Space Dynamics LABORATORY
Utah State University Research Foundation

Integrated CubeSat Test Facility for Precision Pointing and Power Generation

Steve Wassom, Quinn Young, Lynn Chidester, Rees Fullmer, Mitch Whiteley,
Robert Burt, Mike Watson, Bryan Bingham, Keegan Ryan

7th Annual CubeSat Developers' Workshop
Cal Poly San Luis Obispo
21-23 April 2010

Introduction

- Motivation
  - Requirements-based missions need pre-mission verification
  - Current industrial verification base is for larger spacecraft
  - CubeSats need novel approaches due to small disturbance torques
- Goal
  - Provide verification capability to enable requirements-based missions
  - Make test facility available to community
- Implementation
  - Class 1 and Class 2 spacecraft up to 10 kg (see table below)
  - Upgrades to follow as required

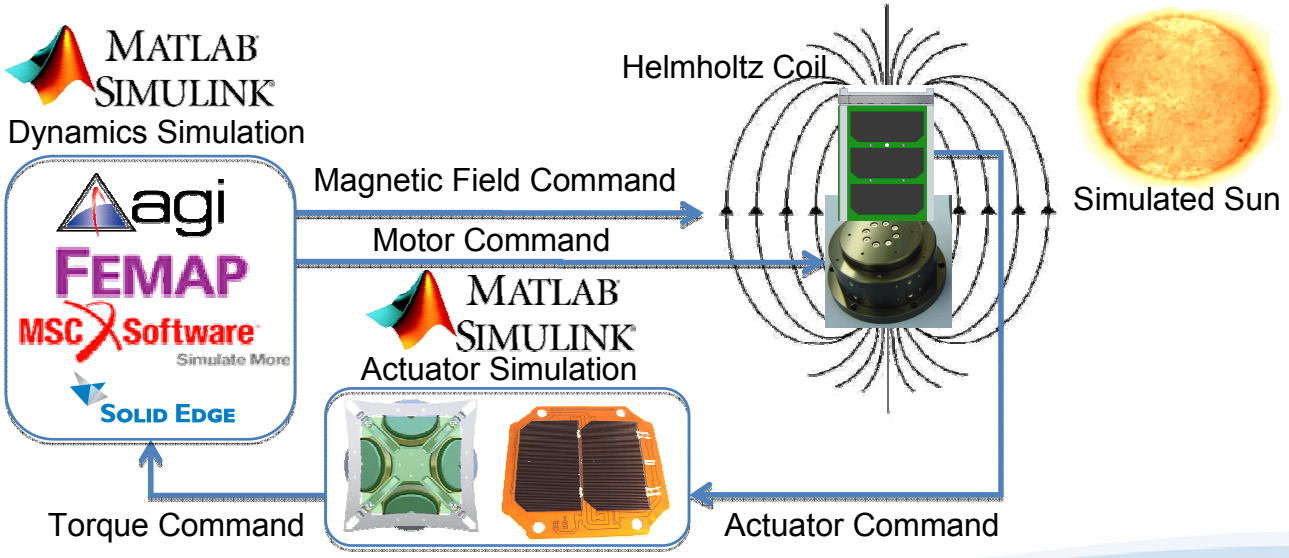
Class	Descriptive Feature	Typical Knowledge Accuracy	Typical Control Accuracy
1	Spinning	1°	5°
2	Sun/Mag	0.2°	0.2°
3	Star Tracker	0.01°	0.02°

Overview

- Internally funded project
- Phase 1 complete August 2010
- Focus for Phase 1
  - Class 1 and Class 2 spacecraft
  - Verification of attitude control components
  - Verification of mass properties
  - End-to-end verification of power subsystem
  - End-to-end verification of attitude control subsystem
  - End-to-end system test

