

STEREO *IMPACT*

Environmental Test Plan

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Document Revision Record

Rev.	Date	Description of Change	Approved By
A	2001-Sep-10	Preliminary Draft	-
B	2002-July-22	Provide additional detail per Project outline	-
C	2002-Nov-8	Respond to Project comments: <ul style="list-style-type: none"> • Thermal Vac -> 7 cycles, 4 hour dwells, 3C/Min Max (5C/Min for IDPU) • Add Pressure Profile/Leakage section • Add operating hours section including logging requirement and pre-subassembly integration goal Updated I&T Flow diagrams	-
D	2003-12-30	<ul style="list-style-type: none"> • Update test flow charts and matrix • Add reference to Verification Matrix • Modify self-shock plan for boom 	unreleased
E	2004-02-17	<ul style="list-style-type: none"> • Update test flow diagrams • Updated test matrix 	-

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1. Introduction

This document describes the Environmental Test Plan for the STEREO IMPACT instrument suite. This plan covers testing of flight and protoflight hardware prior to delivery to Observatory integration, plus IMPACT participation and requirements on Observatory-level tests. This test plan is intended to meet the requirements of the STEREO Environmental Test Specification (reference 1).

Note that at this time details such as the facilities to be used, and in some cases the method to be employed are TBD. These details will be firmed up by the Pre-Environmental Review, either in a new rev of this document, or in the test procedures.

1.1. Document Conventions

In this document, **TBD** (To Be Determined) means that no data currently exists. A value followed by **TBR** (To Be Resolved) means that this value is preliminary. In either case, the value is typically followed by code indicating who is responsible for providing the data, and a unique reference number.

1.2. Applicable Documents

The following documents include related documents and STEREO Project policies. In the event of a conflict between this document and the following documents, this document takes precedence (**waivers will be submitted where this plan violates Project requirements such as those called out in reference 1, 2, and 5**). All documents can be found on the Berkeley STEREO/IMPACT FTP site (some are referenced by a hyperlink to the secure APL web site due to ITAR restrictions):

<http://sprg.ssl.berkeley.edu/impact/dwc/>

1. Project/EnvSpec7381-9003 – STEREO Environmental Test Specification
2. Project/EMC_7381-9030 – STEREO EMC Requirements
3. Specifications/IMPACTPerformanceSpec – Instrument Performance Specification
4. Plans/VerificationMatricies – IMPACT Instrument Verification Matricies
5. Project/ContaminationControlPlan7381-9006 – Project Contamination Control Plan
6. Project/EnvironmentalTestOutline – Project outline for this document
7. Plans/IMPACTVerificationMatrix – Matrix outlining how all the different requirements will be verified.

2. Verification Requirements

Verification Requirements come from GEVS-SE, and the STEREO Project Environmental Test Spec (Reference 1) and EMC Requirements (Reference 2). In the event of a conflict, this document takes precedence, followed by the Project documents, then GEVS.

3. Verification Matrices

Reference 4 includes the verification matrices for the testing to be performed on the IMPACT Suite down to the subassembly level. This is summarized at the top level in

Table 3-1. The functional and calibration tests and analyses are designed to verify the Reference 7 calls out all the different requirements (of which environmental requirements are a subset).

Table 3-1 Environmental Test Matrix

System	EMC	Bakeout	Thermal Vac Cycling (Op/NonOp)	Thermal Balance	Sine Vib	Random Vib	Accoustic	Mass props	Failure Free Hours
SEP		√							
- SEPT-NS	Mag Screening	H	-30 - +40C -40 - +50C	√	√	√		√	24
- SEPT-E	Mag Screening	H	-30 - +40C -40 - +50C	√	√	√		√	24
- SIT	Mag Screening	H	-30 - +30C -35 - +35C	√	√	√	√	√	24
- HET, LET, Common Elec.	Mag Screening	H	-30 - +35C -40 - +40C	√	√	√	√	√	24
Boom Assy		√	-33 - +40C -33 - +40C (*)		√ (*)	√ (*)		√	
- Boom	Mag Screening	H	H	√	H	H		Mass	N/A
- SWEA	Mag Screening	H	-25 - +30C -30 - +50C**	√	√	√		Mass	24
- STE	Mag Screening	H	-25 - +30C -30 - +50C**	√	H	H		Mass	24
- Mag Sensor		H	H		H	H		Mass	24
IDPU	Mag Screening	√	-23 - +55C -30 - +60C		√	√		√	24
Flight Harness		√							
IMPACT Suite	RS,RE,CS,CE per EMC Requirements								100

