Tools for Software Based Validation and Verification of Small Satellites

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ITC Developed Simulators
Overview

What is NOS$^3$?

- Based upon Simulation-to-Flight 1 (STF-1) hardware, but sufficiently generic
- Easily-interfaces to Core Flight System (CFS), but CFS not required
- A collection of Linux executable and libraries, deployed ready-to-run
- Allows the testing of flight software as it is flown

What is it used for?

- FSW early-development – NOS$^3$ provides real-world inputs to FSW
- FSW V&V – Testing FSW, invalid inputs, behavior, stress conditions
- FSW Integration – Applications can be tested with simulated hardware
- Mission Planning – Example: power analysis, command and telemetry
NOS³ Components

- Virtual Machine – NOS³ environment
- NOS Engine Middleware
- Hardware Models
- FSW Hardware Abstraction Layer
- Orbit Inview & Power Prediction (OIPP) Tool
- CFS – Flight Software
- 42 – Dynamics Simulation and Visualization
- COSMOS – Commanding & Telemetry
NOS³ Architecture

- **cFS**
  - Linux (x86, ARM/Pi)
  - NOS Engine
  - Hardware Models
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- **STF-1**
  - Hardware Lib

- **OS Abstraction Layer (OSAL)**

- **Ground System Software (COSMOS)**

- **Commanding & Telemetry**

- **NOS³ UI & Control**

- **Flight Hardware**
  - FreeRTOS (AVR32)

- **Hardware Adapter**
  - i2c / SPI

**NOS³**

**NASA Operational Simulator for Small Satellites**

**Independent Test Capability**
Ease of Deployment

• Ready-to-run after unpacking a .tar
• Install Vagrant and VirtualBox
• Run nos3_installer
• Developer build tools installed
• Convenience scripts for building/running
NOS Engine Middleware

- ITC developed middleware
- Common server to communicate to all data nodes (CFS, Hardware simulators, Time ticker, Command terminals)
- C/C++ API
- I2C, UART and SPI protocols
- Asynchronous and Synchronous
Hardware Models

• Modeled based on characteristic data, or manufacturers data specifications

• Currently have modeled
  – Novatel GPS
  – Clyde Space EPS
  – Honeywell Magnetometer
  – ISISpace Antenna System
  – Gomspace A3200 support chips (FRAM, Gyro)
Hardware Models

NOS Engine Interface → NOS Engine Message
NOS Engine Interface → NOS Engine Message
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Hardware Model

Environment Data Provider

NASA Operational Simulator for Small Satellites

Independent Test Capability
Flight Software (CFS)

• Open source flight software developed by GSFC

• Includes an OS Abstraction Layer
  – Allows building for flight and NOS$^3$ targets on same machine without source code changes

• Additional Platform-Support-Package (PSP) added to sync CFS time with NOS$^3$
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GSFC Open Source Dynamics Simulator

- NOS$^3$ TCP/IP Socket Integration
- Simulation time synchronized with NOS$^3$
- Moving toward closed loop
COSMOS

• Open Source software for embedded system commanding and telemetry

• Currently connects to CFS TO_lab
  – Future plan is to have radio simulator to replace TO_lab

• Can be used for operator training, testing table loads to SC, verifying command and telem databases, etc.
Orbit, Inview, and Power Prediction

• Web page: Generated daily by cron job
• TLE Data pulled from http://celestrak.com as obtained from NORAD
• Time Periods (configurable)
  • Yesterday, Today, Future
• Displays
  • Ground station in-views
  • Sunlight and Eclipse times
Orbit, Inview, and Power Prediction (OIPP)
Acquiring NOS$^3$

- Stop by the GSFC booth and see us
- Email us: ivv-dl-nos3-support@mail.nasa.gov