Simulation To Flight - 1

NASA CubeSat Launch Initiative (CSLI)

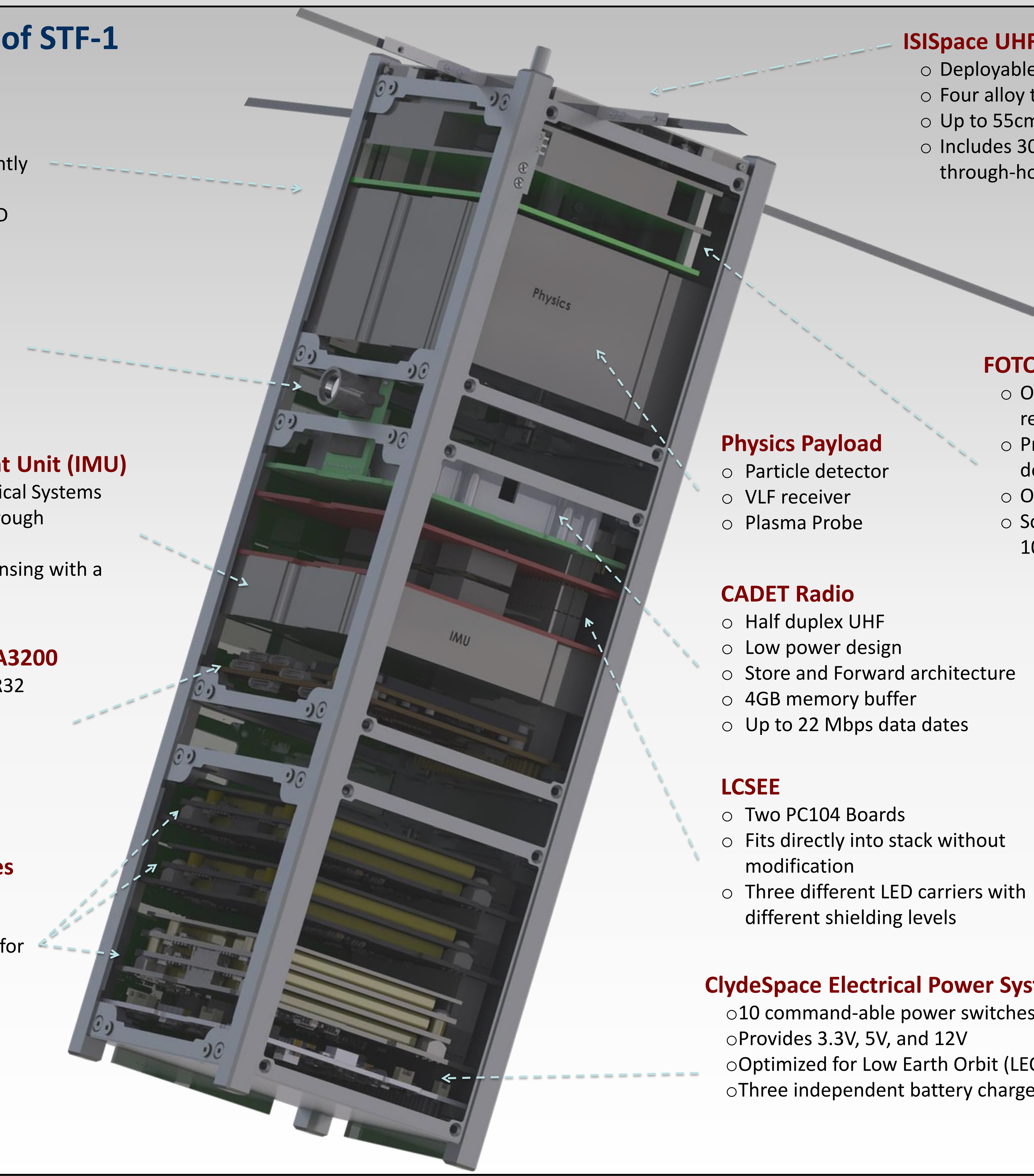
Introduction

The Simulation-To-Flight (STF-1) CubeSat Mission aims to demonstrate how legacy simulation technologies may be adapted for flexible and effective use on missions using the CubeSat Platform. These technologies, named NASA Operation Simulator (NOS), have demonstrated significant value on several missions such as James Webb Space Telescope, Global Precipitation Measurement, Juno, and Depp Space Climate Observatory in the areas of software development, mission operations/training, verification and validation (V&V), test procedure development, and software systems check-out. STF-1 will demonstrate a highly portable simulation and test platform that allows seamless transition of mission development artifacts to flight products. This environment will decrease development time of future CubeSat missions by lessening the dependency on hardware resources. In addition, through a partnership between NASA GSFC, the West Virginia Space Grant Consortium, and West Virginia University, the STF-1 CubeSat hosts payloads for three secondary objectives that aim to advance engineering and physical science research in the areas of navigation systems of small satellites, provides useful data for understanding magnetosphere-ionosphere coupling and space weather, and verify the performance and durability of III-V Nitride-based materials.