2004-2-17 DWC

(*) = Boom Assy without SWEA (**) STE detectors test colder H = test at higher level of assembly

Figure 4-1a IMPACT Boom Suite / IDPU FM1 I&T Flow, updated 2004-2-17

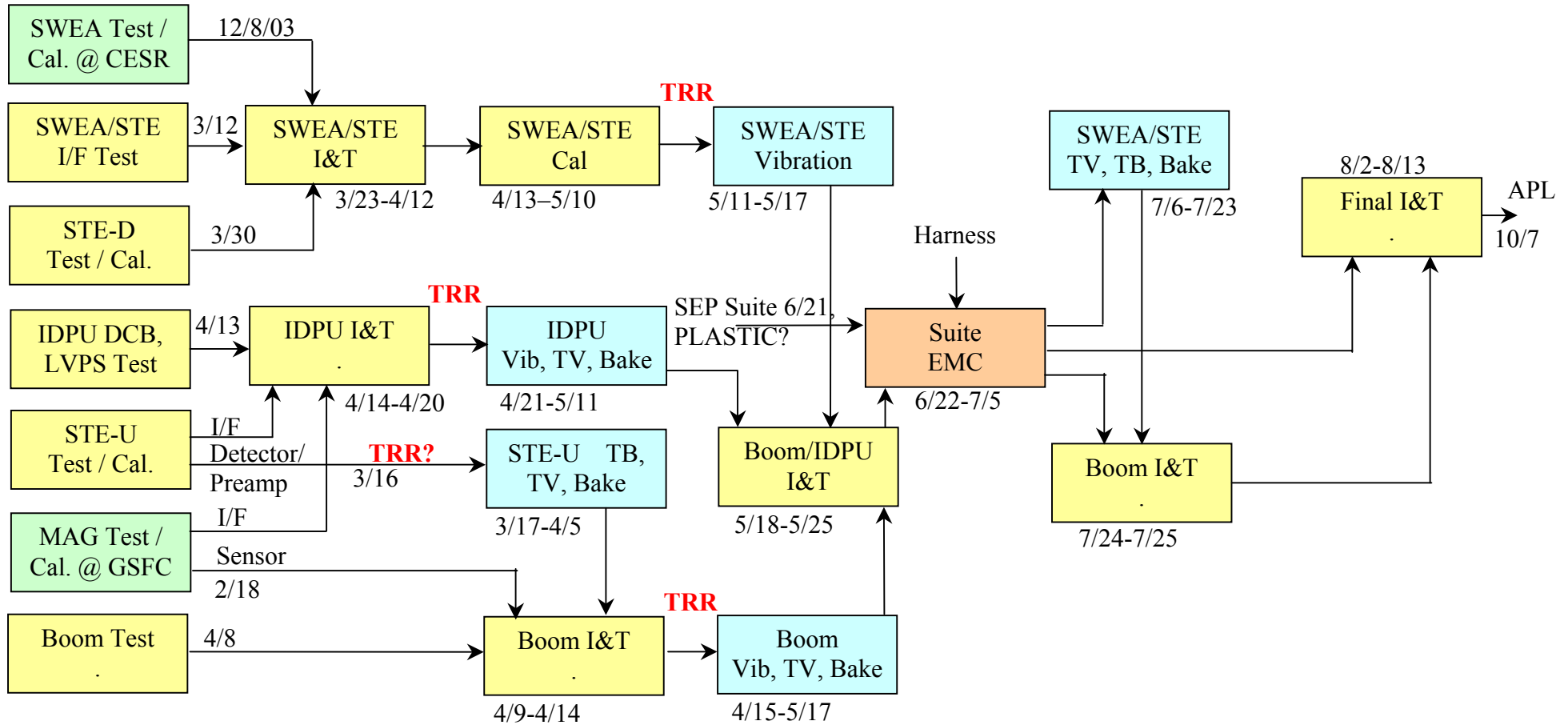
