

Simulation-to-Flight 1 West Virginia's First Spacecraft

- NASA CubeSat Launch Initiative (CSLI)
 - ELaNa XIX, Rocket Labs USA
 - 85 inclination at 500km altitude
 - Mission Readiness Review: March 20
 - Delivery: April 2017
 - Launch: June 2017
- Partnering with GSFC/WFF Small Satellite Teams
- NASA Independent Verification and Validation (IV&V)
 - C&DH hardware/software, integration and testing
- West Virginia University (WVU)
 - Science payload hardware and software
- West Virginia Space Grant Association (WVSGC)
 - Statewide outreach

Mission Objectives

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STF-1 NOS ³	Primary Objective	NASA IV&V
GPS and IMU	Science Objective	WVU MAE
Space Weather	Science Objective 2	WVU Physics & Astronomy
III-V Nitride Materials	Science Objective	WVU LCSEE
Earth Viewing Camera	Science Objective 4	NASA IV&V
STEM Education	Outreach Objective	WVSGC

Anatomy of STF-1

ISISpace UHF/VHF Antenna

- Deployable Di-pole system
- Four alloy tape antennas
- Up to 55cm in length

L3 CADET Radio

- Half duplex UHF
- Store and Forward
- 4GB memory buffer
- 3.0Mbps with 18M dish

GomSpace Nanomind A3200

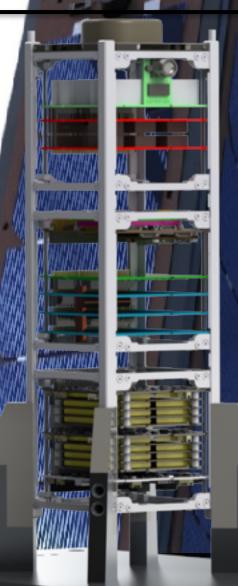
- AVR32 w/ 512KB flash
- 125Mb NOR flash
- 32MB SDRAM
- I²C, UART, and CAN-Bus

Physics

- Particle detector
- VLF receiver
- Plasma probe

ClydeSpace 40WHr Batteries

- Lithium Polymer
- Independent for redundancy
- Internal headers



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ArduCAM Mini Camera

- 2MP, I²C and SPI
- Optional filters

Gallium III-V Nitride Payload

- Three different LED carriers
- Measure effects of shielding

Novatel OEM615 GPS

On-orbit reprogrammable Precise orbit determination Open loop tracking Data: 100Hz phase, TEC, S4

Inertial Measurement Unit

- 32 MEMs sensors
- Account for errors via calibration pre-flight

ClydeSpace EPS

- 10 command-able switches
- Provides 3.3V, 5V, and 12V
- Optimized for LEO
- Three independent battery charge regulators (BCRs)

NASA IV&V Objective

- Demonstrate development lifecycle value of a software-only SmallSat simulator
- Objectives
 - Open source CubeSat risk reduction solution
 - Produce evidence of cost and time savings
 - Develop advanced toolset to identify & resolve software issues (Share this technology with the GSFC SmallSat teams)
 - Perform meaningful science driven from research institutions
 - Foster and spread knowledge throughout IV&V Program

NASA Operation Simulator for Small Satellites

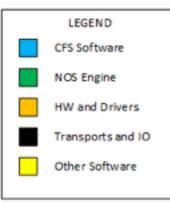
- What is **nos**³?
 - An open source software test bed for small satellites
 - A collection of Linux executable and libraries
 - Current simulations based on COTS HW from STF-1
 - Easily-interfaces to cFS FSW, but not required
- Why should you care?
 - Shift FSW development forward
 - Provides real-world inputs with development environment
 - FSW V&V
 - Testing FSW, invalid inputs, behavior, stress conditions
 - FSW Integration
 - Used for early-app development and payload team integration
 - Mission Planning

