

The logo for nos³ features the letters 'nos' in a dark grey, lowercase sans-serif font, followed by a superscripted '3' in orange. To the left of the text is a decorative graphic of eight orange circles of varying sizes arranged in a loose arc.

nos³

NASA Operational Simulator
for Small Satellites

Tools for Software Based Validation
and Verification of Small Satellites

Matt Grubb

Matthew.d.grubb@nasa.gov

Small Sat Workshop 2016



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

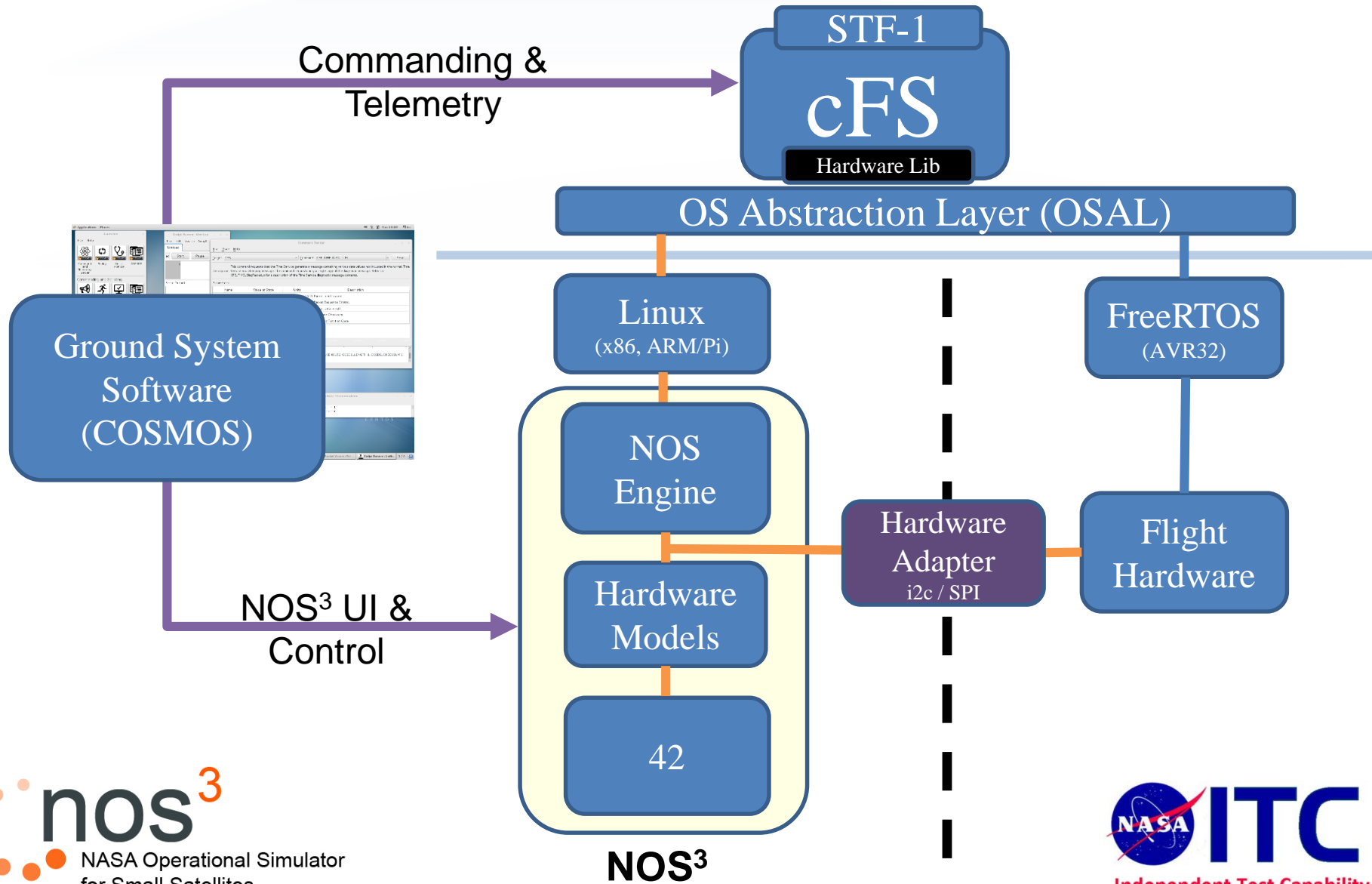
What is it used for?