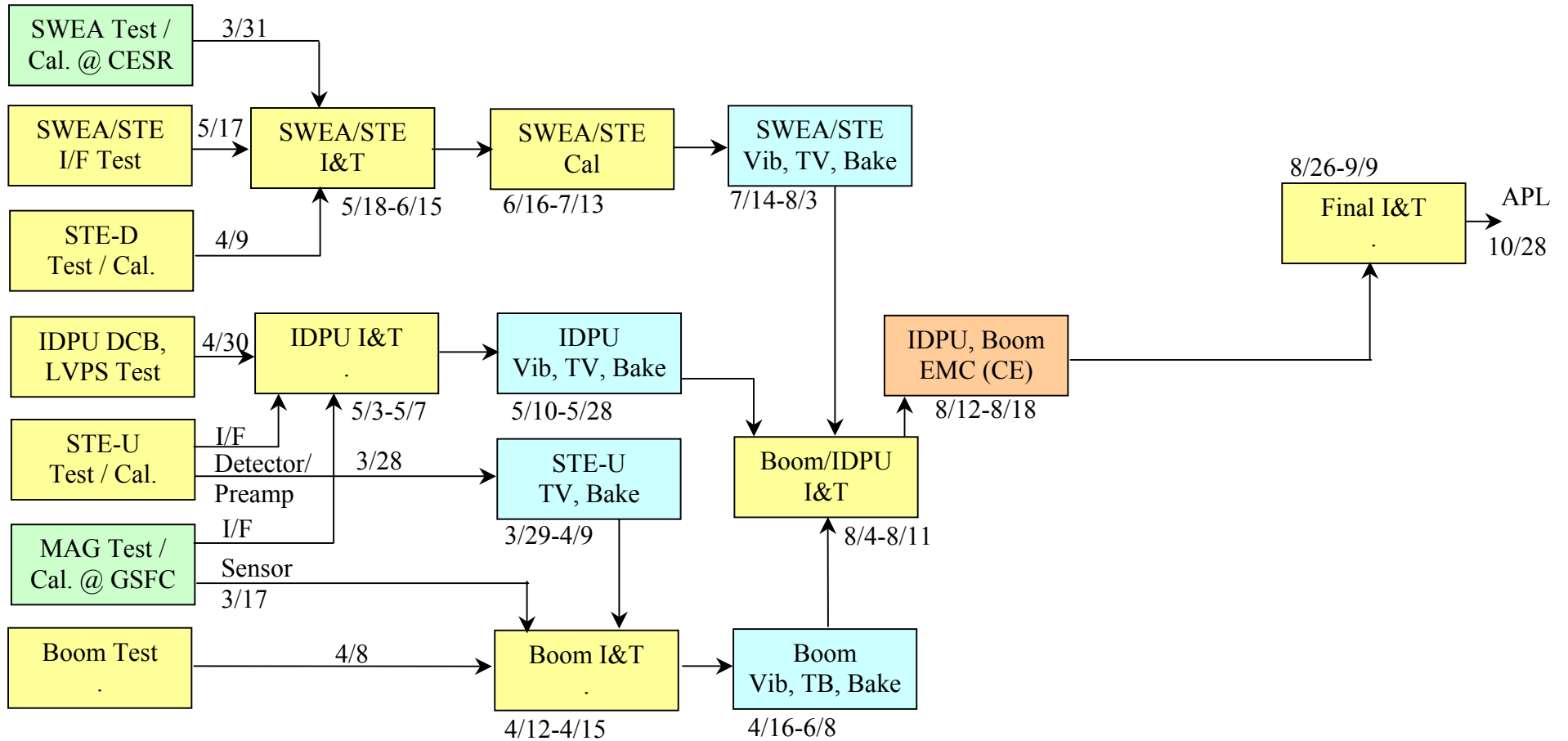
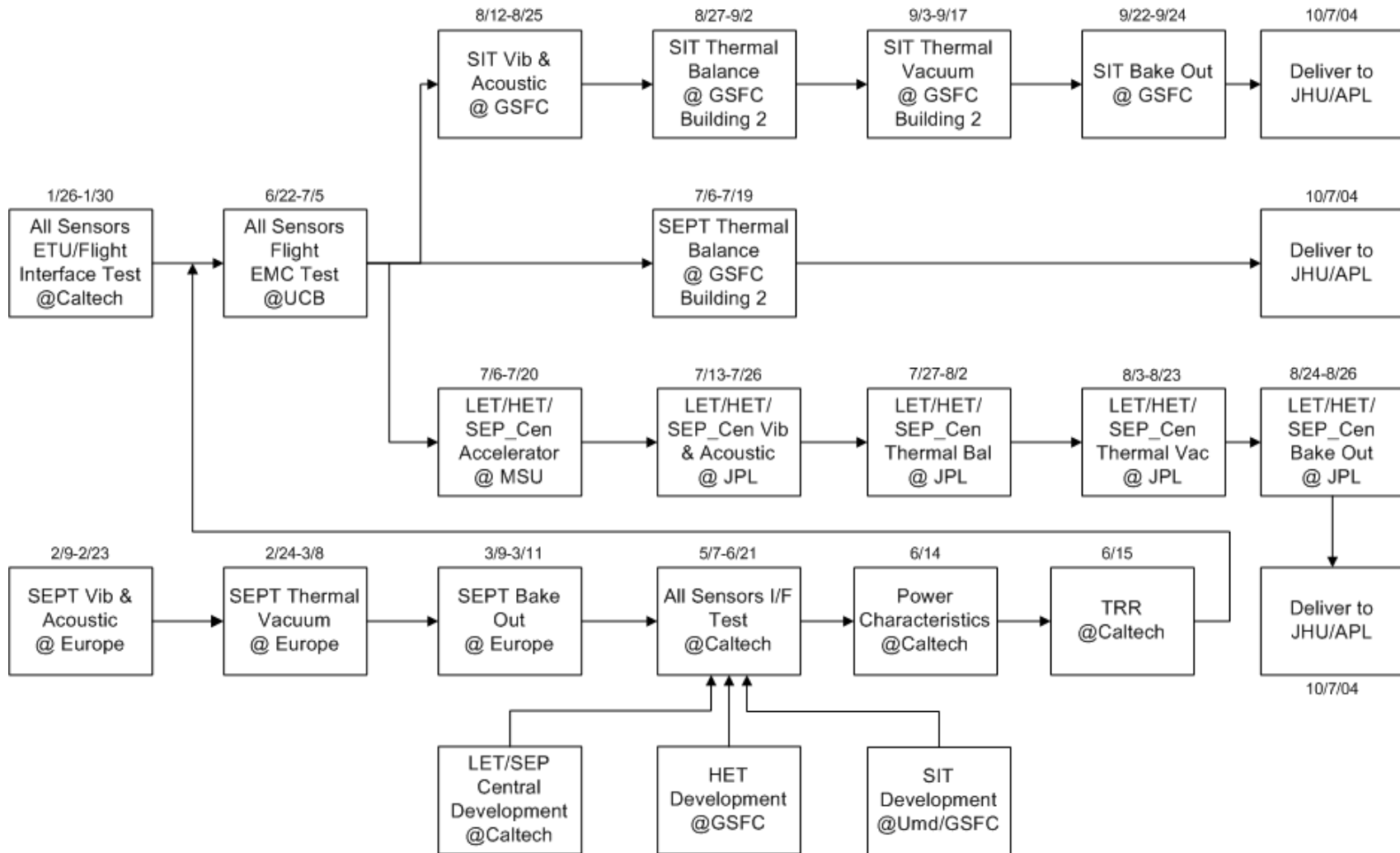