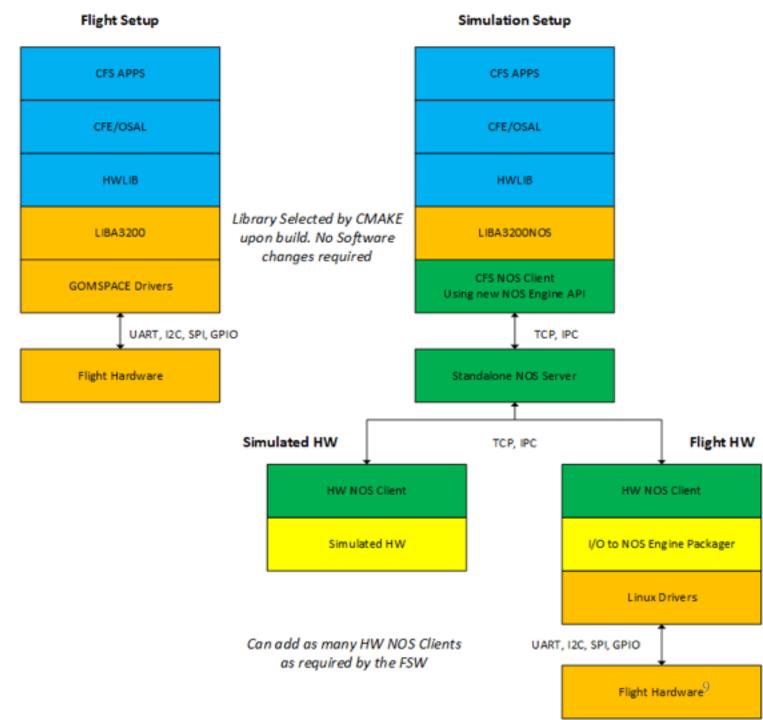
NOS³ Components

- Core Flight System (cFS)
 - Open source, project independent, reusable FSW framework
- COSMOS Ground Station
 - Open source, ground system software provided by Ball Aerospace
- Hardware Models
 - Written for a specific piece of flight hardware
 - Focuses on I/O of device and is fully customizable based on vendor options
 - Models developed and currently in use:
 - Honeywell Magnetometer, ClydeSpace EPS, NovAtel GPS, ISISpace Antenna
- NOS Engine
 - Middleware specifically designed for use in simulation
 - Includes time synchronization, data manipulation, and fault injection
 - I²C, UART, and SPI protocols
 - Serves as the glue to tie all components to a common interface

NOS³ Components

- Orbit, Inview, and Power Planning
 - Utilize current or projected TLEs to project contact windows
- Vagrant
 - Virtual machine is created on-the-fly by the user
 - Provides full development environment with all capabilities
 - Additional scripts to build and run FSW with simulators provided
- 42
 - Open source, NASA GSFC developed, visualization and simulation tool for spacecraft attitude and orbital dynamics
 - Serves as an environmental data provider
 - For example provides magnetic field data based on current location



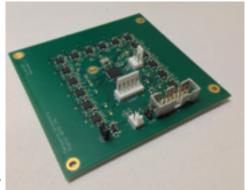




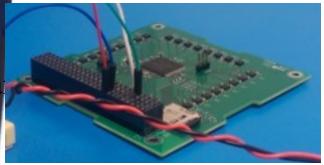
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MEMS IMU Swarm

- Designed to overcome Size, Weight, and Power (SWaP) constraints
- Large cluster of redundant MEMs IMUs
- Developed under Small Satellite Technology Partnership (SSTP)
- Gen-2 flew on the sounding rocket MUSIC on March 1st
- Gen-3 is custom-built for STF-1 in the PC104+ form factor
- Calibrated on student designed rate tables a temperature chambers
- Storing raw data for analysis on ground



Gen-2





GNSS Receiver and Precise Orbit Determination

- NovAtel OEM615 GPS Receiver
- Dual frequency L1/L2 receive
- Focus to develop and assess estimate strategies that will maximize POD accuracy from data obtained during duty-cycled operations
- Provide PVT to C&DH
- Post processing utilizes
 NASA JPL's GIPSY-OASIS
 package



Space Environment and Weather

- Characterize the environment in which the STF-1 mission will operate
- A Langmuir probe to measure local electron density and temperature contrasted with regional GPS TEC
- A VLF receiver to monitor the PSD of lowfrequency waves driving the electron flux
- Measurement at times of intense solar and/or ionospheric activity
- Comparable payloads flew on sounding rocket MUSIC

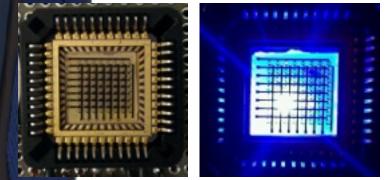


WVU ROCKSAT LP and VLF



III-V Nitride-Based Materials

- Precision optoelectronic sensor module containing arrays of LEDs and PDs can be used for short-range distance measurement and shape rendering
- Due to the harsh environment, shielding is usually needed
 This shielding effects the range of these sensors
- Levels of shielding will be tested over time to determine the optimum amount
 - Current and voltage data collected
- Fabricated by students at WVU



Fabricated array of LEDs

Earth Science Camera

- ArduCam Mini OV2640
 - 2MP Sensor
 - Filters can be applied pre-flight
- Able to change settings on orbit
 Fully command-able via I2C and SPI
- Allows us to:
 - Verify deployment operations



ArduCam-Mini

- Assess COTS product in space environment
- Observe Earth's surface and atmosphere over mission lifetime

Statewide Outreach Plans and Programs

- Website and Blog (www.stfl.com)
- Spaceflight Mission Development course for WVU Undergraduates
- STF-1 Mission Patch design competition
- Educator's Guide for teachers of K-12 students
- NASA-Produced materials on space exploration, satellite operation, Space Station facts, etc.
- Cardboard and 3-D printable models
- Student Partnership for Advancement of Cosmic Exploration (SPACE)





