

**TEST and CALIBRATION PLAN for the  
IMAGER for SPRITE and UPPER ATMOSPHERIC LIGHTNING (ISUAL)  
INSTRUMENT**

\_\_UCB Document # 8645-W7-Rev A\_\_

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## **INTRODUCTION**

This document is intended to specify the testing and calibration activities which will be done on the ISUAL prior to delivery to the NSPO. Please see document 8445-w7 for a description of the science and the technology used on the ISUAL.

The ISUAL is a single string instrument which is being developed at the University of California, Berkeley, Space Sciences Laboratory using design methodologies and fabrication techniques developed at the laboratory over the past 30 years. Because the instrument design is based on extensive heritage from past programs, a selected subset only of the designs will be breadboarded, and so testing at the breadboard level will be very limited. We will, however, fabricate a relatively complete Engineering Test Unit (ETU) as well as a complete flight unit and flight level spare modules of selected sensor subassemblies.

The sections below describe in detail all of the testing and calibration procedures which will be performed at each level of assembly, including both those that the ISUAL instrument Project believes are necessary to verify the design and the fabrication, and those which are done to fulfill contractual requirements.

## BREADBOARD LEVEL TESTING

Because the ISUAL has extensive heritage from previous spacecraft instruments developed at the Space Sciences Laboratory, breadboards will be fabricated only for those systems which are substantially changed from those of past programs. These include the Data Processing Unit (DPU), the Data Compression Module (DCM), and the CCD control electronics in the Sprite Imager, the Front End Camera (FEC).

Test plans for each of these items are described in the sections below:

### DPU Breadboard Unit

Description of test article:	The DPU breadboard consists of a copy of the PCB for the IMAGE FUV DPU which has been partially loaded and equipped with added circuitry to conform to the ISUAL circuit design.
Test equipment used:	Oscilloscope, Triple power supply, 8085 Monitor GSE, and the early version of the ISUAL System GSE.
Items verified in test:	Receipt and echo of commands. Generation of SOH including processor parameters and dummy values for the analog multiplexor. Generation of dummy science data output. Limited demonstration of instrument control functions.
Documentation Method:	Laboratory notebook.

### DCM Breadboard Unit

Description of test article:	TBD
Test equipment used:	Laboratory power supplies, Logic analyzer, DCM dedicated GSE, Oscilloscope.
Items verified in test:	Power consumption. Compression of test files. Speed. Interface parameters.
Documentation Method:	Laboratory notebook.

### Sprite Imager FEC assembly

Description of test article:	Breadboard system is comprised of copies of four boards from the IMAGE WIC camera along with a vector board version of the ISUAL CCD board, and with cut traces and modifications to adapt the circuit to the Dalsa CCD.
Test equipment used:	Triple power supplies, oscilloscope, dedicated FEC GSE based on a PC with a Dalsa CCD interface board and a custom adapter circuit.
Items verified in test:	Power consumption. Image resolution. Interface parameters
Documentation Method:	Laboratory notebook.

## ETU LEVEL TESTING

An Engineering Test Unit (ETU) of the entire ISUAL system will be built with the exception of the Spectrophotometer which will have only two of the six photometer modules installed. Testing on the ETU will include subsystem level tests done at the board and component level, and functional testing done at the level of the fully integrated system. A selected subset of environmental tests will also be done at the component level. The outline below describes all tests which will be performed.

### ETU Subsystem Level Testing

#### Low Voltage Power Supply (LVPS) functional test

Description of test article:	LVPS ETU PCB mounted in frame with control board and Modular devices DC-DC converter modules.
Test equipment used:	28 volt bench power supply, Oscilloscope, Current Probe, custom LVPS test panel with plug in load resistors, adjustable power resistor box, temperature probe, four Fluke 85 DMM's.
Items verified in test:	Regulation of +5 and +/- 12 volt supplies with load and line variations. Calibration of output voltages. Operation of POR circuit. Operation of AP power control relays. Operation of redundancy circuit. Operation of LVPS thermistors. Temperature rise of MDI modules under maximum power output.
Documentation Method:	Laboratory notebook.