Figure 4.1b IMPACT Boom Suite / IDPU FM2 I&T Flow (Updated 2004-2-17)

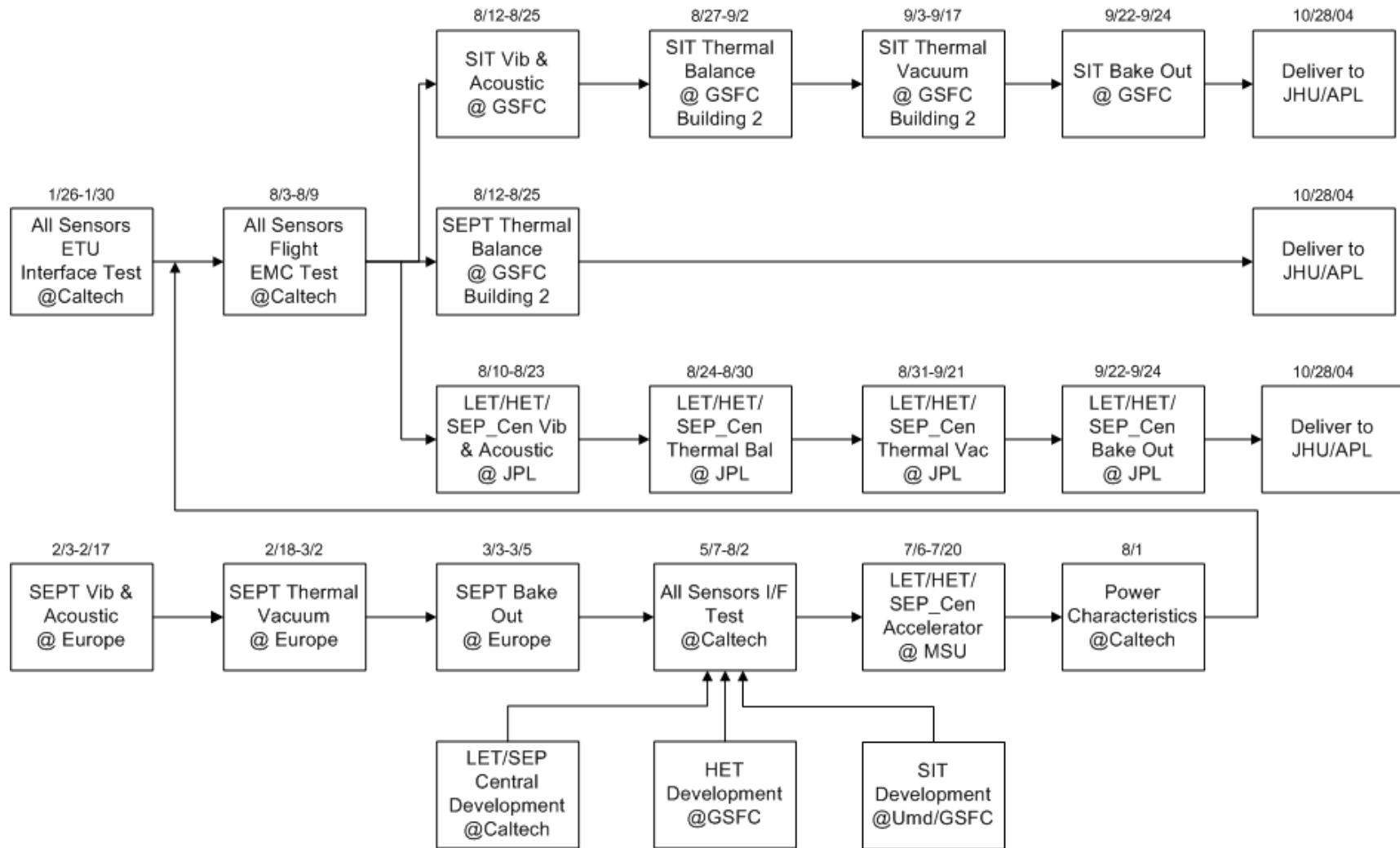


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SEP Suite FM1 (Ahead Unit) Test Flow (2/5/04)



SEP Suite FM2 (Behind Unit) Test Flow (2/5/04)



4. Test Plan

Environmental testing is performed at various levels of assembly, as appropriate. Figures 4-1 and 4-2 show the planned assembly and test flow. Dates shown in this figure are approximate.

Flight hardware shall be complete prior to the start of testing, including flight software. Any change to the hardware or software after the start of test may require repeating some or all of the tests, at the discretion of the IMPACT project manager.