- 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

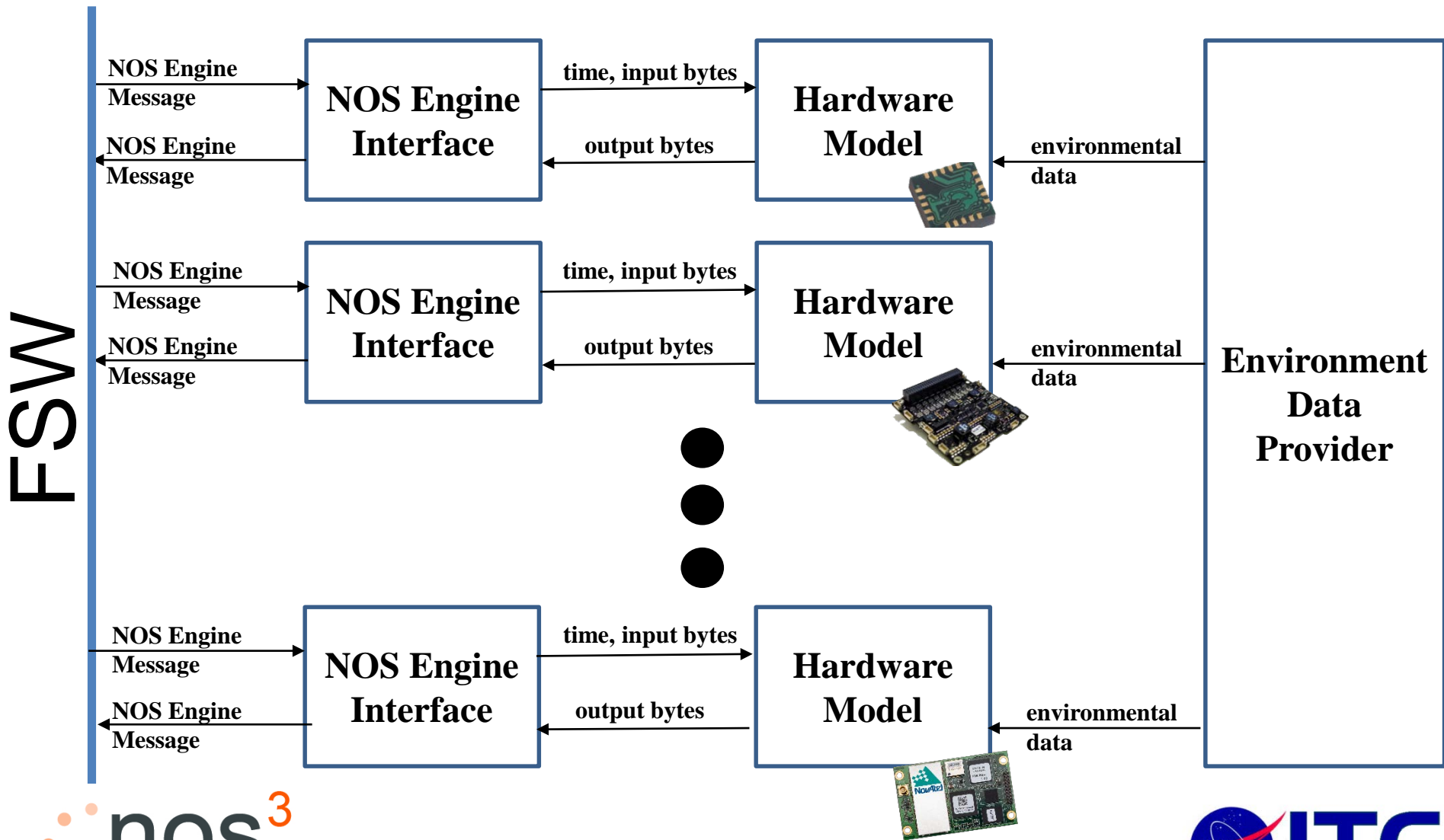
NOS³ Components

- 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



NOS³ Components



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

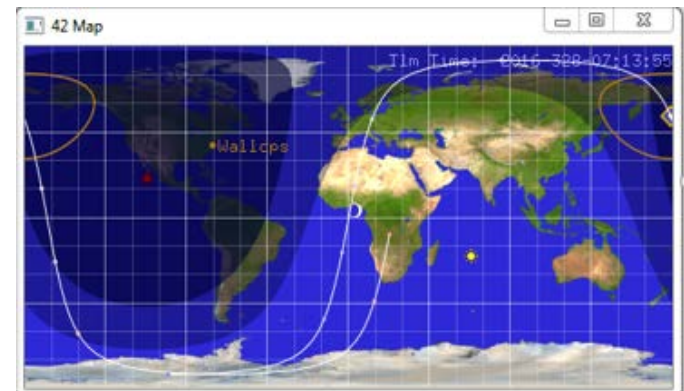
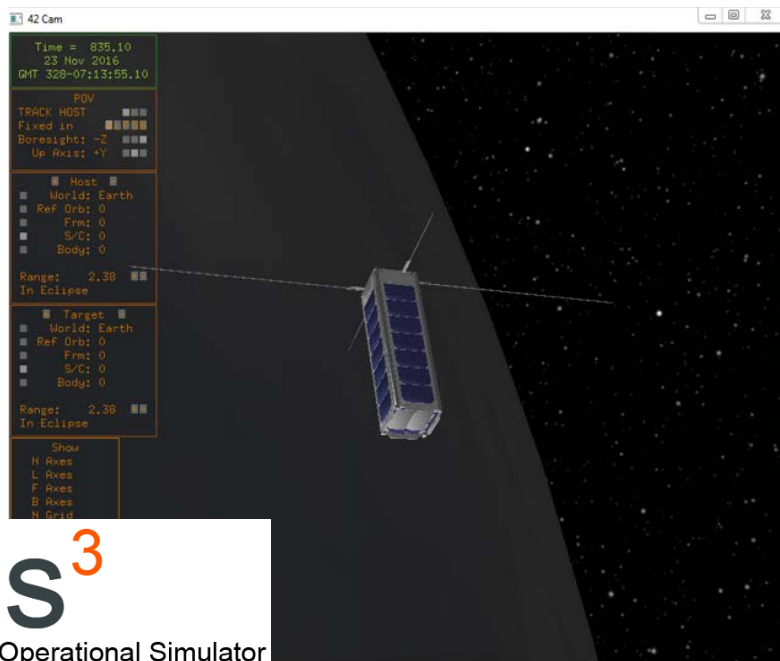
Flight Software (CFS)

- 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

42

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

The screenshot displays the COSMOS software interface. On the left is a 'Launcher' window with icons for Command and Telemetry Server, Replay, Limits Monitor, and COSMOS. Below it are 'Commanding and Scripting' and 'Telemetry' sections. The main area contains several windows: 'Script Runner: Untitled' with a 'Start' button; 'Command Sender' showing a command 'CFE_TIME_DIAG_TLM' and a table of parameters; 'COSMOS Command and Telemetry Server - Demo Configuration' with a 'Cmd Packets' tab showing a table of packets; and a terminal window showing system logs and a command prompt.

Name	Value or State	Units	Description
CCSDS_STREAMID:	6149		CCSDS Packet Identification
CCSDS_SEQUENCE:	49152		CCSDS Packet Sequence Control
CCSDS_LENGTH:	1		CCSDS Packet Data Length
CCSDS_CHECKSUM:	0		CCSDS Command Checksum
CCSDS_FC:	2		CCSDS Command Function Code

Target Name	Packet Name	Packet Count	View Raw	View in Command Sender
CFS	CFE_ES_CLEAR_ERLOG	0	View Raw	View in Command Sender
CFS	CFE_ES_CLEAR_SYSLOG	0	View Raw	View in Command Sender
CFS	CFE_ES_DELETE_CDS	0	View Raw	View in Command Sender
CFS	CFE_ES_DUMP_CDS_REG	0	View Raw	View in Command Sender
CFS	CFE_ES_NOOP	0	View Raw	View in Command Sender

