Tools for Software Based Validation and Verification of Small Satellites

Matt Grubb
Matthew.d.grubb@nasa.gov

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Overview

What is NOS³?

• A software test bed for small satellites – Currently a Functional Beta
• Based upon STF-1 hardware, but sufficiently generic
• Easily-interfaces to CFS, but CFS not required
• Openly distributed solution Ready-to-Run (RTR)
• A collection of Linux executable and libraries
• Test as you fly

What is it used for?

• FSW early-development – NOS³ provides real-world inputs to FSW
• FSW V&V – Testing FSW, invalid inputs, behavior, stress conditions
• FSW Integration – Used for early-app development and payload team integration
• Mission Planning – Example: power analysis
NOS³ Components

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

Ground System Software (COSMOS)

Commanding & Telemetry

NOS³ UI & Control

STF-1

cFS

Hardware Lib

OS Abstraction Layer (OSAL)

Linux (x86, ARM/Pi)

NOS Engine

Hardware Models

42

FreeRTOS (AVR32)

Flight Hardware

Hardware Adapter i2c / SPI
NOS³ Components

- NOS Engine Message
- NOS Engine Interface
- Hardware Model
  - Environmental data

FSW

NASA Operational Simulator for Small Satellites

Independent Test Capability
Virtual Machine Auto Generation

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

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

• Modeled based on characteristic data, or manufacturers data specifications

• Currently have modeled
  – Novatel GPS
  – Clyde EPS
  – Honeywell Magnetometer
  – ISISpace Antenna System
  – A3200 support chips (FRAM, Gyro
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$^3$
GSFC Open Source Dynamics Simulator

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

• Open Source 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)
Backup Slides
NOS$^3$ Utilization Example for STF1