Guidance, Navigation and Control
Tools and Testing Capabilities
Moog Broad Reach has assembled a team of Guidance, Navigation and Control (GN&C) engineer experts with experience developing and implementing GN&C designs for a variety of LEO and GEO missions. A suite of tools and algorithms that have proven successful on Moog Broad Reach avionics hardware is used by the team. This approach has success with the XSS-11 mission, and at GEO with the ANGELS and EAGLE missions.

The Moog Broad Reach-built Processor-in-the-Loop (PIL) includes hardware I/O cards specifically designed to interface with the Integrated Avionics Unit (IAU) and executes real-time models of the satellite for “spacecraft on the bench” testing. The pedigree of this software significantly reduces mission risk while delivering a proven and flexible high performance GN&C implementation.

Heritage:

Heritage GN&C software architecture is derived from that used on the MSTI-1,2, and 3 spacecrafts and, more recently, the XSS-10, 11, ANGELS and EAGLE missions.

The complete software suite, including the flight software, GN&C, and also a complete development and verification environment, was originally developed for the AFRL XSS-11 and later evolved for the ANGELS and EAGLE missions.

Software Features:

GN&C Simulink models include extensive features that are suitable to most applications. Models contain the following functionality:

- Sensor processing for gyros, accelerometers, star trackers, sun sensors and GPS
- Actuator processing for thrusters and reaction wheels
- Custom interfaces to camera image processing modules and image processing for star and object images
- Attitude determination Kalman filter to support multiple star trackers and gyros
- Navigation Kalman filter to support accelerometer and GPS inputs
- Autonomous position and attitude guidance for most pointing regimes
- Relative guidance and navigation using “angles-only” or angle and ranging data
- Optimal fuel utilization thruster firing mode
- Low jitter stepping profiling for solar array drives
Tools and Verification

MathWorks provides a flexible framework for control system design, analysis, implementation, and test.

- MATLAB® and Simulink® are used for analysis, using models of spacecraft and environment, as well as controller, sensors and actuators
- Real-Time Workshop® generates C-code from Simulink®, also generated for the spacecraft simulator

MATLAB scripts automate processing of the Command and Telemetry database and create Simulink® interface objects. The high level of automation streamlines integration of the generated GN&C code and the C&DH flight software.

For verification, Moog Broad Reach follows a spiral development and rapid prototyping approach to develop GN&C software.

- Workstation Simulation – Simulink® models are used for controls design and analysis
- System Simulation – Real-Time Workshop® is used to generate C-code for controller and spacecraft simulator and is deployed on the PIL.
- PIL Tests – PIL is configured as spacecraft simulator and connected to the IAU; can accommodate multiple CPU cards for extra sensor processing or image generation
- HIL Tests – GN&C sensors and actuators can be connected via breakout harness

Processor-in-the-Loop

PIL Testing

PIL (left) mimicking spacecraft components and environment to test IAU (right).

Key Features

- Facilitates Test Like You Fly integration and testing
- All desired hardware interfaces are verified
- Flight software runs real-time
- Full control of testing
- Realistic throughput testing supported
MOOG SPACE LOCATIONS

Ireland
Japan
The Netherlands
United Kingdom
United States