4.1. *Comprehensive Performance Test*

Before the start of environmental tests, between tests, and in some cases during tests (as indicated in section 5), a Comprehensive Performance Test (CPT) shall be performed. This test verifies the functionality (though not the calibration) of all parts of the instrument, with the exception of the SWEA and SIT high voltage and MCP detectors. These cannot be operated in air. These systems shall be verified in vacuum before environmental tests start, during Thermal Vacuum tests, and after observatory environmental tests complete. Besides the SWEA and SIT High Voltage constraint, the CPT is an end-to-end test, from the detectors through the instrument interface. Detectors shall be stimulated using radiation sources. SWEA and SIT shall use test pulsers as far upstream as possible to test all of the electronics chain. For suite-level tests (notably the EMC test and Observatory-level tests), the CPT shall be an end-to-end test all the way to the spacecraft interface and beyond. Data shall be collected during CPTs for trending analysis.

4.2. *Aliveness Test*

A short aliveness test shall be used to verify a subset of the instrument functionality. This test shall rely primarily on state of health housekeeping being within limits. This verifies communications paths, power converters, and power consumption, but is light on detector testing.

4.3. *Contamination Control*

The IMPACT contamination sensitive detectors shall be sealed by instrument covers or bagged and at least periodically purged during testing. The exterior of the instruments shall be maintained at good housekeeping levels, being handled with gloves and bagged when not in use. Minimal contamination requirements shall be imposed on the environmental test facilities. This is described in more detail in the IMPACT contamination Control Plan (TBS), and reference 5.

5. Test Levels

5.1. *EMC Tests*

EMC test levels are called out in Reference 1 and 2. EMC testing will be done at the suite level using flight intra-instrument harnesses. The PLASTIC instrument shall also be tested with the IMPACT Suite.

Bonding and isolation tests shall be performed to verify the requirements of Reference 2, section 5.3.

Emissions tests shall be performed with the instrument in its normal operating mode. The exception shall be that high voltages shall be generally off or at a low level, since operation in air can damage detectors (PLASTIC, SWEA, SIT). The IMPACT boom shall probably not be deployed due to lack of space. The instrument shall be bagged with RF-transparent material and purged to avoid contamination (unless the EMC facility chosen happens to meet the contamination requirements). Instrument covers shall be open.

Susceptibility shall be determined by monitoring instrument state of health telemetry for out-of-limits values or significant changes such as processor resets, and instrument telemetry such as count rates.

A Comprehensive Performance Test shall be performed following EMC tests to verify no damage or changes have occurred to the instrument during the tests.

Note that the full EMC suite is only required on one Flight Unit. The second unit will get a reduced (CE) test at the subassembly level as specified in reference 2.

5.1.1. Magnetism

IMPACT Suite elements shall be surveyed magnetically at the subsystem (instrument) level no later than the EMC test using equipment provided by the MAG team. Of particular interest is the boom suite components mounted close to the MAG sensor. Tests shall include static (DC) measurements, plus dynamic (AC) measurement with the instruments powered ON and in a normal operating mode (with the same High Voltage constraints indicated in the EMC test section). Success criteria are based on reference 1 section 3.5, scaled to the distance from the instrument to the MAG sensor on the spacecraft.

5.2. *Vibration Tests*

Vibration testing (Sine and Random) shall be as listed in Reference 1, section 3.4, at the level of integration that they are attached to the spacecraft (see Table 3-1). Boom and bracket mounted instruments shall be vibrated on their booms and brackets. Tests shall be performed in all 3 axes to the levels, limits, and durations indicated in reference 1, section 3.4. Comprehensive performance tests shall be performed before and after testing (but not necessarily between axes). The tests shall be preceded by a low-level sine sweep

survey to determine modal frequencies and any required exciter notching for subsequent tests. This data shall also be used to verify Finite Element Model results where applicable (the IMPACT Boom). The unit under test shall be instrumented with accelerometers adequate to measure response.

The subsystems shall be vibrated in launch configuration (powered off).

5.2.1. Acoustics

Instrument-level acoustic tests shall only be performed if indicated by analysis or heritage. While IMPACT contains a number of thin foils, they are mostly identical to foils previously qualified and flown. Some acoustic qualification testing of foils will be performed on ETU units, as indicated in reference 4.

5.2.2. Strength

An analysis will be performed to verify that the instruments meet the instrument design load factors indicated in reference 1, section 3.4.1.1. Sine sweep as indicated in section 5.2 is the only strength testing planned.

