B.6 HELIOPHYSICS LIVING WITH A STAR SCIENCE

Amended August 1, 2016: Final text released. The Strategic Capabilities element is not being competed in ROSES-2016. Targeted Science Team proposals, whereby a single large proposal covers the entire breadth of a Focus Science Topic, will not be permitted in ROSES-2016. The Cross-Discipline Infrastructure Building element is not being competed in ROSES-2016.

Proposal submission to all calls in Heliophysics will be done by a two-step process, in which a Notice of Intent is replaced by a required Step-1 proposal. The proposal title, science goals and objectives, and investigators cannot be changed between the Step-1 and Step-2 proposals. See Section 5 for details.

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. See Section 5 for details.

1. Scope of Program

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. The ultimate goal of the LWS program is to provide a scientific understanding of the system, almost to the point of predictability, of the space weather conditions at Earth and the interplanetary medium, as well as the Sun-climate connection.

The LWS program objectives are based on these goals and are as follows:

1. Understand solar variability and its effects on the space and Earth environments with an ultimate goal of a reliable predictive capability of solar variability and response.
2. Obtain scientific knowledge relevant to mitigation or accommodation of undesirable effects of solar variability on humans and human technology on the ground and in space.
3. Understand how solar variability affects hardware performance and operations in space.

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 program elements, 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 *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).

2. Strategic Capabilities

NOTICE: The Strategic Capabilities element will not be competed in 2016. 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-2017, at the earliest.

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. Over time, the Targeted Investigations provide advances in scientific understanding to address these challenges.

The Targeted Investigations element this year consists of three Focused Science Topics (FSTs).

3.1. Focused Science Topics

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

1) Advances Toward a Near Real Time Description of the Solar Atmosphere and Inner Heliosphere;
2) Characterization of the Earth's Radiation Environment;
3) Studies of the Global Electrodynamics of Ionospheric Disturbances.

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 2013 and 2014, 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 Focus Science Topic. However, such TSTs will not be permitted in ROSES-2016. Instead, LWS Science will adopt 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 be in the range of \$200k – \$250k. (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, up to six selections will be made for each Focused Science Topic. The expected duration of FST awards is four years.

Once selected, these investigators will form a team in order to coordinate their research programs. Due to the collaborations that will arise from coordination of 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.

3.1.1 Advances toward a Near Real Time Description of the Solar Atmosphere and Inner Heliosphere

Target Description: The Sun's atmosphere (photosphere, chromosphere, transition region, and corona) and solar wind play a critical role in space weather. Understanding of the global state of the solar atmosphere and inner heliosphere to 1 AU thus underlies nearly all of the LWS Strategic Science Areas (SSAs, and especially SSA-1 (Physics-based Geomagnetic Forecasting Capability), SSA-3 (Physics-based Solar Energetic Particle Forecasting Capability), and SSA-4 (Physics-based TEC Forecasting Capability).

Currently, models of the solar atmosphere and solar wind rely primarily on maps of the photospheric magnetic field, available from a number of ground-based and space-based observatories, to generate steady state solutions. Remote observations of the Sun (such as images and spectra in the ultraviolet, visible, and infrared), as well as *in situ* measurements of solar wind properties, are used to validate theoretical explanations and test model solutions. This topic focuses on the innovative creation and use of heliophysics data products to address the time-dependent state of the inner heliosphere- from the solar surface to 1 AU. Methods such as "data assimilation," and "ensemble modeling," which are used in the meteorological community, can be highly beneficial in this context. However, the nature and sparseness of some heliophysics data implies that these techniques may not be directly translatable to the solar/heliospheric environment, but must be adapted using novel techniques. Examples include, but are not limited to, (1) the innovative use of sequences of magnetograms and/or magnetic maps in combination with other data products for the purposes of predicting the state of the solar atmosphere and/or solar wind parameters, (2) the use and planning for multiviewpoint magnetograms, solar disk and heliospheric images, and solar wind measurements from existing NASA spacecraft (e.g., Solar and Heliospheric Observatory (SOHO), Solar Terrestrial Relations Observatories (STEREO), Advanced Composition Explorer (ACE), Wind, etc.). Planning for data from future missions may be presented as a long-term benefit of the proposed study, but the use of existing data sets must be the primary focus of the proposed study.

