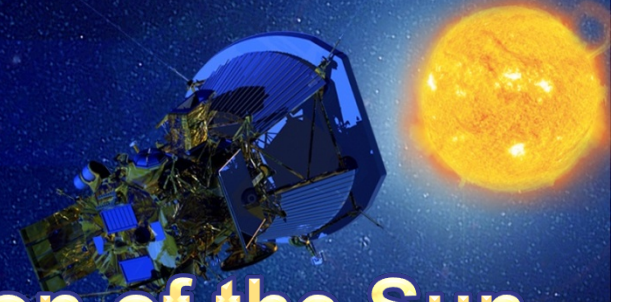


Solar Probe Plus

A NASA Mission to Touch the Sun



Integrated Science Investigation of the Sun Energetic Particles

Preliminary Design Review

05 – 06 NOV 2013

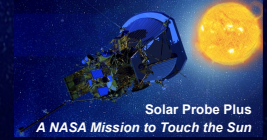


Verification

Nigel Angold



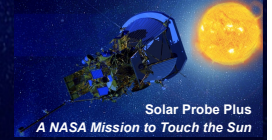
Outline



- 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
- Verification Summary



Documentation

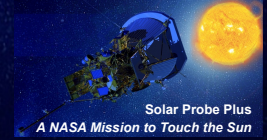


SPP System Verification and Validation Plan, 7434-9099
ISIS Verification and Validation Plan, 16105-ISIS_VVP-01

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



Verification Process Definition

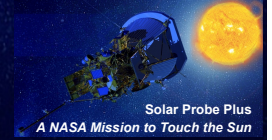


Verification Program Concept:

- 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

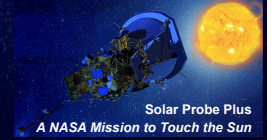


Verification Program Planning:

- Verification and Validation Plans produced before PDR.
- Test and Calibration Plans, inputs for I&T produced 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.

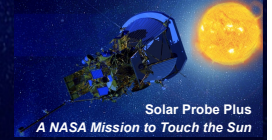
- Inspection

Used to verify a 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

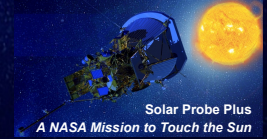


Requirement Verification Matrix:

- 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



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 $\leq 0.05\text{MeV}$ to $\geq 0.5\text{MeV}$.	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 $\leq 30^\circ$.	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 $\geq \pi/2$ 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				

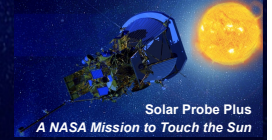
⁽¹⁾ Verification Method: Test, Analysis, Inspection or Demonstration.

⁽²⁾ Closure Status: Open, Closed, Waived or N/A

Currently tracking 82 instrument requirements in the IRD Verification Matrix



Verification Process Definition

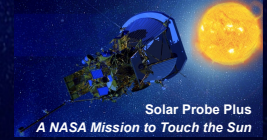


Verification Process:

- Development of Verification Procedures
 - Procedures approved by the design engineer, the systems engineer, the project manager, and QA and released prior to execution.
 - They 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

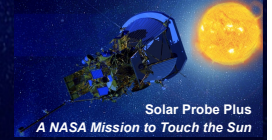
- Test results are reviewed and approved by the ISIS SE to ensure adequate verification of requirements.
- All hardware non-conformances or failures shall be documented.
- Any corrective actions identified shall be processed by the cognizant engineer and elevated as appropriate.
- For any test failure, 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

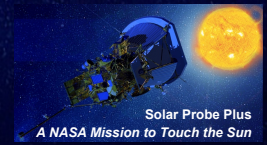


Verification Process continued:

- Requirement Closure
 - A requirement will be declared “closed” when all verification activities planned for 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:

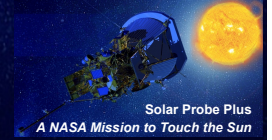
- Level 1 Requirements for the Solar Probe Plus Mission
- SPP Mission Requirements Document (Level 2), 7434-9047
- SPP Level 3 Payload Requirements Document (Level 3), 7434-9051
- ISIS Instrument Requirements Document (Level 4), 16105-ISIS-IRD-01

Level 2 - 4 documents:

- Each document contains a Requirement Verification Matrix.
- Level 2 and 3 verification typically inspection of documentation verifying lower level requirements found in the ISIS IRD.
- ISIS Systems Engineer will flow verification data up to the appropriate document owners.
- The Requirement Verification Matrix is maintained as an Excel spreadsheet that the SPP Requirements & Verification Engineer uses to import data into the SPP System Requirements Database, DOORS.



Environmental Requirements



Environmental requirements are defined in:

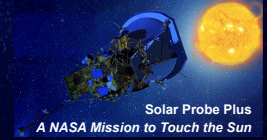
- SPP Contamination Control Plan, 7434-9011
- SPP Environmental Design and Test Requirements Document, 7434-9039
- SPP Electromagnetic Environment Control Plan, 7434-9040

Environmental requirements documents:

- Each document contains a Requirement Verification Matrix.
- ISIS Systems Engineer will flow verification data up to the appropriate document owners.



Interface Requirements



Interface requirements are defined in:

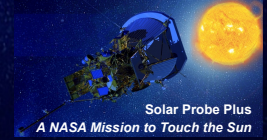
- SPP to ISIS ICD, 7434-9058
- SPP General Instrument to Spacecraft ICD, 7434-9066
- MOC to SOC ICD 7434-9078

Interface requirements documents:

- Each document contains a Requirement Verification Matrix.
- ISIS Systems Engineer will flow verification data up to the appropriate document owners.



Assurance Requirements



Assurance requirements are defined in:

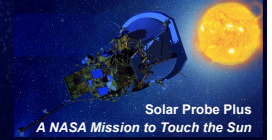
- SPP Product Assurance Implementation Plan (PAIP), 7434-9003
- EPI-Lo Product Assurance Implementation Plan (PAIP), 7464-9001
- EPI-Hi Product Assurance Implementation Plan (PAIP), CIT-SPP-004

Assurance requirements documents:

- Each document contains a Compliance Matrix
 - Comply
 - Do not Comply
 - Comply with Caveats
 - N/A
- The SPP System Assurance Manager is responsible for verification of Assurance requirements.



Verification Summary



- ISIS has a clearly defined Verification Process that is documented in the ISIS Verification and Validation Plan.
- Requirement Verification Matrices will be used to track Performance, Environmental and Interface Requirements.
- Assurance Requirements will be tracked using Compliance Matrices.