5.2.3. Stiffness

A stiffness test shall be performed on the deployed IMPACT boom to verify that it meets the requirements of reference 1, section 3.4.1.2, as well as to verify the boom Finite Element Model results. This test shall consist of a measurement of the boom primary vibrational mode by means of measuring its response to the boom tip being released from a small displacement while the boom spacecraft interface is firmly held.

5.2.4. Self-Induced Shock

Sources of self-induced shock include IMPACT boom actuation and the SIT, SEPT, SWEA, and STE door actuations. These units will be subject to at least two actuations followed by an inspection and performance test to verify no damage has occurred. In the case of the IMPACT Boom this test must be performed with the instruments attached in flight configuration. Due to the difficulty and risk involved in doing the boom deployment with flight instruments attached, this test will only be performed once. An instrumented test of the qualification boom unit indicated that the shock levels are enveloped by the normal vibration test levels.

5.3. **Mass Properties**

Mass, CG, and Moments of Inertia shall be provided to the accuracy stipulated in Reference 1 section 3.4.4. Measurements shall be made where the required accuracy cannot be verified by analysis. Measurements shall be made at the level of assembly that the instruments are attached to the spacecraft.

5.4. **Thermal Vac**

Subassemblies shall be subjected to seven thermal vacuum cycles as called out in reference 1 section 3.2.2, to the temperature limits called out in table 3-1. Thermal modeling shall verify a 10°C margin between these temperatures and predicts (no margin required where maintained by heaters). One cycle shall include un-powered excursion to

the non-op limits to verify survivability and survival thermostat/heater operation. Functional testing shall be included at each operational plateau; the first and last operational cycle shall have comprehensive functional testing (including turn-on), while the intermediate cycles may use a shorter aliveness test. A Cold-start (power-on) test shall be performed at the non-op lower and upper temperature limits, including an aliveness test to verify minimum functionality and power dissipation.

Transition rates shall not exceed 3 degrees C per minute. Dwells at temperature extremes shall last at least 4 hours, with concurrent testing. The IDPU shall be limited at 5C/minute.

Mechanism operation (Boom, doors) shall be verified at least once at each temperature extreme (note that for the boom this is the pre-deployment temperature extreme).

A cryo-pumped chamber shall be used to minimize the risk of contaminating detectors. The chamber and equipment in the chamber shall be cleaned prior to installation of the instrument to avoid cross-contamination. The first thermal cycle will be hot to help in out-gassing the equipment. A hot soak will be added prior to every chamber break to ensure that all parts of the instrument exceed the dew point.

5.5. Thermal Balance

Thermal Balance testing is used to verify thermal modeling results. The test shall simulate interfaces to the spacecraft and to space in a vacuum environment, without requiring accurate simulation such as a solar simulator. The differences between the space environment and the test environment shall be modeled. The instruments shall be in flight configuration for this test, with thermal blankets installed. Bracket mounted instruments shall be tested on their brackets. Boom-mounted instruments shall be tested on brackets that simulate their attachment to the deployed boom. Typically this test is performed as part of the Thermal Vac test. The details of the thermal balance test shall be negotiated with the APL spacecraft thermal engineers to the extent that the test must verify the spacecraft-level thermal modeling also. Note that only one unit of each assembly requires Thermal Balance test.

5.6. Bakeout

The subassemblies shall be cleaned and baked out, and outgassing rates shall be verified by TQCM monitoring per reference 5. Following this step instruments shall be bagged or otherwise maintained in a clean environment to meet the delivery cleanliness requirements called out in reference 5. For instruments with thermal constraints that preclude a high bakeout temperature, those parts of the instrument that can be will be baked out prior to assembly to minimize the final bakeout time.

5.7. Deployment Tests

Flight mechanisms shall be operated a minimum of 6 times prior to delivery to the spacecraft, including at least one operation at each temperature extreme of thermal vacuum tests as indicated in section 5.4.

The IMPACT boom deployment tests shall require an off-load fixture for deployment. Boom deployment tests are currently planned to be made in a vertical configuration. A deployment force test shall be performed to ensure adequate margin. Post-deployment stiffness tests shall ensure that the boom has locked up and meets its stiffness requirement.