Goals and Measures of Success: The goal of this focus topic will be to develop quantitative methods for incorporating heliophysics data into models and developing improved data products for use in such models. The goal of these products and techniques is that they can eventually be used to produce a (near) real-time description of the solar atmosphere and inner heliosphere, consistent with available data and suitable for modeling other processes (such as the propagation of CMEs, other transients, etc.). All studies must address uncertainty analysis and describe the propagation of errors from the input data and theoretical assumptions and how these impact the uncertainty of the results.

Types of investigations: Investigations could include, but are not limited to:

- Studies that utilize extreme ultraviolet, white light, radio, Interplanetary Scintillation (IPS), and other space-based or ground- based data to modify/improve/correct model estimates of relevant parameters, such as values at L1.
- Studies that innovatively use magnetograms/magnetic maps, either space or ground-based, to drive models or develop improved magnetic maps or source surface parameters that can be used to drive these models.
- Studies that develop mathematical techniques for incorporating data into solar atmosphere/solar wind models (e.g., assimilation, data driving, etc.)
- Studies that derive solar atmosphere/solar wind state quantities (i.e., density, temperature, velocity) such that they could be used to drive/modify/improve/correct models of the solar atmosphere and/or solar wind.

It is sufficient to demonstrate the above concepts in simple models; the use of a sophisticated model may be desirable, but is not required. It is anticipated that selected PIs will collaborate and identify specific time periods to model, for comparison between and validation of the different approaches.

Interactions with User Communities: To facilitate useful validation activities and communication of the results to user communities, the LWS Program Officer will contact relevant modeling/operational centers to identify liaisons for the project. Liaison(s) will be encouraged to participate in the annual meetings.

3.1.2 Characterization of the Earth’s Radiation Environment

Target Description: The Radiation Environment Strategic Science Area (SSA-6) and the Geomagnetic Variability Strategic Science Area (SSA-1) outline broad needs for advancing the characterization of the science of the radiation environment in a varying environment. The radiation environment between the troposphere and outer magnetosphere can change rapidly due to varying galactic cosmic ray (GCR) and solar energetic particle (SEP) influx. This environment can also be affected by solar wind pressure effects due to high-speed streams (HSS), coronal mass ejections (CME), and periods of southward interplanetary magnetic field (IMF). The GCR background is typically variable on the timescale of days with a long-term trend that changes slowly and is modulated by the solar IMF varying with the approximate eleven-year solar cycle. The SEP environment can be highly time variable, with impulsive, order of magnitude changes associated with solar eruptive events occurring in a matter of seconds to minutes. HSS, CME, and solar wind pressure increases cause changes to the radiation belt environment on a scale of tens of minutes to days with the probability of occurrence of these events being dependent on the solar cycle. Together, the effect of these phenomena on the Earth’s Magnetosphere–Ionosphere–Thermosphere (M-I-T) system, create the "weather" of the radiation environment.

Recent observations and modeling developments have permitted substantial progress in understanding the drivers and responses of the radiation environment. However, the variability and prediction potential of the coupled systems describing this radiation environment are not yet well quantified and this remains a long-term community research goal. First principles and empirically based models, combined with new data streams, are needed to achieve substantial progress toward future predictability. In the near-term, there is great value in comparing existing models and observational data sets for validation, leading to an ability to conduct ensemble modeling so as to characterize uncertainty in the radiation environment.

<u>Goals and Measures of Success:</u> The primary goal of this FST is to promote existing data–model comparisons for the global radiation environment, ranging from the lower atmosphere through the inner magnetosphere during quiet, active, and extreme conditions. An additional goal is to promote the continued innovative expansion, as well as development of calibrated data sources that can help understand the dynamic variation of this radiation environment in near real-time. A critical measure of success for investigations through this FST will be the demonstrated comparison of the temporal, spatial, and magnitude variability in the radiation environment, from tropospheric altitudes through the radiation belts, using observations and existing models reported with appropriate metrics of uncertainty.

<u>Types of Investigations:</u> This FST intends to bring together modelers and observers who can make significant progress toward validating existing modeling systems. This solicitation does not encourage the development of fundamentally new models at this time. Rather, the user communities, including Government agencies, international partners, and commercial airlines, have expressed strong interest in understanding the accuracy and uncertainty of existing models and data.

