this high visibility Topic are expected to include, but not be limited to, collaboration between the solar and climatological data analysis and modeling communities, as well as contributions from all of the following elements: (i) specification of relevant changes in total and spectral irradiance and other energetically-significant input from the Sun; (ii) multivariate analyses of climate observations as a function of geographic region, atmospheric height, phase and amplitude, and the combined impact of other climate drivers; and (iii) comparison with and validation of model results for the response of the coupled climate system to solar variations.

b. To quantify the response of thermospheric density and composition to solar and high latitude forcing.

Goals and measures of success: Research on this Topic will produce improved first principle thermosphere-ionosphere models sufficient to specify thermospheric density and composition models, and their variation with latitude, longitude, local time, solar flux, season, magnetic activity level, and IMF changes. These predictions will be validated against both empirical models and data with the goal of improving our ability to specify solar radiative and high latitude inputs for first principle models.

Types of solicited investigations**:** It is expected that the research objectives of submitted proposals will include, but not be limited to, investigations that deal with (i) techniques to improve specification of solar radiative inputs to the thermosphere-ionosphere system; (ii) techniques to improve the specification of high latitude inputs for global first principle thermosphere-ionosphere models; (iii) energy transfer from the magnetosphere to the thermosphere-ionosphere system; (iv) thermosphere-ionosphere coupling; (v) neutral wind responses; (vi) fundamental understanding and improved numerical models for the processes driving thermospheric density and composition; and (vii) validation of the resulting thermospheric simulations by comparison with related data sets.

c. To determine the mechanisms responsible for the formation and loss of new radiation belts in the slot region in response to geo-effective solar wind structures.

Goals and measures of success: The goal of this Topic is to develop and validate usable, quantitative, models that describe the dynamic evolution of the radiation belt slot region and adjacent outer zone flux peak around the L4 libration point. Such models must include losses as well as injection rates of charged particles and use particle flux measurements at geosynchronous and other high and low Earth orbits loss-cone measurements to provide input on radial distribution of fluxes. Measurements of input solar wind conditions are essential both for magnetohydrodynamic (MHD) and empirical models of the magnetospheric response to solar wind driving conditions. Plasma sheet observations may also be needed to further constrain model calculations of evolving particle phase space density.

Types of solicited investigations: It is expected that the proposals for this Topic will address, but not be limited to, the following types of investigations: (i) the analysis and interpretation of those solar wind parameters (e.g., solar energetic particle events, density, velocity, and IMF orientation) needed to predict conditions within the radiation belts; (ii) particle observations at the inner edge of the plasma sheet, geosynchronous orbit, near the plasma pause, and in the slot region; (iii) ULF and VLF wave observations in these regions; (iv) the development of numerical models that incorporate the relevant physical processes; and (v) validation studies designed to test proposed models for particle diffusion and trapping/detrapping associated with fast Interplanetary Coronal Mass Ejections (ICMEs).

d. To relate solar-energetic particles to their origin at the sun and inner heliosphere.

Goals and measures of success: The goal of this Topic is to develop usable, quantitative models for solar-energetic particle acceleration near the Sun by realistic CMEs that propagate these particles in realistic coronal and heliospheric magnetic fields throughout the heliosphere. Another goal of this Topic is to identify the particle sources and to assess their relative contributions to intensities observed at 1 AU.

Types of solicited investigations: Proposals are encouraged that relate solar-energetic particles to their origin at the Sun and inner heliosphere, and characterize their variability at L1. Proposals involving numerical models should emphasize combining particle acceleration and transport with realistic, three-dimensional CME structures thought to be characteristic of coronal and heliospheric magnetic fields. Such proposals should also emphasize comparisons with observations of various particle species, including the ultra-heavy ions (trans Ni) that cause damage to *in situ* space systems. Theoretically based proposals should target aspects of this problem that lead to basic scientific understanding of the necessary coupling described above. Proposals involving spacecraft observations should attempt to constrain numerical and analytic models.

Objectives include, but not limited to: (i) the time scale for accelerating particles; (ii) the location of acceleration region; (iii) particle distributions; and (v) the variability of these particle distributions at L1.

e. To determine the topology and evolution of the open magnetic field of the Sun connecting the photosphere through the corona to the heliosphere.

Goals and measures of success: The goal of this Topic is to develop useable models that quantitatively determine the dynamic evolution and complexity of the open magnetic flux of the Sun from inputs of the types likely to be returned by future LWS missions. The new models will provide the understanding that is necessary to develop predictive capability for the dynamic Sun-heliosphere system.

Types of solicited investigations: It is expected that the proposals will include, but not be limited to: (i) the analysis and interpretation of solar and/or heliospheric observations; (ii) the development of theories for the fundamental processes that control the evolution of open and heliospheric flux; and (iii) the development of numerical models that incorporate the relevant physical processes and that can be tested with the observations.

f. To determine the solar origins of the plasma and magnetic flux observed in an Interplanetary Coronal Mass Ejection.

Goals and measures of success: The goal of this Focused Science Topic is to advance the understanding of the relationship between the physical properties of ICMEs and CMEs. The prime measure of success for this work would be a quantitative improvement in the ability to predict the geo-effective properties of ICMEs at Earth from solar and heliospheric observations. However, the development of models/understanding that directly enable such an improvement in capability would also constitute a measure of success for this Topic.

