Instrument Considerations for Step 1 and Step 2 Proposals

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TASK SUMMARY

- What information is expected on an instrument for Step 1?

- What information is expected on an instrument for Step 2?

Study Process and Application

- Evaluate results from five TMC panels to identify technical area deficiencies that are common to many proposals

- New Frontiers 2011 Step 2	1 Panel
- Discovery 2010 Step 1	3 Panels
- Solar Probes Plus	1 Panel

Evaluation Areas Addressed

- Science Traceability Matrix
- Signal-to-Noise Ratio
- Instrument Constraints on the Spacecraft System and Vice Versa
- Instrument Design
- Instrument Alignment Requirements and Performance
- Instrument Calibration Requirements
- Instrument System Thermal Requirements
- Field-of-View and Scanning Requirements
- Instrument/spacecraft Pointing Requirements
- Supporting instrumentation needed for mission implementation
- Technology Readiness Level
- Contamination Effects
- Radiation Effects on Instrument System Performance
- Test requirements, Plans and Schedules
- Radar Remote Sensing Systems
- Radio Science
- Surface Measurements

Science Traceability Matrix

Step 1

Proposals should fully complete the Science Traceability Matrix defined in the AO showing traceability from the end measurements back to NASA goals and objectives. Show required accuracies and precisions for all geophysical parameter measurements needed to meet the science objectives. The STM should show projected science performance based on end-to-end simulations, i.e. the process of going from instrument signals observed to geophysical parameters using errors estimated from the pre-Phase A design. It is especially important that the projected science performance exceeds the required with margin in the presence of realistic instrument errors.

Step 2

Update the Step 1 information based on the Phase A instrument design. Show the new geophysical parameter expected accuracies and precisions derived from results obtained using simulations of measured signals with the updated systematic and random errors added. The projected performance should exceed the required performance with significant margin. Care should be taken to assure that performance data is consistent throughout the proposal. This STM should provide a solid base that can be used to generate both the Science Requirements Document and the Mission Requirements Document.

Signal-to-Noise Ratio

Step 1

Proposals should include sufficient information to justify the required and expected SNRs. Expected signal levels in scientific units and results of calculations such as SNR versus altitude or wavelength should be provided. Enough information should be included to show that the pre-Phase A studies were adequately thorough to give confidence in the SNRs stated in the proposal. Key system parameters assumed in the SNR estimate such as optics size, optical efficiency, and detector parameters should be included.

Step 2

Update the Step 1 information based on the Phase A instrument design performance. Show the new signal calculations and provide the details of any tests, calculations or studies completed to support the SNR levels claimed. Information needed to verify the projected SNR capabilities should be provided including e.g., detector sensitivities, detector spatial area, frequency bandwidth, optics size and efficiency, electronics noise factors, integration times, étendue, and required detector temperature and stability. Discuss effects of the measurement environment on the SNR capability.

Instrument Constraints on the Spacecraft System and Vice Versa

Step 1

The proposal should provide preliminary information on constraints that any instrument imposes on the rest of the flight system such as for example, spacecraft magnetic or electric field limitations, outgassing effects, radioactive emissions, etc. The discussion should also include potential effects of instrument induced spacecraft motions on science data collection by other instruments on the spacecraft.

Step 2

Update the Step 1 information based on the Phase A instrument design study. Preliminary analysis of spacecraft interactions such as vibration impacts on instrument performance should also be provided. Other considerations such as effects of thruster plume impingement, FOV intrusions, FOV stability, momentum unloads, variable solar panel positions etc. should also be identified and quantified.

Instrument Design

Step 1

Provide an instrument block diagram for all instruments, showing the basic design and describe the instrument transfer function, detector types and layouts, spectral filtering approaches, and where calibration sources are located. Provide tabular instrument requirements and predictions. For systems dealing with low contrast scenes, provide a preliminary discussion of the approach to achieve sufficient stray light rejection performance. Discuss any special purpose encoding. Show dimensions on drawings and discuss all mechanisms.

Step 2

Include the Step 1 information plus supply enough additional information to thoroughly evaluate the instrument design and to calculate the performance. For optical systems include the diffraction limit and depth-of-field and clearly state the object size, image size, stand-off distance, focal length, aperture area, detector type and design and other key information. Describe a preliminary system model and provide experimental data supporting the model showing that requirements such as detector array performance across the measurement field, stray light rejection and tight system alignment tolerances will be met with sufficient margin. Provide details for all operating modes including data rates for each mode.

Instrument Alignment Requirements and Performance

Step 1

Describe internal alignment specifications, alignment stability requirements and design features to ensure that the instrument and intra-instrument alignments will be maintained in the presence of the expected thermal environment, and payload launch and landing loads.

