Generalized Nanosatellite Avionics Testbed Lab

Research Facility that Provides Rapid Testing Capability for Actively Controlled Small Satellites

The Generalized Nanosatellite Avionics Testbed (G-NAT) lab at NASA Ames Research Center provides a flexible, easily accessible platform for developing hardware and software for advanced small spacecraft. A collaboration between the Mission Design Division and the Intelligent Systems Division, the objective of the lab is to provide testing data and general test protocols for advanced sensors, actuators, and processors for CubeSat-class spacecraft. By developing test schemes for advanced components outside of the standard mission lifecycle, the lab is able to help reduce the risk carried by advanced nanosatellite or CubeSat missions. Such missions are often allocated very little time for testing, and too often the test facilities must be custom-built for the needs of the mission at hand. The G-NAT lab helps to eliminate these problems by providing an existing suite of testbeds that combines easily accessible, commercial-off-the-shelf (COTS) processors with a collection of existing sensors and actuators.

As seen in Image 1, the main testbed is built around an air bearing that allows for three degrees-of-freedom (3-DOF) rotational motion within a CubeSat-scale Helmholtz cage. This Helmholtz cage is operated through MATLAB©, which uses an orbit propagation routine to calculate the magnetic field that would be encountered in a particular low Earth orbit. In addition to producing a relevant magnetic field vector, the testbed also makes use of a COTS sun emulator bulb which produces a sun vector with a known inertial orientation. Thus, full spacecraft state information can be collected using the magnetic field vector, the sun vector, and angular velocity information collected from an on-board inertial measurement unit (IMU). Attitude determination information is in turn validated through the use of a novel "attitude truth" system, which uses a posteriori pose

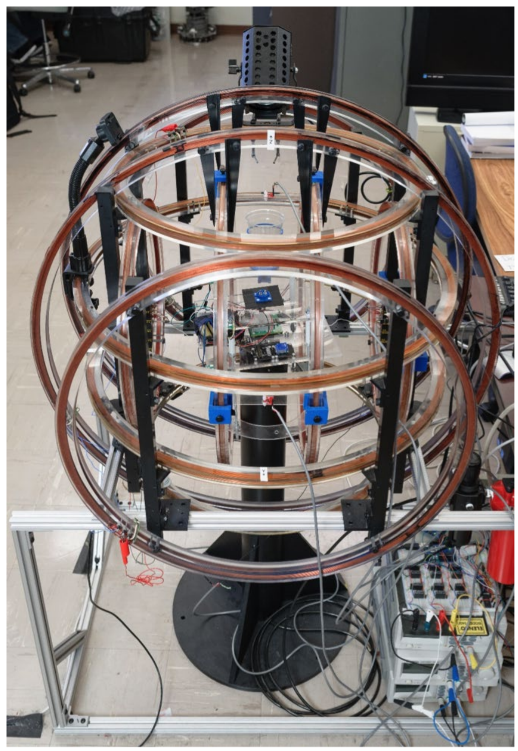

Image 1. Major elements of the testbed include a Helmholtz cage for simulating the magnetic field encountered on orbit, a sun emulator bulb, and an air bearing, which provides three degrees of rotational freedom for hardware testing.

information resolved from a set of infrared LEDs being tracked using a simple COTS digital camera. The true attitude of the test apparatus can be tracked throughout any test campaign, providing a key validation for any test.

Attitude control can also be investigated using typical CubeSat-class actuators, such as reaction wheels or torque rods. Any test apparatus placed on the air bearing can rotate a full 360° about the vertical axis, and up to 45° about either horizontal axis. This range of motion is sufficient to allow

NASA Ames researchers to study three-axis reorientation maneuvers using a wide variety of control actuators. The lab is also currently developing a web-based user interface that will allow collaborators at other field centers or in academia to directly control the testbed over the Internet. Users will be able to select specific control laws or control parameters that they wish to see implemented, and those results will then be tested on the physical hardware in the G-NAT lab in real time. Test results will be posted to the same web interface, allowing for detailed collaborations related to CubeSat attitude determination and control without requiring all the team members to be located at NASA Ames.

A typical use-case for the lab is illustrated by the BioSentinel mission, a 6U CubeSat that will be launched on the Space Launch System's first Exploration Mission (EM-1) planned for July 2018. This spacecraft will be the first NASA Ames-built CubeSat to operate in deep space, and for the spacecraft Safe Mode it is critical to have a high quality IMU. As part of the early design process for this mission, the G-NAT lab has been investigating the performance of a number of different candidate IMUs that conform to the power and volume constraints of the spacecraft. Tests being performed in the lab include bias stability, single- and multi-axis rotation accuracy, and sensor response to a vibrational environment. This test data is being shared with the BioSentinel spacecraft team, and additional tests can be quickly implemented based on the needs of the mission.

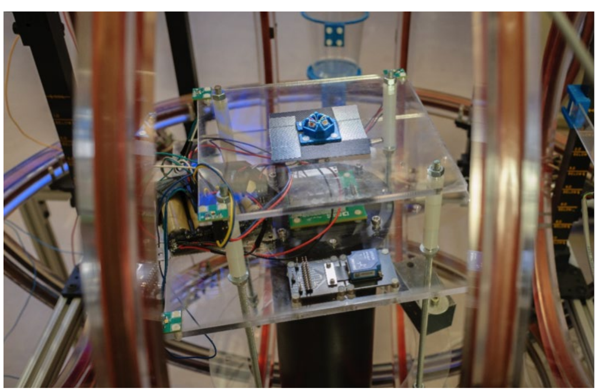

Image 2. An example testbed, with a sensor suite capable of determining the 3-axis attitude of a representative small spacecraft.

For more information about the Ames Engineering Directorate, visit:

http://www.nasa.gov/centers/ames/engineering/

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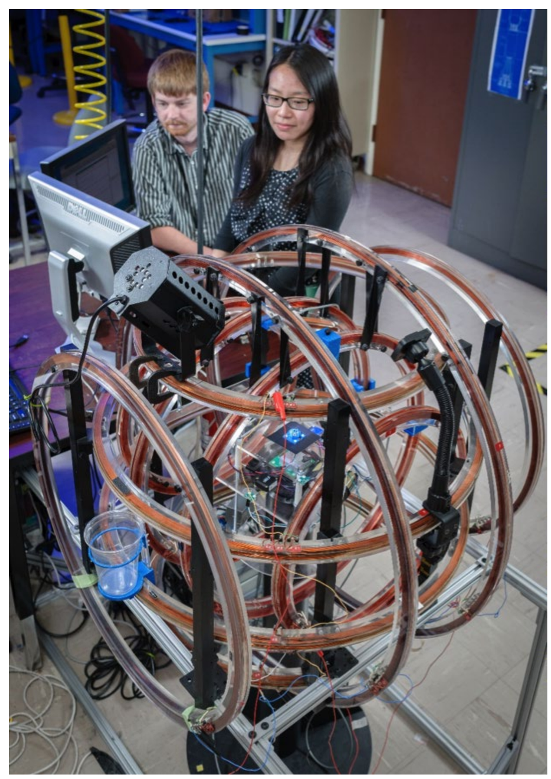

Image 3. The G-NAT lab is currently engaged in collaborations with a number of universities, and supports numerous intern programs.

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