Space Active Modular Materials ExperimentS
(SAMMES)

Low Earth Orbital Mission aboard the
Space Test Experiments Platform (STEP-3)

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SAMMES/STEP-3 Overview

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SAMMIES/STEP-3 Team

Program Manager: Lt. Col. Michael Obal, USAF (SDIO/TNI)

Principal Investigator: David Brinza (Jet Propulsion Laboratory)

Experiment Support Group: John Durrett, Leader (W.J. Schafer Associates)
Graham Arnold (Aerospace Corp.)
Michael Robyn (Aerospace Corp.)
Robert Kraus (W.J. Schafer Associates)

Prime Contractor: Physical Sciences, Inc.
Program Manager: Vic DiCristina
Project Engineer: Prakash Joshi

Major Sub-Contractors:
Test Modules: Research Support Instruments, Inc.
System Control Module: Northeastern University
Environmental Test: Fairchild Space Co.

STEP-3 Mission Manager: Lt. Janet Mayer, USAF (SMC/CUL)

STEP-3 Experiment Integrator: Douglas Wille (TRW)
SAMMIES System Architecture

- Autonomous Modular System
  - System Control Module
  - Distributed Test Modules
  - Internal MIL-STD-1553 Communications Bus

- Spacecraft Interface Adaptability
  - Host 1553, RS-232, RS-422 Standard Interfaces
  - TM Operations Controlled by SCM
  - Data Storage (8 Mbyte) Within SCM

- Flight Experiment Flexibility
  - Up to 8 Test Modules Controlled by SCM
  - Data Acquisition Asynchronous to Spacecraft Operations
  - On-board Data Processing Capability
  - Uplinkable Code for Operations and Data Processing

- STEP-3 Configuration
  - One System Control Module and Five Test Modules
    - LEO Environment Monitor Module, Ram/Wake Calorimeter Modules,
    - TQCM/Actinometer Module and Solar Photovoltaic Module
SAMMIES System Architecture

S/C ← System Control Module → Other Modules

- LEO Environment Monitor Module
- TQCM/Actinometer Module
- Calorimeter Module
- Solar Photovoltaic Module

MIL-STD-1553B

- TQCM Radiator
- Calorimeter
- TQCM
- Sun Position Sensor
- Actinometer
- Solar Cell
- Photodiode
SAMMIES System Control Module

- **Electronic Design**
  - **Host Microcontroller**
    - S/C Commands, Data Transfer
  - **TM Microcontroller**
    - TM Operations, Data Acquisition
- **Program Memory**
  - 128 kByte + 16 kByte Dual Port
- **Data Memory**
  - 1 MByte EEPROM, 7 Mbyte DRAM (battery back-up)
- **Communications**
  - SCM/TM: MIL-STD-1553B
- **Power Management**
  - Auto-quiescent Mode, Conditioning, Heaters
- **Health and Status**
  - Temperatures, Microcontroller Status

- **Mechanical**
  - **Dimensions:** 7.875" x 7.500" x 6.063"
  - **Weight:** 4.71 kg (Mg), 6.08 kg (Al)
SAMMES Test Module (Typical)

- Architecture
  - Microcontroller
    - SCM Commands, Experiment Control, Data Transfer
  - Analog Signal Conditioning & ADC
  - Sensor Temperature Measurement and Control
  - Sensors
    - Temperature-Controlled Quartz Crystal Microbalances
    - Temperature-Controllable Reichard-Triolo Calorimeters
    - Temperature-Controlled Atomic Oxygen Actinometers
    - RADFET Total Radiation Dose Monitors
    - Sun Position Sensors, Photodiodes
    - Solar Photovoltaic I-V Diagnostics
    - Temperature Sensors (PRT & AD590)
- Operational Modes
  - Quiescent Mode: Maintain Specimen Temperatures
  - Acquisition Mode: Sensor Sampling, Temperature Control
- Mechanical
  - Dimensions: 6.500" x 6.000" x 5.500" (excluding radiators)
  - Weight: 2.5 - 3.2 kg
SAMMES on STEP-3

- Test Module Configuration on STEP-3 Vehicle

- Solar Photovoltaic Module
- LEO Environment Monitor
- Ram Calorimeter Module
- TQCM/Actinometer Module
- Wake Calorimeter Module
- System Control Module (Internal)
SAMMES/STEP-3 Mission Objectives

- Assess LEO Space Environmental Effects on SDIO Materials
  - Performance (a/e) of Thermal Control Materials (Ram/Wake)
  - Durability of Optical, Thermal Control, Protective Coatings
  - Performance of Advanced Solar Photovoltaics