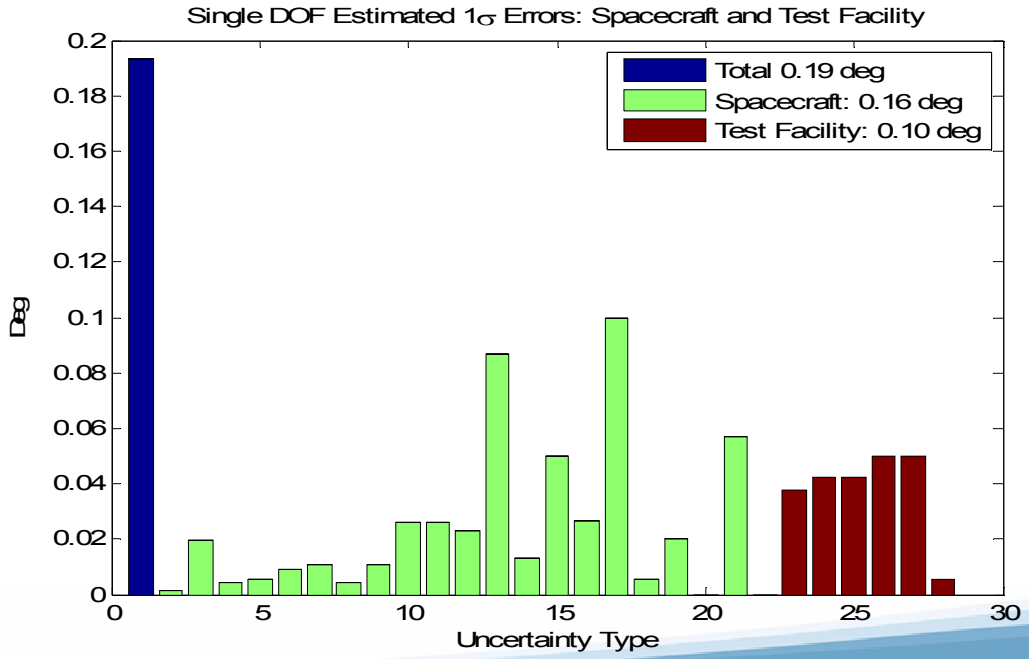
System Level Testing

- Purpose
  - End-to-end system testing and verification
- Capability
  - Flat-sat (real-time-model-based) avionics and flight software verification
  - End-to-end attitude control verification
  - Assembled spacecraft independent operation and verification



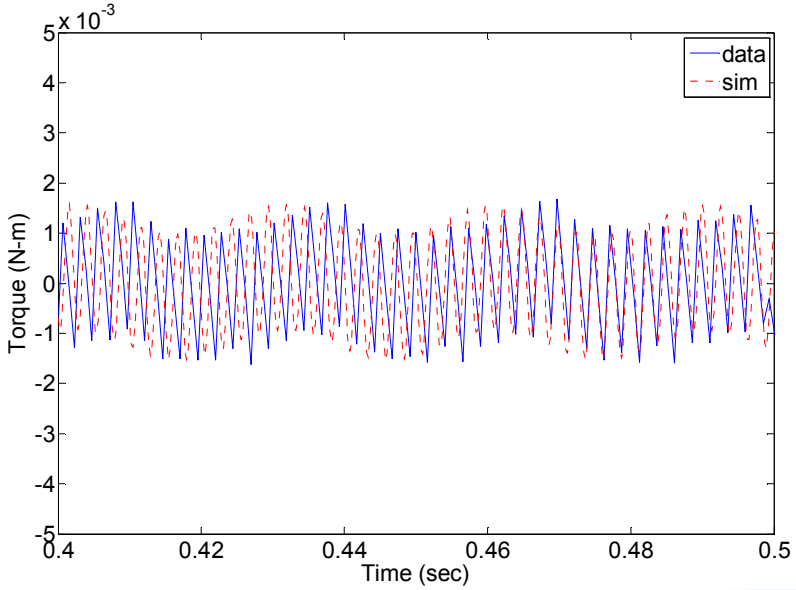
System Level Attitude Control Verification

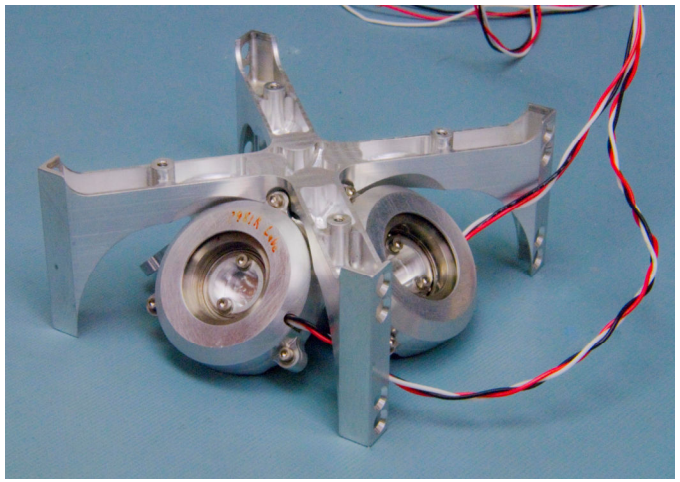
- Single-axis testing uses air bearing and encoder
- Three-axis testing uses real-time simulation and hardware-in-the-loop
- Predicted accuracy < 0.2°
- Class 3 upgrades will include Stewart platform, star simulator



