Tools for Software Based Validation and Verification of Small Satellites

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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

NOS³ UI & Control

- FreeRTOS (AVR32)
  - Hardware Adapter i2c / SPI
  - Flight Hardware

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 NOS³ targets on same machine without source code changes

• Additional Platform-Support-Package (PSP) added to sync CFS time with NOS³
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.
COSMOS
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