Tools for Software Based Validation and Verification of Small Satellites

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Overview

What is NOS\textsuperscript{3}?

- 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 – NOS\textsuperscript{3} 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
NOS$^3$ Components

- Virtual Machine – for running NOS$^3$
- 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
NOS$^3$ Architecture

- **Ground System Software (COSMOS)**
- **NOS$^3$ UI & Control**
- **STF-1**
  - cFS
  - OS Abstraction Layer (OSAL)
  - Linux (x86, ARM/Pi)
  - FreeRTOS (AVR32)
  - Flight Hardware
  - Hardware Lib
- **Hardware Adapter**
  - i2c / SPI

- **NOS Engine**
- **Hardware Models**
- **42**

- **Commanding & Telemetry**

NASA Operational Simulator for Small Satellites

Independent Test Capability
NOS$^3$ Components

NOS Engine Interface

NOS Engine Message

time, input bytes

output bytes

Hardware Model

Environmental data

Environment Data Provider

NOS Engine Interface

NOS Engine Message

time, input bytes

output bytes

Hardware Model

Environmental data

NOS Engine Interface

NOS Engine Message

time, input bytes

output bytes

Hardware Model

Environmental data

NOS Engine Interface

NOS Engine Message

time, input bytes

output bytes

Hardware Model

Environmental data

NOS Engine Interface

NOS Engine Message

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Hardware Model

Environmental data
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

- NOS³ TCP/IP Socket Integration
- Simulation time synchronized with NOS³
- 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

NASA Operational Simulator for Small Satellites

Independent Test Capability
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)

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Backup Slides
NOS³ Utilization Example for STF1