Tools for Software Based Validation and Verification of Small Satellites

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Overview

What is NOS\(^3\)?

- 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\(^3\) 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
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

nasa ITC
Independent Test Capability

nos³
NASA Operational Simulator for Small Satellites

open source

open source

open source
NOS³ Architecture

Ground System Software (COSMOS)

Commanding & Telemetry

STF-1

CFS

Hardware Lib

OS Abstraction Layer (OSAL)

Linux (x86, ARM/Pi)

FreeRTOS (AVR32)

NOS Engine

Flight Hardware

Hardware Models

Hardware Adapter i2c / SPI

42

NOS³ UI & Control

Ground System Software (COSMOS)

NASA Operational Simulator for Small Satellites

Independent Test Capability
NOS$^3$ Components

- NOS Engine Interface
- Hardware Model
- Environmental Data Provider

FSW

- NOS Engine Message
- NOS Engine Interface
- Hardware Model
- Environmental Data Provider

Output bytes

Time, input bytes
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)

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Walops Antenna Day Shift

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Morehead Antenna Day Shift

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SRI Palo Alto Antenna Day Shift

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S/C 39404 In Sunlight Times

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- Wallops Antenna - S/C 77777 Invieves: 12:43 pm - 12:50 pm
- Duration: 0.12 hours

nos3

NASA Operational Simulator for Small Satellites

ITC

Independent Test Capability
Backup Slides
NOS³
Utilization
Example for
STF1