Post-deployment temperature survival tests for the boom shall be performed on a representative sample only due to the difficulties of getting something as large as the boom as cold as the post-deployment temperatures. The sample shall include a joint and tube section, and shall be loaded during the test to prove adequate strength is maintained when cold.

5.8. Pressure Profile, Leak Tests

IMPACT has no sealed volumes, and all units are adequately vented, so these tests are not applicable.

5.9. Operating Hours

Operating hours shall be tracked starting at first application of power at the sub-assembly level (IDPU, SWEA/STE-D, STE-U, SEPT-E, SEPT-NS, SIT, HET, LET, SEP-Central). At least 24 hours of trouble-free operation shall be expected prior to integration into the next higher level of assembly. At least 100 hours of trouble-free operation is required before delivery to the spacecraft. Operational hours shall continue to be tracked through launch.

6. Observatory Level Tests

The IMPACT instrument shall support observatory-level environmental tests as required, mostly consisting of performing Comprehensive, Functional, and Aliveness testing of the instrument at appropriate times in the test sequence.

Comprehensive tests require the use of radiation sources close to the spacecraft. The SIT instrument shall have a stimulus box attached for Comprehensive tests, and some minimal switching on the box shall be required during the test. The SIT stimulus box is battery powered and connected only to the instrument. No other connection to the instrument is required.

Early in the test sequence, interfaces with PLASTIC and SWAVES must be verified. PLASTIC will have mated with IMPACT earlier during instrument-level tests, and a normal PLASTIC CPT test will verify correct interaction between PLASTIC and IMPACT. Spacecraft integration will be the first test of the interface between the IMPACT and SWAVES flight units, since communication is via the spacecraft 1553 bus. The SWAVES test will include a stimulus from the SWAVES GSE rack to stimulate SWAVES and MAG simultaneously. This will verify the accuracy of the relative timing of the two systems, as well as their coordination via the RT to RT interface over the spacecraft 1553 bus.

SIT and SWEA high voltage and MCP detectors can be tested only during thermal vacuum tests. Radioactive sources are desired in the chamber to stimulate the detectors during thermal vacuum Comprehensive Performance Tests. The SIT stimulus box will not be used during thermal vacuum tests.

SIT and SWEA have enable/disable plugs for their high voltages. Access to these plugs is required prior to closing the thermal vacuum chamber and prior to encapsulation. At all other times the high voltage will be disabled to avoid accidental damage to the detectors by powering them on in air. In addition, for SWEA, the enable plug must be installed to actuate the SWEA and STE covers (a special plug that only enables cover actuation will be available).

There are component and observatory-level magnetics tests (component magnetic “Sniff test”, observatory swing test, and observatory magnetic (dynamic) characterization). The IMPACT magnetometer will participate in the planning and implementation of these tests.

Actuators shall be tested at least once to verify functionality via the spacecraft interface. In the case of doors, this will require extra bagging and purging to avoid contaminating detectors. An actuator simulator (consisting of one of the same actuators used by the flight hardware) will be provided to allow the spacecraft to test the actuators in a wider variety of configurations without subjecting the flight hardware to repeated tests.

Actuations of the IMPACT boom shall be limited due to the difficulty in configuring the off-load system, as well as the re-stowing of the boom (requires removal of the boom from the spacecraft). It is expected that we will fully deploy the boom at least once for Observatory EMC testing. The boom will deploy horizontally for this test (TBR), and we will walk the boom out. Stands will be required to support the boom in the deployed configuration. A first motion test is expected to be performed earlier in the test sequence, where we fire the actuator but restrain the boom to deploying.

Following Observatory Environmental tests, SWEA and SIT need to be removed for a final inspection and tests. These instruments cannot be operated in air (at least their microchannel plate detectors cannot), and the level of testing that can be performed during spacecraft thermal vacuum tests is very limited. These instruments will be returned to their home institution for about 2 weeks to perform this final verification that the instruments survived observatory tests. Following re-integration a performance test of these instruments will be performed (in air, so no high voltage). STE, HET, LET, and SEPT can be adequately tested on the spacecraft, and so would not need to be removed unless test data indicates a problem. The IMPACT Boom and IDPU also do not need to be removed.