- This FST encourages proposers to make results of these comparisons available to users. Individual proposals may show how they support the FST with a systematic approach for comparing and validating modeling approaches that lead to model/observational validations.
- Investigations that can also validate calibrated dose and dose rate measurements at various altitudes and orbits for helping with these comparisons are especially solicited.
- Proposals that improve our understanding of radiation variability are particularly useful for improving future modeling and defining the sources of uncertainty.

<u>Interactions with User Communities:</u> NASA will facilitate interaction between selected teams and user communities. FST proposals should identify how research elements enable predictive developments that would be significant to specific user communities.

3.1.3 Studies of the Global Electrodynamics of Ionospheric Disturbances

<u>Target Description:</u> The large-scale electrodynamics of Earth's ionosphere reflects the state of magnetosphere–ionosphere convection, energy transport between the magnetosphere and ionosphere, and plays a key role in the dynamics of the ionosphere and thermosphere. This includes transport and heating of ionospheric plasma and the neutral atmosphere. At high latitudes the electrodynamics reflect magnetospheric convection and energy dissipation both via Joule heating and mechanical acceleration of the neutral gas. At middle and low latitudes, the

electric field is largely generated by the thermospheric winds although during storm times the high-latitude dynamics can substantially impact the low- to mid-latitude ionosphere through penetration electric fields and storm-time dynamo winds. Ionospheric electrodynamics determine the energy dissipation that drives thermospheric upwelling, reflects the convection driver for plasmaspheric plumes and TEC evolution, and governs where intense ionospheric electric fields occur that drive a range of ionospheric irregularities causing scintillation. In addition, violent changes in the near space electric currents systems such as ionospheric currents, magnetopause current, and ring current drive rapid variations of the magnetic field on the surface of the Earth. These externally driven ground magnetic field fluctuations, or dB/dt, induce a geoelectric field on the surface of the Earth. The geoelectric field that is strongly dependent on, for example, local ground conductivity conditions drive geomagnetically induced currents (GIC) that can flow in power grids, pipelines, and railway systems. Large dB/dt can also hamper geophysical exploration surveys.

Deriving ionospheric electrodynamics applicable for storm times is, therefore, of particular importance to: LWS SSA-2 Physics-based Satellite Drag Forecasting Capability; SSA-4 Physics-based TEC Forecasting Capability; and SSA-5 Physics-based Scintillation Forecasting Capability.

Most existing theories and models of the global electric field in the ionosphere focus on regional scales (e.g., limited latitudinal ranges), assume equipotential field lines, and/or impose ad hoc or statistical boundary conditions that do not apply generally and, in particular, not to storm conditions. Quantifying dissipation and neutral wind dynamics, distinguishing between heating and mechanical acceleration, and understanding the relationships of electrodynamics to particle precipitation require concurrent knowledge of ionospheric conductivities. Measurement of the global electric field, field aligned currents, and ground magnetometer equivalent ionospheric currents can be used to solve ionospheric electrodynamics to infer the effective conductivities. However, in practice, differences in spatial and temporal coverage, and sampling cadence require use of assimilative approaches, including as much information as possible for the conductivities and electrodynamics in under-sampled regions. In addition, the role of interhemispheric connectivity is often overlooked despite evidence of conjugate effects at subauroral latitudes. To advance SSA-2, 3, and 5, it is critical to quantitatively characterize storm-time ionospheric electrodynamics observationally and validate existing empirical and physics-based models against the most complete suite of observations possible.

Now is an opportune time to focus attention on this topic and overcome the deficiencies noted above, given recent advances in modern computer technology and computational algorithms, and contemporaneous observations from space- and ground-based resources. This Focused Science Topic targets the determination of storm-time ionospheric electrodynamics from observations as fully as possible using these recent data sets and quantitatively testing existing empirical and physics-based models, and deriving advances in modeling capabilities to improve quantitative predictive capability.

This FST should motivate future research into the roles of neutral winds and auroral structuring for ionospheric electrodynamics. In particular, characterizing the role of neutral winds in modifying energy transport and dissipation, and the contributions of smaller scale field and precipitation structures (below ≈10s of km) in altering energy dissipation and creating density irregularities may be significant.

