Swift Observatory Space Simulation Testing

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The Swift Observatory is a Middle-Class Explorer (MIDEX) mission that is a rapidly re-pointing spacecraft with immediate data distribution capability to the astronomical community. Its primary objectives are to characterize and determine the origin of Gamma Ray Bursts (GRBs) and to use the collected data on GRB phenomena in order to probe the universe and gain insight into the physics of black hole formation and early universe. The main components of the spacecraft are the Burst Alert Telescope (BAT), Ultraviolet and Optical Telescope (UVOT), X-Ray Telescope (XRT), and Optical Bench (OB) instruments coupled with the Swift spacecraft (S/C) bus. The Swift Observatory will be tested at the Space Environment Simulation (SES) chamber at the Goddard Space Flight Center from May to June 2004 in order to characterize its thermal behavior in a vacuum environment.

In order to simulate the independent thermal zones required by the BAT, XRT, UVOT, and OB instruments, the spacecraft is mounted on a chariot structure capable of maintaining adiabatic interfaces and enclosed in a modified, four section MSX fixture in order to accommodate the strategic placement of seven cryopanels (on four circuits), four heater panels, and a radiation source burst simulator mechanism. There are additionally 55 heater circuits on the spacecraft. To mitigate possible migration of silicone contaminants from BAT to the XRT and UVOT instruments, a contamination enclosure is to be fabricated around the BAT at the uppermost section of the MSX fixture.

This paper discusses the test requirements and implemented thermal vacuum test configuration for the Swift Observatory.
Swift Observatory
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Agenda

- Gamma Ray Burst (GRB) Science History
- Swift Mission
- Test Requirements, and Configuration
- Lessons Learned
Gamma Ray Burst Science History

- 1967: Military satellite detection
- 1991-2000: Compton Gamma Ray Observatory
  - Burst and Transient Source Experiment (BATSE)
- 1997: BeppoSAX
BATSE GRB Detection Sites

2704 BATSE Gamma-Ray Bursts
Swift Mission - Overview

- Medium Class Explorer (MIDEX) mission
  - Burst Alert Telescope (BAT)
  - X-Ray Telescope (XRT)
  - Ultraviolet Optical Telescope (UVOT)
Swift Observatory
BAT Capabilities

- Large FOV instrument
- Burst detection through coded aperture mask
- Modes: Burst and Survey
  - Determine critical GRB triggers
  - Relay 1-4 arcmin. position within 15 sec.
  - Hard X-ray survey
BAT Instrument
BAT (on Observatory)
XRT

- Focusing X-Ray telescope
- Three readout modes: Imaging, Timing, and Photon-counting
- 5 arcsec. accuracy within 10 sec.
XRT Instrument

- XRT
- Electronics Box
- Radiator
- Other Swift Science Instruments
XRT (Instrument TV Configuration)
UVOT

- Based on X-ray MM-Newton Optical Monitor
- Simultaneous UV and optical measurement
- Photon counting detectors
UVOT (Instrument TV Configuration)
UVOT (on Observatory)
Test Requirements

- Deep space environment
- Ability to simulate gamma ray burst
- Light-tightness during UVOT testing
- Maintain 0.1 degree orientation tilt on BAT
- Maintain cleanliness level of instruments
Test Objectives (1/3)

- Mission Simulations
- Optical Bench (OB) Cycling
- Instrument
  - UVOT Door Module (DM)-Cold Survival
  - UVOT Detector Electronics Modules (DEM)s - TV Cycling, Hot/Cold Operational TB
  - UVOT High Voltage Test
Test Objectives (2/3)

- Instrument (cont.)
  - BAT Image Processors (IPs) - TV Cycles, Hot/Cold TB
  - BAT Power Control Box (PCB) - TV Cycles
  - BAT Detector Array - TV Cycles
Test Objectives (3/3)

- Instrument (cont.)
  - XRT Telescope Door-Cold Survival Balance
  - XRT Power-up and Venting
  - XRT Heater-Induced Deflection Test
  - XRT Heat Rejection System (HRS) Testing
  - XRT Light Leak Test
  - XRT FPCA Camera Door Opening Test
  - XRT Hot Pixel Measurement
  - XEP Cycling
**Thermal Profile**

- Pre-TV Aliveness Test (1.91)
- Power up SC in Launch Config (1.11)
- Cool Down & Power up Observatory and Config (1.12)
- Open XRT FPCA Vent per SIM 1B (L&EO Procedure)
- Transition - SIM 2B Cont (1.42)
- Transition (1.2)
- HOT TB - Prim Side (1.3)
- XRT Heater Induced Deflection and TAM Alignment Chks
- HOT TB - Mission Mode - Mission Ops SIM 2B (1.41)

**NOTE**
- * Pre and Post TV AIST and OITL Tests will be performed in the SCA to facilitate testing.
- ** Denotes that Observatory not powered OFF after AIST
- Cold TB (1.7)
- XRT TAM Alignment Chks
- XRT HRS Test - Cold (4.3)
- OITL Continued (4.5)
- XRT FPCA Door Open Test
- XRT Light Leak Test
- Post TV Aliveness Test at Ambient (4.8)
- Close FPCA Door and UVOT HV Test (4.7)

**Hot Start A-Side**
- BAT - AIST Pwr Up
- UVOT - AIST Pwr Up
- XRT - Recovery Pwr Up

**Hot Start B-Side**
- BAT - AIST Pwr Up
- UVOT - AIST Pwr Up
- XRT - AIST Pwr Up

**Cold Survival Balance/Heater Triggering (1.81)**
- UVOT - Door and DEMs
- XRT Door
- BAT - IPE
- OB - Survival Heaters
- SC Bus - ST, IRU

**Cool Down & Power up Observatory and Config (1.12)**

**Close FPCA Door and UVOT HV Test (4.7)**

**XRT Door**
- BAT - AIST Pwr Up
- UVOT - AIST Pwr Up
- XRT - AIST Pwr Up

**XRT HRS Test - Cold (4.3)**
- OITL Continued (4.5)
- XRT FPCA Door Open Test
- XRT Light Leak Test
- Post TV Aliveness Test at Ambient (4.8)
- Close FPCA Door and UVOT HV Test (4.7)
Test Setup

- 384 T/Cs and 57 Silicone Diode channels
- 68 Heater ckts (7 ZQ channels)
- 7 Cryopanels on 4 TCUs
- 3 Cryopanels on LN2 ckts (w/heaters or bucking plates)
- 5 TQCMs
- 4 Scavenger Plates
- Contamination Enclosure
Test Configuration (1/2)
Test Configuration (2/2)
Test Configuration - Plan View
Lessons Learned

- Design allowance >6 in.
- Design for increased heat load in vacuum (90W. $\Delta \Delta 80^\circ$C).
- Negligible difference in thermal loss between applied heaters and bucking plates on cryopanels.
- LN2 line losses of 10-30°C.
- Zero-Q method on pre-existing chariot titanium block interface not commutable to Swift setup.
Swift Observatory Status