Reaction Wheel Testing

- Purpose
  - Characterization of reaction wheels or similar components
- Capability
  - High-precision measurement of wheel speed
  - Analytical (model-based) and empirical determination of torque
  - Characterization of jitter





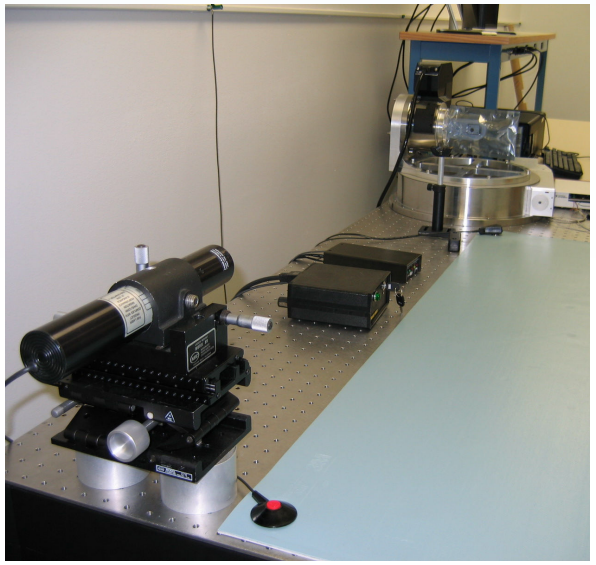
Magnetometer / Torquer Coil Testing

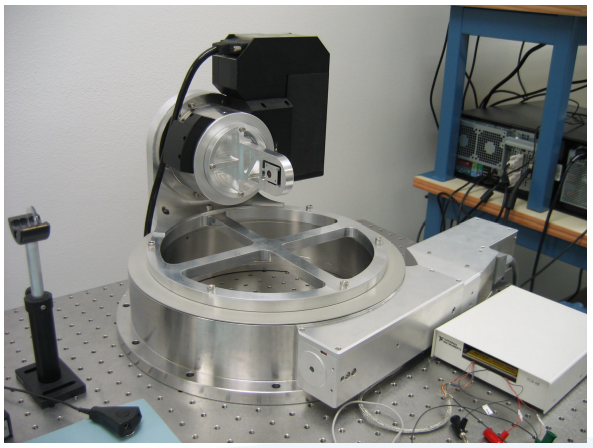
- Purpose
  - Characterization and/or calibration of magnetic field sensors and actuators
- Capability
  - Three-axis Helmholtz cage
  - Closed loop control of magnetic field
  - Dual differential magnetometers
  - Two-meter cage, 60-cm nominal working volume
  - Moveable coils provide choice of smaller highly-uniform field or larger less-uniform field
  - Zero-gauss chamber for calibration

Helmholtz cage under construction

Sun Sensor Testing

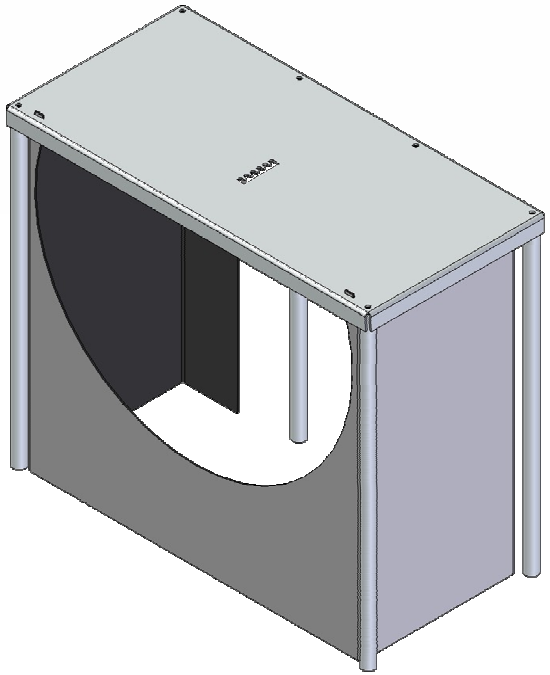
- Purpose
  - Calibration and characterization of sun sensors
- Capability
  - Sun source
  - Two-axis precision gimbal
    - ≤0.002°repeatability
    - ≤ 0.01°accuracy