#### Power Controller with LVPS functional test:

Description of test article:	Test LVPS ETU with ETU Power Controller mated to it.
Test equipment used:	28 volt bench power supply, Oscilloscope, Current Probe, adjustable power resistor box, temperature probe, and four Fluke 85 DMM's. Also a custom PC test panel with plug in load resistors and switches which send commands to PC Actel and an LED display of the analog multiplexor outputs.
Items verified in test:	Operation of power switches. Current limiting characteristics of each power service. Analog multiplexor addressing. Calibration of voltage and current monitors. Thermistor operation. Temperature rise on power switches under maximum power dissipation conditions.
Documentation Method:	Laboratory notebook.

#### ETU DPU Board

Description of test article:	DPU ETU Board
Test equipment used:	Oscilloscope, Triple power supply, logic analyzer, processor test pod, 8085 Monitor GSE, and the ISUAL System GSE.
Items verified in test:	Receipt and echo of commands.

Generation of SOH including processor parameters and dummy values for the analog multiplexor.  
Generation of dummy science data output.  
Limited demonstration of instrument control functions.

Documentation Method: Laboratory notebook.

#### Integrated ETU AEP – Power System and DPU

Description of test article: LVPS, PC, and DPU boards stacked together.

Test equipment used: Oscilloscope, 28 volt bench power supply, logic analyzer, processor test pod, 8085 Monitor GSE, and the ISUAL System GSE.

Items verified in test: Receipt and echo of commands.  
Generation of SOH including processor parameters and dummy values for the analog multiplexor.  
Generation of dummy science data output.  
Limited demonstration of instrument control functions.

Documentation Method: Laboratory notebook.

#### Integrated ETU AEP with MM – Power System, DPU, and Mass Memory Board

Description of test article: LVPS, PC, DPU, and MM boards stacked together.

Test equipment used: Oscilloscope, 28 volt bench power supply, logic analyzer, processor test pod, 8085 Monitor GSE, and the ISUAL System GSE.

Items verified in test: Read and write all portions of memory from DPU.  
Oscilloscope verification of bus timing.  
Verify operation of DCM, SI, SP, and AP interfaces (how to do this?)  
Verify operation of arbitration circuit. Try to cause bus conflicts and data loss.

Documentation Method: Laboratory notebook.

#### Integrated AEP with Sensor Interface Board

Description of test article: LVPS, PC, DPU, MM, and Sensor Interface boards stacked together.

Test equipment used: Dummy DCM board, Oscilloscope, 28 volt bench power supply, logic analyzer, processor test pod, 8085 Monitor GSE, and the ISUAL System GSE.

Items verified in test: Repeat Mass Memory tests.  
Oscilloscope verification of bus timing.  
Verify operation of arbitration circuit. Try to cause bus conflicts and data loss.  
Pump dummy data from the three sensor interfaces into the MM.

Check operation of sensor power services. Check voltage of +5 bus at sensor circuits.

Check operation of CDI commands to sensor interfaces.

Commanding of B/B or ETU FEC.

Receipt of data from FEC.

Measure Sensor Interface Board power consumption.

Exercise SP interface circuits.

What can we test on the AP interface?

Documentation Method: Laboratory notebook.

Integrated AEP with DCM Board  
Description of test article:

LVPS, PC, DPU, MM, and DCM boards stacked together. No Sensor Interface Board.

Test equipment used: Oscilloscope, 28 volt bench power supply, logic analyzer, processor test pod, 8085 Monitor GSE, DCM test pod with DCM GSE, and the ISUAL System GSE.

Items verified in test: DCM power consumption.  
DCM / MM interface operation.  
CDI commands to DCM.  
Proper DCM handling of commands.  
Operation of DCM on simulated data files loaded into Mass Memory.

Documentation Method: Laboratory notebook.

Sprite Imager ETU High Voltage Power Supply functional test (done on two units)

Description of test article: ETU HVPS fully assembled in metal case with all staking and potting completed.

Test equipment used: +12 volt bench supply, HVPS test panel, 1000:1 HV divider box, Fluke 85 DMM, and oscilloscope.