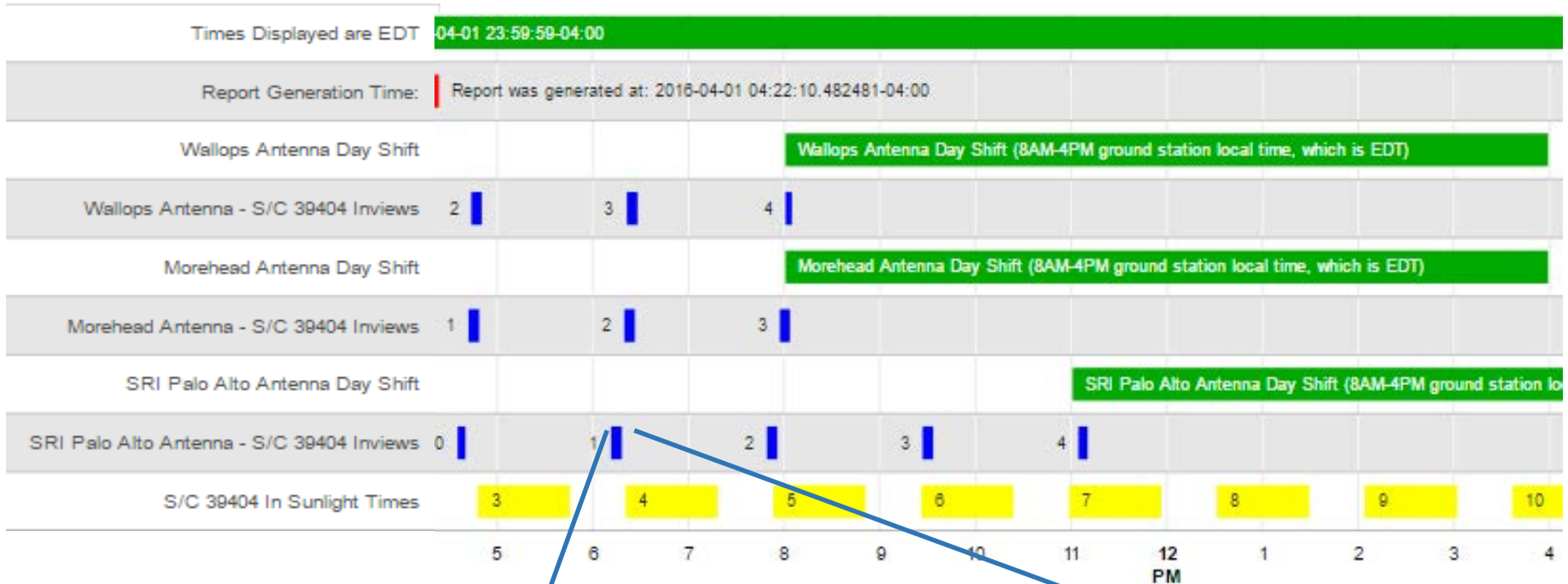
```
2015/09/29 15:54:59.684 INFO: Marshal Load success: /home/itc/cosmosdemo/outputs/tmp/marshal_fc700089659a221d33e33c8a7d522525.bin
2015/09/29 15:54:59.714 INFO: Creating thread for interface CFS_INT
2015/09/29 15:54:59.714 INFO: Creating thread for router PREIDENTIFIED_ROUTER
2015/09/29 15:54:59.765 INFO: Starting packet reading for CFS_INT
2015/09/29 15:54:59.765 INFO: Connecting to CFS_INT...
2015/09/29 15:54:59.765 INFO: CFS_INT Connection Success
2015/09/29 15:54:59.765 INFO: Starting packet reading for PREIDENTIFIED_ROUTER
2015/09/29 15:54:59.766 INFO: Connecting to PREIDENTIFIED_ROUTER...
```

```
itc@localhost:~/cosmosdemo
File Edit View Search Terminal Help
92.168.1.82 1234 1235 nil nil 128 nil nil
[itc@localhost cosmosdemo]$ ruby Launcher
```