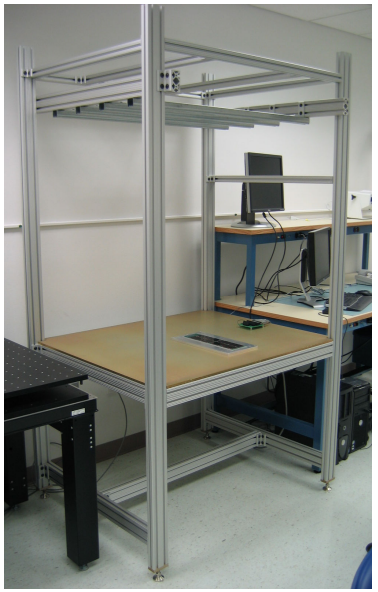
Horizon Sensor Testing

- Purpose
  - Calibrate and characterize horizon sensors
- Capability
  - Earth simulator (variable temperature)
  - Space simulator (liquid nitrogen cooled)
  - Rotary mount to simulate terminator crossing



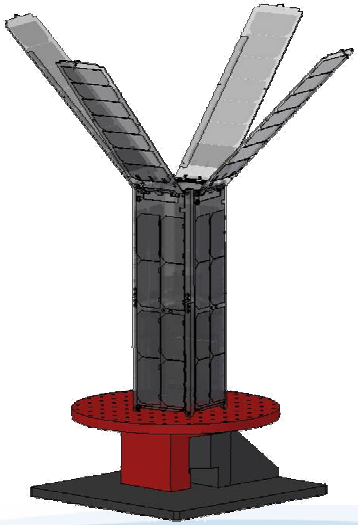
Solar Panel Testing

- Purpose
  - Test solar panel assemblies and/or power control system
- Capability
  - Continuous AM0 light source
  - Meets Class BBA (IEC 60904-9)
    - B: Spectral Concurrence to the sun (0.6 to 1.4)
    - B: Irradiation non-uniformity (≤ 5%)
    - A: Temporal Stability (≤ 2%)
  - Target Area 300 x 300 mm
  - NIST-traceable pyranometer measures intensity



Mass Properties Testing

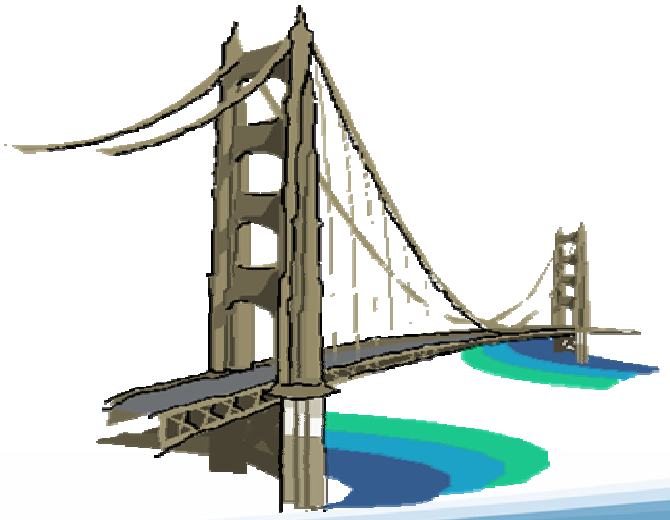
- Purpose
  - Measure mass, center of mass, and moments of inertia
- Capability
  - Center of mass (CM) table
    - Three-point kinematic mount with load cells
    - Static and dynamic balancing
  - Moment of inertia (MOI) table
    - Innovative design restricts translational motion
    - Leverages SDL experience with special pivots
    - Optically measure period of oscillation



Summary

- SDL's CubeSat test facility will provide requirements verification
  - Ensure requirements are met prior to launch
  - Enable testing and verification of individual components as well as system
  - Upgrade to higher capabilities as need arises
- Resource to help our government, industry, and academic partners transition from current CubeSat capabilities to the next generation

Current CubeSat Capabilities and Missions



Next Generation CubeSat Capabilities and Missions