Items verified in test: Power consumption.  
Input short circuit protection.  
Output short circuit protection.  
Gain from Vc to output.  
Voltage and current monitors.  
Thermistor operation.

Documentation Method: Laboratory notebook.

Spectrophotometer ETU High Voltage Power Supply functional test (done on 2 or 3 units)

Description of test article: ETU HVPS fully assembled on PCB with all staking and potting completed.

Test equipment used: +12 volt bench supply, ETU of HV common board, HVPS test panel, 1000:1 HV divider box, Fluke 85 DMM, and oscilloscope.

Items verified in test: Power consumption.

Input short circuit protection.  
Output short circuit protection.  
Gain from Vc to output.  
Voltage and current monitors.  
Thermistor operation.

Documentation Method: Laboratory notebook.

Photo Multiplier Tube Testing  
Description of test article:

Potted or unpotted PM tubes as delivered by vendor.

Test equipment used: Optics measurement test set up including:  
Calibrated light source.  
Monochrometer.  
Calibrated photodiode.  
Keithley Electrometer.  
Bench high voltage supply.

Items verified in test: PM tube power consumption.  
PM tube gain vs applied voltage measurement.  
PM tube gain vs wave length of input light.  
Use flashed LED to measure time response.

Documentation Method: Laboratory notebook.

Integrated Photometer Module Testing  
Description of test article:

Assembled Photometer Modules including PM tube, filter and heater, lens, aperture disk, stimulation LED, and HV and signal connectors.

Test equipment used: Optics measurement test set up including:  
Calibrated light source.  
Monochrometer.  
Calibrated photodiode.  
Keithley Electrometer.  
Bench high voltage supply.  
Bench +12 volt power supply.  
Fluke 85 DMM.

Items verified in test: Heater and thermistor operation.  
Photometer gain vs wave length of input light.  
Map input spatial response.  
Use flashed LED to measure time response.

Documentation Method: Laboratory notebook.

Spectrophotometer circuit board  
Description of test article:

Fully loaded PCB with all connectors.

Test equipment used: Triple bench power supply, pulse generator, oscilloscope, Fluke 85 DMM,

Items verified in test: Heater control switches.  
Preamplifier response.  
Power consumption.

Documentation Method: Laboratory notebook

Sprite Imager electrical system

Description of test article: SI electrical board, Day Sensor assembly, and Filter Wheel Position Sensor assembly.

Test equipment used: Triple power supply, Fluke 85 DMM, pulse generator, calibrated light source, and oscilloscope.

Items verified in test: Verify operation of:  
250 volt power converter.  
Photocathode bias switch.  
Stepper motor driver circuit.  
Filter wheel position indicator.  
Continuity of heater circuits.  
Thermistors.

Documentation Method: Laboratory notebook.

**ETU Component Level Testing**

Fully integrated AEP Functional Test

Description of test article: LVPS, PC, DPU, MM, DCM, and Sensor Interface boards stacked together. (This is the complete AEP).

Test equipment used: AEP test harnesses (for separating boards), Oscilloscope, 28 volt bench power supply, logic analyzer, processor test pod, 8085 Monitor GSE, DCM test pod with DCM GSE, and the ISUAL System GSE.

Items verified in test: Repeat all Mass Memory tests.  
Oscilloscope verification of bus timing.  
Verify operation of arbitration circuit. Try to cause bus conflicts and data loss.  
Pump dummy data from the three sensor interfaces into the Mass Memory.  
Operation of DCM on simulated data files loaded into Mass Memory.  
Check voltage of all power busses.  
Commanding of B/B or ETU FEC.  
Receipt of data from FEC.  
Exercise SP interface circuits.  
Repeat any test of the AP interface.

Documentation Method: Laboratory notebook.

Integrated ETU Sprite Imager assembly

Description of test article: Fully integrated Sprite Imager with Filter Wheel assembly, Lens assembly, Intensifier, TEC, Day Sensor, FEC assembly, and Electrical board.



