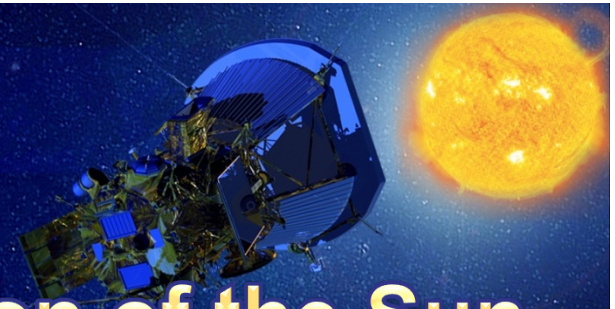
Solar Probe Plus

A NASA Mission to Touch the Sun



Integrated Science Investigation of the Sun
Energetic Particles

Preliminary Design Review
05 – 06 NOV 2013

Verification

Nigel Angold

Verification - Outline

- Documentation
- Verification Process Definition
  - Verification Program Concept
  - Verification Program Planning
  - Verification Methods
  - Requirements Verification Matrix
  - Verification Process
- Performance Requirements
- Environmental Requirements
- Interface Requirements
- Assurance Requirements

Documentation

SPP System Verification and Validation Plan, 7434-9099

ISIS Verification and Validation Plan, 16105-ISIS_VVP-01

- These documents define the Verification Process:
  - Verification Program Concept
  - Verification Program Planning
  - Verification Methods
  - Requirement Verification Matrix
  - Verification Process

Verification Process Definition

Verification Program Concept:

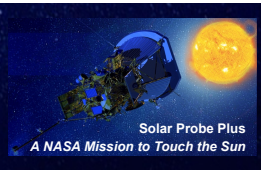
- ISIS instrument requirements verification is part of the overall SPP verification campaign.
- EPI-Lo requirements will be verified by APL.
- EPI-Hi requirements will be verified by Caltech.
- Tracking of all ISIS requirements verification will be performed by the ISIS Systems Engineer, reporting to the SPP Requirements & Verification Engineer.

Verification Process Definition

Verification Program Planning:

- Verification and Validation Plans produced before PDR.
- Test and Calibration Plans, inputs for I&T before CDR.
- Test, Verification and Calibration reports generated throughout all pre-launch phases.

Verification Process Definition

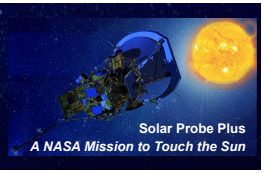


Verification Methods:

- **Test**
  Most requirements should be verified by test or supported by quantitative test data.
- **Analysis**
  Some requirements cannot be verified by test (e.g. due to cost or physical limitations) or may not be fully verifiable by testing alone.
- **Demonstration**
  Applied to some qualitative requirements that cannot be easily tested or requirements that cannot be tested over a full range of relevant scenarios.
- **Inspection**
  Used to verify a describe a design characteristic or method or where a requirement may be satisfied solely by the review of documentation.

Every requirement must be verified by one or more of the above methods.

Verification Process Definition



Requirement Verification Matrix:

- Tracking of verification by means of matrices containing:
  - Requirement reference number
  - Requirement Description
  - Verification Method: one or more of Test, Analysis, Demonstration and Inspection
  - Verification Activity
  - Closure Status: closed, open, waived, deferred, etc.;
  - Closure Date
  - Responsible Organization
  - Comments

Verification Process Definition

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Example Verification Matrix entries from ISIS IRD:

Req. #	Requirement	Verification Method [1]	Verification Activity	Closure Status [2]	Closure Date	Responsible Organization	Comments
ISIS-100	The EPI-Lo instrument shall provide measurements of energetic electrons with an energy range of <=0.05MeV to >=0.5MeV.	Analysis & Test	Simulation and spot test using radiation sources.				
ISIS-110	The EPI-Lo instrument shall provide measurements of proton and heavy ion angular distributions using sectors of width ≤30°.	Analysis & Test	SIMION analysis and test. Test in accelerator with articulation stage.				
ISIS-123	The EPI-Lo instrument shall comply with maximum mass constraints, as specified by the SPP to ISIS ICD, 7434-9058	Test	EPI-Lo mass measurements				
ISIS-207	The EPI-Hi instrument shall be capable of measuring protons and heavy ions with at least 6 bins per decade.	Analysis & Test	Test pulser measurements and Monte Carlo simulations with spot checks using accelerator beams.				
ISIS-218	The EPI-Hi instrument shall have ≥π/2 unobstructed field of view (FOV) in both sunward and anti-sunward hemispheres for the measurement of energetic protons/heavy ions including coverage within 10° of the spacecraft-Sun line, subject to the constraints and FOV obstructions specified in the SPP to ISIS ICD, 7434-9058.	Analysis & Inspection	Analyze obstructions using CAD model and inspect mounting on the spacecraft after integration to verify the accuracy of that analysis.				
ISIS-224	The EPI-Hi instrument shall comply with maximum power constraints, as specified by the SPP to ISIS ICD, 7434-9058.	Test	EPI-Hi CPT				
ISIS-350	The ISIS instruments shall be capable of implementing real-time commands via CCSDS packets in files uplinked via CFDP, as defined in the MOC to SOC ICD, 7434-9078.	Test	ISIS instrument CPTs				
ISIS-356	The ISIS instruments shall be capable of providing real-time instrument health and status data in telemetry formats specified by the SPP to ISIS ICD, 7434-9058, when required by mission operations for routine monitoring of housekeeping data and status.	Test	ISIS instrument CPTs				

[1] Verification Method: Test, Analysis, Inspection or Demonstration.