Goals and Measures of Success: The goals of this FST are to provide an improved understanding that would enable a predictive capability of storm-time ionospheric electrodynamics. Specifically: (1) assess storm-time ionospheric electrodynamics from observations including the ionospheric conductivity, currents, and electric fields; (2) quantify the validity of existing empirical and physics-based models of ionospheric electrodynamics; (3) identify key areas of discrepancy and assess techniques, including potentially data-assimilation, to incorporate available data into ionospheric/thermospheric models and to infer external forcing where not well measured. All studies must consider uncertainty analysis and how the sources of error impact the results.

Types of Investigations: This FST intends to bring together modelers and observers who can make progress toward deriving storm-time ionospheric electrodynamics, validating existing models, and identifying and/or substantially improving existing modeling systems. Efforts are solicited in several areas: a) derivation of ionospheric electrodynamics from the broadest available suite of observations; b) empirical and/or first-principle theory and modeling of the global electrodynamics of the ionosphere for comparison against the observationally constrained electrodynamics; c) further development/assimilation of global data sets into the models to advance the capability to predict storm-time ionospheric electrodynamics; d) studies that translate modeled or observed global electrodynamics to magnetometer and/or GIC measurements that can be validated on the ground.

Interactions with User Communities: NASA will facilitate interaction between selected teams and user communities. FST proposals should identify how research elements enable predictive developments that would be significant to specific user communities.

4. Cross-Discipline Infrastructure Building Programs

> **The Cross-Discipline Infrastructure Building element, which includes summer schools, postdoctoral fellowship programs, and community workshops, is fully subscribed from ROSES-15 and will not be competed in ROSES-2016. Focused Science Topics proposals should not include workshop support or other travel beyond necessary team intercollaboration.**

5. Submission and Evaluation Process

5.1 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's Authorized Organizational Representative (AOR). No budget or other elements 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.

5.1.1 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 Focus Team Effort."

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 E-mail when they are able to submit their Step-2 proposals.

5.2. <u>Step-2 Proposals</u>

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 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 noncompliant letter are not eligible to submit a Step-2 proposal.

5.2.1 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 7 below).
- Margins: no less than 1 inch on all sides, with a 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 inch. 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 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.

Guidelines for submitting Step-2 full proposals, other than those listed above, are specified in the *NASA Guidebook for Proposers*. The Guidelines above supersede those found in the Guidebook. The criterion for relevance includes relevance to one of the Focused Science Topics in Section 3 and is an essential requirement for selection. As such, NASA has instituted a compliance check as described below.

In order to be compliant with this ROSES element, each FST Step-2 proposal submitted must contain a section that 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 without review. 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.

5.2.2 Step-2 Evaluation Criteria

Compliant proposals will be evaluated according to the criteria specified in Section VI(a) of the *ROSES Summary of Solicitation* and section C.2 of the *NASA Guidebook for Proposers*. These criteria are (1) intrinsic scientific/technical merit and (2) work effort realism/reasonableness. In addition, the relevance of the proposed science goals and objectives to those of the FST will be evaluated.

Work effort realism/reasonableness includes assessing the amount of work to be accomplished versus the amount of time proposed. Open-ended proposals or those with a large number of science questions to be addressed typically do not fare well in this evaluation. Only necessary Co-Investigators and Collaborators should be included, and their specific tasks and roles in the investigation must be clearly laid out in the proposal work plan. 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."

For Focus Science Topics described in Section 3.1, the evaluation for relevance is dependent on the particular Focus Science Topic. Each proposal must demonstrate that the investigation is appropriate for the FST selected. This will be strictly enforced. In addition, 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 may result in the proposal being returned without review.

6. 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 Summary of Solicitation*, Section II (a).

7. Summary of Key Information

Expected annual program budget for new awards	~$3.75 M
Number of new awards pending adequate proposals of merit	~15-20
Maximum duration of awards	Focused Science Topics: 4 years
Due date for Step-1 proposals	See Tables 2 and 3 in the *ROSES Summary of Solicitation*.
Due date for Step-2 proposals	See Tables 2 and 3 in the *ROSES Summary of Solicitation*.
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 Chapter 2 of 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 this program are, by definition, relevant to NASA. Responses to the FSTs must also show relevance to the specific FST described in section 3.
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 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	NNH16ZDA001N-LWS
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