- Quantify Orbital and Local Environments
  - Measure Atomic Oxygen Flux and Fluence
  - Assess Contaminant Accretion, Species ID, and Effects
  - Determine Sun Angle, Earth Albedo and Irradiance
  - Measure Total Radiation Dose

- Demonstrate Modular Experiment Concept
  - Autonomous Operations
  - Internal Power Management
  - Uplink Operational and Data Processing Code
SAMMES/STEP-3 Mission Requirements

- Orbit Parameters, Mission Duration
  - LEO Circular Orbit (~500km)
  - Ram and Wake Exposure Environments
  - 1-Year Minimum, 3-Year Goal

- Data Integrity and Validation
  - Material Pedigree
  - Contamination Control
  - Complete Environmental History (Early Mission Phase)
  - Test Material Temperature Control/Knowledge
  - Benchmark Material Performance

- SAMMMS/STEP-3 System Requirements
  - System Mass: < 25 kg
  - System Power:
    - Peak (Operating): < 30 W
    - Average (Quiescent): < 20 W
  - Data (average) < 1 Mbyte/day
SAMMES/STEP-3 Orbital Operations

- Early Operations (Insertion --> Post-Checkout)
  - Power-up SAMMES, Early Operations Initiate Command
  - Verify SCM Status (if not operating, recycle power & initiate)
  - Activate Specimen Heaters
  - Autonomous SAMMES Operation:
    Sample and Store Data from Selected Sensors (up to 8 Mbyte)
    Power: ~28 W (Power-fault tolerant)
  - Downlink up to 8 Mbyte Data at end of Check-out Phase

- Nominal Operations
  - Initiate Normal Operations Command (once per day)
  - Autonomous Operation:
    Deactivate Calorimeter Heaters, Stabilize (2 orbits @ ~15W)
    Acquire Sensor Data (1.1 orbits @ ~28 W)
    Transfer Data to S/C Onboard Storage
    Re-activate Calorimeter Heaters
    Return to Quiescent Mode (12 orbits @ ~18W)
    Downlink ~1Mbyte Data

- Special Operations
  - Thermo-Gravometric Analysis (QCM’s), Etc. (TBD)
SAMMES Data Analysis & Dissemination

- **Time-Variant Sensor Data**
  - Full Orbital Temperature Profiles for Calorimeters
  - Frequency/Temperature Data for TQCMs
  - Resistance Measurements for Actinometers and Radiation Monitor
  - I-V and Temperature Data for Solar Photovoltaics
  - Current Measurements for Sun Sensors, Photodiodes

- **Data Conversion and Analyses**
  - Conversion to Engineering Units
  - Calibration Factors
  - Analysis Algorithms
  - Contamination Effects Assessment

- **Data Dissemination**
  - SDIO SEE Database
  - Interim and Final Reports
  - Workshops, Conferences and Publications
SAMMIES Enhancements

- Test Module Autonomy
  - Eliminate Need for System Control Module
  - Expanded TM Data and Program Memory
  - MIL-STD-1553 (Option for: RS-422, RS-232)

- Test Module Miniaturization and Hardening
  - ASIC, Hybrid Circuitry
  - Extensively Remoted Sensors
  - Radiation Hardening via Spot Shielding, Parts Selection

- Expanded Sensor Suite
  - Optical Properties Monitoring
  - Micrometeoroid and Debris Impact Sensing
  - Proton Spectrometer
SAMMES Health Monitor Applications

- General Spacecraft Engineering Data
  - Temperature Monitoring
  - Accelerations, Structural Deformations
  - Power System Monitoring
    - Solar Array Diagnosis
    - Battery Charge Rates

- Orbital Environment Monitoring
  - Atomic Oxygen Flux
  - Internal Radiation Dosage
  - Debris Cloud Detection

- Payload and Mission Specific Monitoring
  - Contamination Events and Effects
  - Optical System Diagnosis
  - Solar Exclusion Monitor (Safing)
SAMMIES Potential Flights

- SDIO TECHSAT
  - Low Earth Orbital Mission
  - Mid-altitude Earth Orbital Mission

- SDIO Testbed and Demonstration Vehicles
  - Brilliant Pebbles Orbital Flight Test Vehicles
  - Brilliant Eyes Dem/Val Spacecraft

- SDIO Operational Spacecraft
  - Brilliant Eyes
  - Brilliant Pebbles

- Other Satellites and Platforms
  - Space Station Freedom and Free-Flyers
  - DoD Spacecraft
  - Civil Spacecraft (NASA, NOAA, Commercial)