Types of solicited investigations: It is expected that this Topic will include, but not be limited to, the following types of investigations: (i) the analysis and interpretation of solar and/or heliospheric observations; and (ii) the development of theoretical, empirical and numerical models for the initiation and evolution of a CME as it propagates through the corona and heliosphere.

1.3 Cross-Discipline Infrastructure Building Programs

Owing to the cross-disciplinary nature of SEC LWS science, proposals to this LWS TR&T program may also propose one or both of the following ancillary activities. In both cases, an extra two (2) pages will be allowed to the page limit for the Science/Technical/Management section of the proposal (see the *Guidebook for Proposers Responding to a NASA Research Announcement* discussed in Section 2 below) for each of these activities.

a. Support of LWS Summer Schools for Graduate Students. The details of the summer school (e.g., format, location, duration, etc.) are left to the proposer to define. However, proposals should provide convincing evidence concerning the breadth of the topics to be considered, the means to be taken to assure participation by recognized authorities, and any institutional support that may be forthcoming (note: shared support of this activity is strongly encouraged). One such proposal will be selected for Summer School activities not to exceed more than two years of a nominal three-year period of performance for the parent research proposal.

b. Support of Postdoctoral Research Associates. Research proposals may propose to support up to two postdoctoral associates who either expect to receive their doctor's degree within one year from the nominal beginning of the period of performance of the parent research award, or have received their degrees within the past two years of that date. Such associates may be supported for two years, with the possibility of a subsequent merit-based extension not to extend beyond the full period of performance of the parent research award. In addition to salary, the terms of the award may include relocation, travel, and research expenses commensurate with contemporary standards. If a suitable candidate is known at the time the proposal is submitted, an additional one page is allowed in the parent proposal that describes the proposed research to be carried out by the associate, including its relevance to LWS program.

2. Programmatic Information

Given the unique nature of the LWS TR&T program, proposal reviewers will include both scientific peers and knowledgeable representatives from the LWS customer community. Proposals will be evaluated on the basis of their feasibility, intrinsic scientific merit, and compliance with requirements to provide public access to any tools and value-added products developed. Proposals should provide a detailed (~1/2 page) description of how the proposed work will benefit the goals and objectives of the LWS program described above, and the timetable over which these benefits will accrue. To this end, the program will provide a WWW site (http://lwstrt.gsfc.nasa.gov/trt_proposals.htm) that provides links to the abstracts of all selected proposals and their annual progress reports, including developed and tested software and/or refined data products.

To aid in the identification of reviewers, it is essential that the electronically submitted *Cover Page* for LWS TR&T proposals (see further below) include a single choice of program descriptor (i.e., T for Targeted Research or C for Cross Discipline Infrastructure) and the relevant program objective under each descriptor as follows:

- T1 - Tools and Methods,
- T2 - Independent Investigations,
- T3a - Solar Forcing of Climates,
- T3b - Solar Forcing of Thermospheric Density,
- T3c - Formation Loss of New Radiation Belts,
- T3d - Solar Energetic Particles,
- T3e - Topology of Open magnetic Field, and
- T3f - Magnetic Flux in ICMEs.

In addition, each proposal may additionally include one or both of the following descriptors as appropriate:

- C1 - Summer School,
- C2 - Post Doctorate Associates.

Therefore, a proposal for Solar Forcing of Climates that includes provisions for both a Summer School as well as a Post Doctorate Associate would be labeled "T3a-C1-C2".

An annual call for proposals for LWS TR&T investigations is now planned for the foreseeable future. The total funding available for new proposals submitted through this NRA and to be funded in Fiscal Year (FY) 2005 is expected to about $6M and is expected to fund of the order of 50 awards. Proposals for efforts up to three years duration are allowed. To give perspective for the number of proposals that may be funded through this program, the average first year value of the selected awards made through the ROSS – 2003 NRA (for which ~$4.25M was available) was ~$113K; however, larger awards for programs of exceptional merit and breadth will be considered.

IMPORTANT INFORMATION

The *Summary of Solicitation* of this NRA points out that NASA Headquarters now uses a single, unified set of instructions, entitled *NASA Guidebook for Proposers Responding to NASA Research Announcements*, that provides detailed guidance for the preparation and submission of proposals to its NRAs. By reference is the current edition, *Guidebook for Proposers–2004*, is incorporated into this Office of Space Science solicitation and is accessible by linking through the menu item "Helpful References" at the Web site http://research.hq.nasa.gov or it may be directly accessed at http://www.hq.nasa.gov/office/procurement/nraguidebook/. Proposers to this Program Element are urged to familiarize themselves with this document, in particular its Chapters 1, 2, and 3, before preparing a proposal. This NRA's *Summary of Solicitation* also contains the schedule and instructions for the electronic submission of both a *Notice of Intent* (NOI) to propose, as well as a proposal's *Cover Page/Proposal Summary/Budget Summary* for the proposal, and the mailing address for the submission of proposals.

Questions about this program element may be directed to the LWS Program Officer:

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