Test equipment used: Triple power supplies, oscilloscope, dedicated FEC GSE based on a PC with a Dalsa CCD interface board and a custom adapter circuit. Fluke 85 DMM, pulse generator, calibrated light source, oscilloscope, and the ETU DPU system with the ISUAL System GSE.

Items verified in test: Operation of intensifier with switched bias on photocathode.  
Reading and setting position of filter wheel.  
Operation of TEC.  
Operation of filter, lens, and body heaters.  
Operation of CCD, TEC, Lens, Stepper motor, and body thermistors.  
Operation of CCD.  
Measure image resolution.  
Test photocathode switching with flashing LED.  
Verify bandpass of the six filter positions

Documentation Method: Laboratory notebook.

#### Integrated Spectrophotometer Assembly

Description of test article: Fully assembled ETU SP unit with two photometer modules, and four dummy photometer modules.

Test equipment used: ETU AEP with system GSE, oscilloscope, Fluke 85 DMM, HV test panel to run HVPS's, Optics measurement test set up including:  
Calibrated light source.  
Monochromator.  
Calibrated photodiode.  
Keithley Electrometer.

Items verified in test: Total power consumption.  
Optical transfer function at a couple of wavelengths.  
Filter heater operation.  
Body heater operation.  
Continuity test on all monitor circuits.

Documentation Method: Laboratory notebook.

#### ETU Component Level Environmental Testing

##### Filter Wheel Life Test

Description of test article: First ETU Filter Wheel assembly

Test equipment used: Small thermal vacuum chamber. Custom wheel test panel.

Items verified in test: Wheel is run at a rate of one move every 15 seconds for a period of 6 months. Temperature is cycled between -40 and +60 degrees C.

Documentation Method: Laboratory notebook.

##### Sprite Imager and Spectrophotometer ETU vibration test

Description of test article: ETU Sprite Imager assembly and ETU Spectrophotometer.

Test equipment used: Outside vendor vibration test facility

Items verified in test: Units are subjected to qualification level vibration and shock. Further functional testing verifies that units are still working.

Documentation Method: Laboratory notebook.

ETU system thermal vacuum test  
Description of test article:

ETU Sprite Imager, ETU Spectrophotometer, and AEP.

Test equipment used: Room 320d thermal vacuum chamber.  
AEP LVPS and DCM DSP are instrumented with thermistors. SP has LED in field of view. Imager is focused on target outside of chamber.

Items verified in test: System is given one cycle over qualification temperature range. Temperature rise of DSP and LVPS is measured. Focus of Imager and detector operation in both Imager and SP are verified over the temperature range.

Documentation Method: Laboratory notebook.

### **ETU System Test**

Description of test article: ETU Sprite Imager, ETU Spectrophotometer, ETU AP and ETU AEP.

Test equipment used: ISUAL bench in room 333.  
ISUAL System GSE with integrated 28 volt power supply.  
Light sources to stimulate SI, SP, and AP.  
Oscilloscope and logic analyzer.  
AEP break out cables.

Items verified in test: AEP must have a complete set of instrument software for this test.  
Power consumption in all operating modes.  
Timing on interfaces between AEP and AI, SP, and AP.  
Timing on interface between AEP and GSE.  
Operation of all thermistors.  
Operation of power system monitors (by using hardware perturbation of actual values).  
Exercise of stim pulsers in SI and SP.  
Stimulation of SI, SP, and AP with external light source.  
Display of all engineering data.  
Display of SI images.  
Display of SP and AP data.  
Operation of DCM on science data that were collected.

Documentation Method: Formal procedure and test report.