[2] Closure Status: Open, Closed, Waived or N/A

Currently tracking 82 instrument requirements in the IRD Verification Matrix

Verification Process Definition

Verification Process:

- Development of Verification Procedures
  - Procedures approved by the design engineer, the systems engineer, the project manager, and QA and released prior to execution.
  - Will comply with the format requirements and configuration control authority of the originating agency (APL, Caltech, or SwRI).
- Performance of Test Readiness Reviews
  - Required before installing flight hardware into a test environment.
- Test Execution
  - Test engineer assigned
  - QA participation
  - Equipment calibrated before test
  - Test procedures under document control

Verification Process Definition

Verification Process continued:

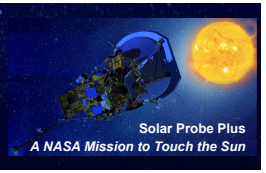
- Post-test Reviews
  - Test results are reviewed and approved by the ISIS SE to ensure adequate verification of requirements.
  - All hardware non-conformances or failures shall be documented.
  - Any corrective actions identified shall be processed by the cognizant engineer and elevated as appropriate.
  - For any test failure, the reason must be identified.
  - Hardware under test / test setup must not be disturbed in any way that prohibits duplication of a test failure.
  - The post-test review will result in a “pass” or “fail”.
- Completion of the Verification Matrix
  - Verification is tracked by entering data into the Verification Matrix.

Verification Process Definition

Verification Process continued:

- Requirement Closure
  - A requirement will be declared “closed” when all verification activities planned for and associated with the requirement have been completed satisfactorily.
- Waivers and Deviations
  - In cases where it may be acceptable that a requirement is not met, a waiver or deviation will be filed with the JHU/APL SPP Project Office, and NASA Goddard Program Office, as appropriate.
  - The SPP waivers and deviations process is documented in the SPP Configuration Management Plan, 7434-9006.
  - All hardware non-conformances or failures shall be documented.

Performance Requirements



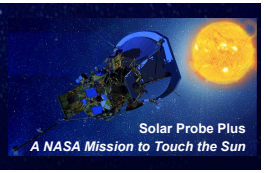
Performance requirements are defined in:

- Level 1 Requirements for the Solar Probe Plus Mission
- SPP Mission Requirements Document (Level 2), 7434-9047
- SPP Level 3 Payload Requirements Document (Level 3), 7434-9051
- ISIS Instrument Requirements Document (Level 4), 16105-ISIS-IRD-01

Level 2 - 4 documents:

- Each document contains a Requirement Verification Matrix.
- Level 2 and 3 verification typically inspection of documention verifying lower level requirements found in the ISIS IRD.
- ISIS Systems Engineer will flow verification data up to the appropriate document owners.
- Performance requirements are formally managed by the SPP Requirements & Verification Engineer and are tracked in the SPP System Requirements Database, DOORS.

Environmental Requirements



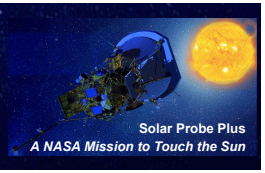
Environmental requirements are defined in:

- SPP Contamination Control Plan, 7434-9011
- SPP Environmental Design and Test Requirements Document, 7434-9039
- SPP Electromagnetic Environment Control Plan, 7434-9040

Environmental requirements documents:

- Each document contains a Requirement Verification Matrix.
- ISIS Systems Engineer will flow verification data up to the appropriate document owners.
- Environmental requirements are not maintained in the SPP System Requirements Database, DOORS.

Interface Requirements



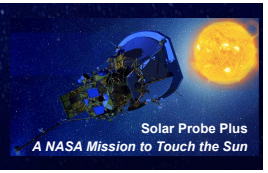
Interface requirements are defined in:

- SPP to ISIS ICD, 7434-9058
- SPP General Instrument to Spacecraft ICD, 7434-9066
- MOC to SOC ICD 7434-9078

Interface requirements documents:

- Each document contains a Requirement Verification Matrix.
- ISIS Systems Engineer will flow verification data up to the appropriate document owners.
- Interface requirements are not maintained in the SPP System Requirements Database, DOORS.

Assurance Requirements



Assurance requirements are defined in:

- SPP Product Assurance Implementation Plan (PAIP), 7434-9003
- EPI-Lo Product Assurance Implementation Plan (PAIP), 7464-9001
- EPi-Hi Product Assurance Implementation Plan (PAIP), CIT-SPP-004

Assurance requirements documents:

- Each document contains a Compliance Matrix
  - Comply
  - Do not Comply
  - Comply with Caveats
  - N/A
- Assurance requirements are not maintained in the SPP System Requirements Database, DOORS.
- The SPP System Assurance Manager is responsible for verification of Assurance requirements.