Step 2

Include the Step 1 information plus provide instrument load calculations, finite element instrument model results, preliminary system thermal model results and applicable test data to demonstrate the ability to survive shock and vibration loads and still operate within required alignment tolerances in the expected thermal environment.

Instrument Calibration Requirements

Step 1

Show instrument calibration requirements and capabilities including what calibration sources will be used, how often calibrations will be performed, how the in-orbit calibrations are tied to ground standards and describe any calibration method heritage.

Step 2

Include the Step 1 information plus describe in detail, how the calibrations will be performed both on the ground and in-orbit to meet the stated requirements including the ground test-bed and in-flight calibration system designs and heritage. Discuss the required instrument alignment and stability in-orbit to view the target and how this will be achieved. Discuss how instruments will be calibrated in the environment to be encountered during cruise, in orbit or after landing on the surface.

Instrument System Thermal Requirements

Step 1

Clearly state the instrument system and detector thermal requirements including detector temperature and stability requirements, top level thermal design, instrument system thermal stability requirements, system assumptions, cooling approaches, and effects of warm objects in the FOV on system cooling including the assumed thermal properties of the object being observed. To support any cooling margin claims, provide sufficient definition of heat flow paths, parasitic heating sources and approaches to compensate for cooler temperature changes either in hardware or mission design.

Step 2

Include the Step 1 information plus describe the conceptual thermal design, instrument/spacecraft thermal isolation requirements, thermal system modeling, what modeling heritage exists, and show calculated thermal design margins including a preliminary analysis of heat loss paths and parasitic heating sources. When heritage thermal designs and models are used, thoroughly elucidate the assumptions, and describe changes from the heritage design and methods used to extrapolate the design to the new system. Describe detector and system cooler design, operation, heritage and cooling characteristics including stability, drift, and cooler heat load margins.

Field-of-View and Scanning Requirements

Step 1

Describe FOV overlap requirements for all instruments, clear instrument and radiator FOV requirements on the spacecraft, and sun avoidance constraints. Clearly describe how altitude scans will be accomplished for limb viewing by emission, solar occultation or stellar occultation instruments (e.g. scanning by the instrument scan mirror or by the spacecraft).

Step 2

Include the Step 1 information plus update FOV requirements and instrument system capabilities based on the Phase A design study. Describe scan ranges, scan rates, scan duty cycles and observing plan interactions. Fully describe duty cycles that show when nadir or limb measurements will be made and how these affect the science timeline.

Instrument/spacecraft Pointing Requirements

Step 1

Describe instrument and/or spacecraft jitter, stability and pointing accuracy specifications in relation to detector and science field-of-view sizes and state any instrument-to-instrument or instrument-to-spacecraft boresight specifications. Provide a top level discussion of how S/C motion, such as uncompensated attitude drift in a limb sounder scan direction for example, effects science results and discuss how these effects are mitigated by the system design or by a software correction approach.

Step 2

Include the Step 1 information plus provide updated instrument and/or spacecraft pointing system design capabilities and analyses to demonstrate that the jitter, stability and pointing accuracy requirements will be met. Describe an approach or approaches to measure boresights pre- and post-launch and where required, during the mission. Provide results of system studies that show that the effects of spacecraft motions are sufficiently mitigated by the system design and data analysis.

Supporting instrumentation needed for mission implementation

Step 1

Fully identify all instruments needed to meet science objectives, including not only direct science instruments but also all science supporting instruments (e.g. optical navigation, laser altimetry) and provide supporting instrument requirements versus performance capabilities.

Step 2

Include the Step 1 information plus when an existing supporting instrument is used in an unchanged form from a prior mission, e.g. such as a laser altimeter previously flown, clearly provide its capabilities or give an easily accessible reference that describes the capabilities. Fully describe any performance capability changes that result from using a repackaged instrument design.

Technology Readiness Level

Step 1

The proposal should justify the TRL value assigned to a given instrument using tables that address key subsystems. When an instrument is not at TRL 6 describe an approach to bring it to TRL 6 by the end of Phase B. Describe the proposer's criteria used to classify the hardware as having reached TRL 6. When inheritance is claimed from an ongoing program discuss the development status of the heritage equipment. Describe qualification rationale and plans including how many and what kinds of units will be built and what tests will be done on each unit.

Step 2

Include the Step 1 information plus include detailed discussion to fully describe and justify TRL levels and provide a detailed plan for advancing an instrument to TRL 6 by the end of Phase B. Include discussion of changes to heritage hardware, plans for requalification, effect of obsoles-cence on claimed heritage, effects on heritage when hardware is built by a different institution than the one that built the original hardware and include clear statements about applicable software heritage listing what parts of the software and the percentage of software that is unchanged. Describe how any differences in the radiation, thermal and structural environments from the heritage application are accounted for in the TRL assessment.