## FLIGHT UNIT LEVEL TESTING

### Printed Circuit Board Thermal Cycling Test

Description of test article: This test will be done following the assembly but prior to conformal coating on all PCB assemblies in the ISUAL including:

- AEP LVPS assembly
- AEP Power Controller Board
- AEP DPU Board
- AEP Mass Memory Board
- AEP DCM Board
- AEP Sensor Interface Board
- SI Electrical Board
- FEC Connector Board
- FEC Digital Board
- FEC Driver Board
- FEC Bias Board
- FEC Analog Board
- FEC CCD Board
- SI 6000V HVPS (2 used)
- SP Analog & Interface Board
- SP 3000V HVPS (6 used)

Test equipment used: Tenny Jr. Thermal Chamber

Items verified in test: This test will be done on one or more units at a time. Boards will be bagged and purged with LN2 boil-off and the assembly placed inside the chamber. Units will not be powered. A single thermocouple will be taped to the board which is closest to the center of the group if multiple boards are processed in on operation. The assembly will be subjected to 8 thermal cycles between -30 degrees C. and +55 degrees C. A one hour dwell (with the temperature read from the thermocouple) will be maintained at each temperature extreme.

Documentation Method: Laboratory Notebook

### Flight PCB's Functional Testing

Description of test article: This test will be done following Thermal Cycling on each of the PCB assemblies listed above

Test equipment used: ETU System hardware test set-up used in the ETU System Test described above.  
Fully functional ISUAL System GSE.  
Break-out cables, oscilloscope, logic analyzer, and light sources as required.

Items verified in test: This test will consist in installing the DUT into the ETU system referred to above and then running those portions of the ETU System Test which could be affected by the item under test.

Documentation Method: Laboratory Notebook

## Flight Component Level Functional Testing

### Associated Electronics Package Functional Test

Description of test article:	Fully assembled Flight AEP
Test equipment used:	ETU System hardware test set-up used in the ETU System Test. Fully functional ISUAL System GSE. Light sources as required.
Items verified in test:	This test will consist in installing the DUT into the ETU system referred to above and then running all portions of the ETU System Test which do not require disassembly or probing of the DUT.
Documentation Method:	Laboratory Notebook

### Sprite Imager Functional Test

Description of test article:	Fully assembled Flight Sprite Imager
Test equipment used:	ETU System hardware test set-up used in the ETU System Test. Fully functional ISUAL System GSE. Light sources as required.
Items verified in test:	This test will consist in installing the Flight Imager into the ETU hardware system and then running all portions of the ETU System Test which concern the operation of the Sprite Imager.
Documentation Method:	Laboratory Notebook

### Spectrophotometer Functional Test

Description of test article:	Fully assembled Flight Spectrophotometer
Test equipment used:	ETU System hardware test set-up used in the ETU System Test. Fully functional ISUAL System GSE. Light sources as required.
Items verified in test:	This test will consist in installing the Flight Spectrophotometer into the ETU hardware system and then running all portions of the ETU System Test which concern the operation of the Spectrophotometer.
Documentation Method:	Laboratory Notebook

## Flight System Level Functional Test

Description of test article:	Fully assembled ISUAL Flight instrument including the AEP, the SI, the SP, and the AP.
Test equipment used:	Fully functional ISUAL System GSE. Light sources as required.

Items verified in test: This test will consist in running all portions of the ETU System Test which do not require disassembly or probing of the DUT.

Documentation Method: Laboratory Notebook

### **Flight Level Environmental Testing**

#### Vibration and shock testing

Description of test article: This test will be done on each of the fully assembled ISUAL Flight components including the AEP, the SI, the SP, and the AP.

Test equipment used: Local vendor vibration test facility

Items verified in test: Vibration and shock testing will be done as specified in the ISUAL Instrument ICD, Astrium Document Number RS2SC-CDRL-029b.

Documentation Method: Formal test procedure and report.

#### Flight System Thermal Vacuum Test

Description of test article: This test will be done on the fully assembled ISUAL Flight instrument including the AEP, the SI, the SP, and the AP.

Test equipment used: SSL room 20 thermal vacuum test chamber.  
Light sources as required.  
Fully functional ISUAL System GSE

Items verified in test: This test will consist in performing thermal cycling under vacuum as described in the ISUAL Instrument ICD, Astrium Document Number RS2SC-CDRL-029b. A total of 8 cycles will be run with the temperature cycled between -30 and + 50 degrees C. The system will be held for four hours at each of the high and low temperature extremes. A reduced version of the Flight System Functional test will be run during at least 4 of the high and 4 of the low temperature dwells.

Documentation Method: Formal test procedure and report.