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

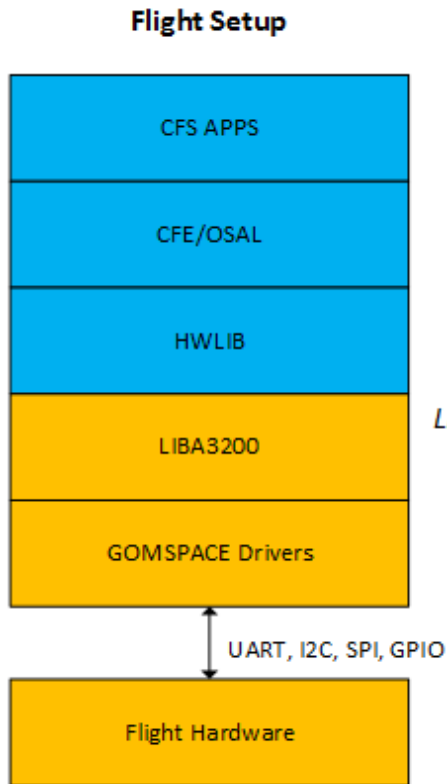
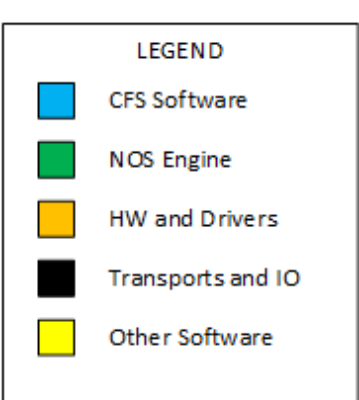
Orbit, Inview, and Power Prediction (OIPP)



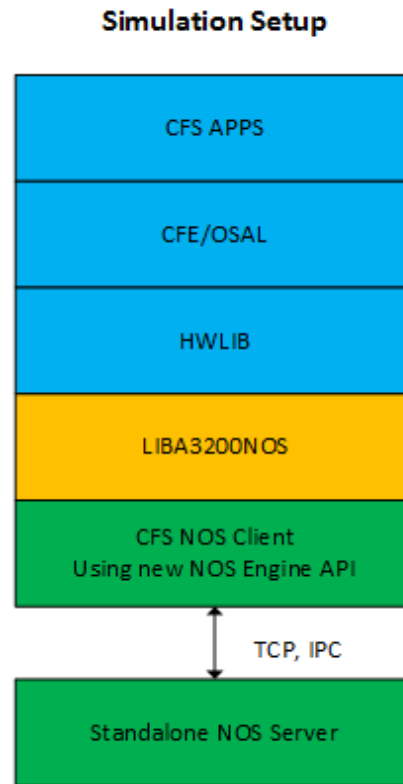
1
 Wallops Antenna - S/C 77777 Inviews: 12:43 pm - 12:50 pm
 Duration: 0.12 hours



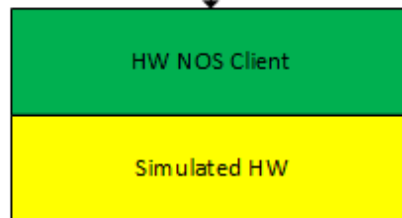
Backup Slides



Library Selected by CMAKE upon build. No Software changes required

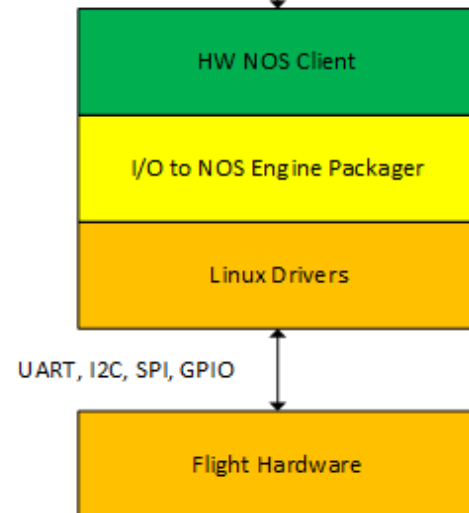


Simulated HW



Can add as many HW NOS Clients as required by the FSW

Flight HW



NOS³ Utilization Example for STF1