Contamination Effects

Step 1

Discuss instrument contamination protection rationale, requirements and design approaches to meet requirements including contamination covers, protection system heritage and design features. Where applicable, address the effects on the science of water vapor trapped in the system and at a top level discuss approaches to drive water out of the system. When the mission sequence could lead to contamination effects (e.g., flying through a comet tail), mitigation approaches should be discussed.

Step 2

Include the Step 1 information plus provide a more thorough description of contamination effects on science results based on the Phase A study, including instrument design features to prevent these effects on the ground and in-orbit. Discuss planned measurements and testing to demonstrate compliance with design requirements. If applicable, include discussion of how water vapor effects will be eliminated or sufficiently reduced. When gases are required for purging or for other reasons, describe gas purity requirements and any difficulties in assuring that quality.

Radiation Effects on Instrument System Performance

Step 1

Discuss the effects of radiation dose and dose rate on the performance of instrument system detectors, and electronics and describe top level planned approaches to sufficiently mitigate these effects on mission science. Even though a detailed design is not needed at this stage, enough information should be provided to demonstrate a thorough understanding of the problems to be solved and that feasible design solutions exist.

Step 2

Include the Step 1 information plus provide detailed discussion of radiation mitigation design features resulting from the Phase A study and provide results of calculations showing that radiation doses and dose rates will not have a significant effect on instrument system lifetime, noise levels, and the ability to deliver the measurements needed to meet science objectives.

Test requirements, Plans and Schedules

Step 1

Describe instrument performance, thermal, and mechanical testing requirements including any stressing tests needed to show proper operation in the expected environments encountered in orbit, during entry, during landing, and on the surface (including dust and atmospheric effects). Describe, top level tests planned, testing schedule and facilities in place or planned to address testing issues. State the number of development, engineering, qual and flight units and how they will be used. Show top level activities for these models and critical components. Define the relationship of the development units to the flight hardware.

Step 2

Include the Step 1 information plus provide a detailed discussion of any Phase A testing conducted, test results, problems uncovered, and methods defined to mitigate effects of any testing issues or science measurement concerns uncovered. Discuss cases where instrument testing cannot be done and describe alternate ways to address these issues. Describe existing facilities or facilities that need to be developed to demonstrate solutions to testing issues defined in the study (e.g. effects of the surface atmosphere on the measurement). Provide a detailed test plan showing all planned tests and their phasing. Include a detailed test schedule and show how it meshes with the overall development schedule.

Radar Remote Sensing Systems

Step 1 and Step 2

Describe the rationale for band selection (e.g. C-band) and provide a block diagram of the system along with a description of the function of the major blocks. For any on-board processing, discuss available test results as well as heritage of the algorithms. Include a link budget and describe how this budget supports SNR claims. Describe the antenna design and any unusual characteristics. For Radar systems whose antenna pattern is affected by the presence of the spacecraft, describe how the impedance match between the antenna and the feed are determined. Demonstrate how the alignment of antenna and feed are maintained during the mission (e.g. are changes in spacecraft shape accounted for in the SNR error budget). Discuss both ground and in-flight radiometric calibrations. If there are any related airplane or earth orbiting results from a similar system, explain how that data supports proposed performance claims. Discuss long-term storage issues and associated test plans for any deployable items.

Radio Science

Step 1 and Step 2

The proposal should provide radio occultation system modeling to show that the assumptions made and science parameter results accuracies stated are consistent with the capability and availability of the needed resources both on the ground and on the spacecraft. Describe interactions with the spacecraft telecom system, the selection and justification for the radio band used (e.g. X- or Ka- band), the capabilities and availability of the USOs selected, projected SNRs, and required timing accuracy. Fully describe duty cycles that show when the radio science measurements will be made and how these measurements affect the science timeline.

Surface Measurements

Step 1 and Step 2

Discuss the contamination issues involved in sampling material on the surface of the body of interest and how the selected sampling approach mitigates these issues. Define platform stability requirements and how local gravity affects the sampling approach. Provide the sequence of events leading up to sampling after landing. Describe the method of surface sampling employed and discuss what requirements this places on other elements of the system (e.g. dust protection). Discuss how the sampling environment affects the choice of lubricants. Provide mechanism stiffness and torque margins on articulating elements. Describe the mechanism test environments . If cameras are employed to support surface operations, provide their requirements for spatial coverage and depth-of-field relative to the work space. Discuss how camera performance is assured over the environmental extremes. Discuss how the work space is illuminated and define the camera alignment with the working volume. If samples are taken in various locations, discuss how cross contamination is avoided. Describe lifetime limitations for surface operations.