STF-1 Areas of Focus

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

Anatomy of STF-1



ISISpace Chassis
- Modular structure
- Each unit can be assembled independently
- COTS component
- Compatible with P-POD Cal-Poly specifications

Camera
- Mounted to a PC104 protoboard
- Optional filters to provide earth science data

Inertial Measurement Unit (IMU)
- Micro Electro-Mechanical Systems
- Accounts for errors through calibration
- High quality inertial sensing with a MEMs IMU cluster

GomSpaceNanomind A3200
- High-performance AVR32
- 512KB build-in flash
- 125Mb NOR flash
- 32MB SDRAM
- I^{2}C, UART, CAN-Bus

3 x ClydeSpace Batteries
- Lithium Polymer
- 70W/Hr
- 3 Independent boards for redundancy
- Internal heaters

ISISpace UHF/VHF Antennas
- Deployable antenna system
- Four alloy tape antennas
- Up to 55cm in length
- Includes 30mm diameter center through-hole for pass-through

FOTON GPS
- On-orbit reprogrammable
- Precise orbit determination
- Open loop tracking
- Science data products: 100-Hz phase, TEC, S4

Physics Payload
- Particle detector
- VLF receiver
- Plasma Probe

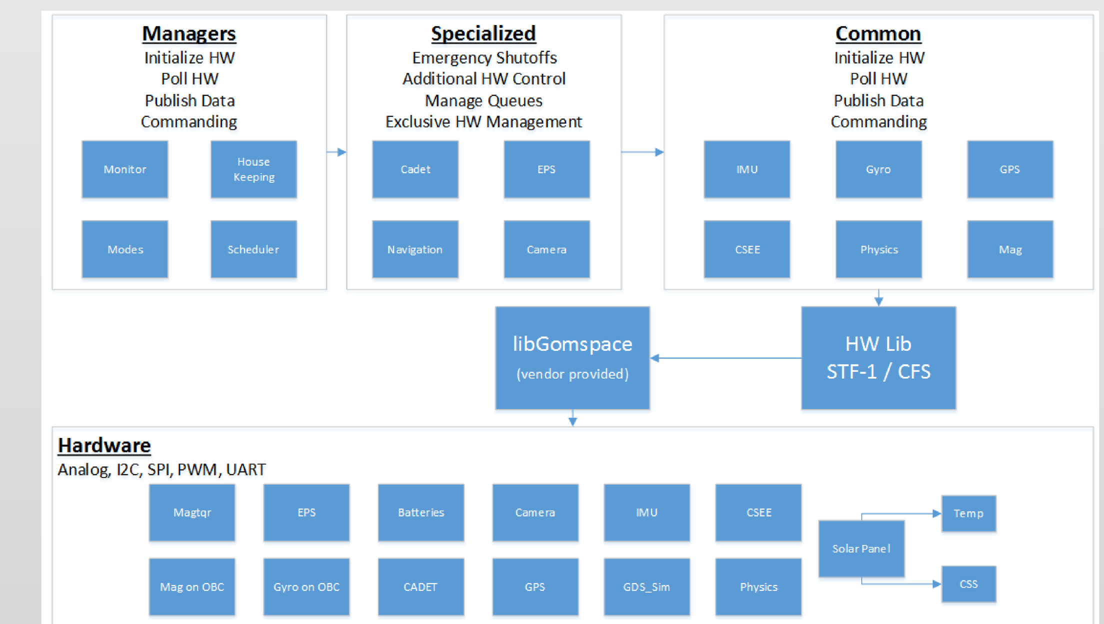
CADET Radio
- Half duplex UHF
- Low power design
- Store and Forward architecture
- 4GB memory buffer
- Up to 22 Mbps data dates

LCSEE
- Two PC104 Boards
- Fits directly into stack without modification
- Three different LED carriers with different shielding levels

ClydeSpace Electrical Power System (EPS)
- 10 command-able power switches
- Provides 3.3V, 5V, and 12V
- Optimized for Low Earth Orbit (LEO)
- Three independent battery charge regulators

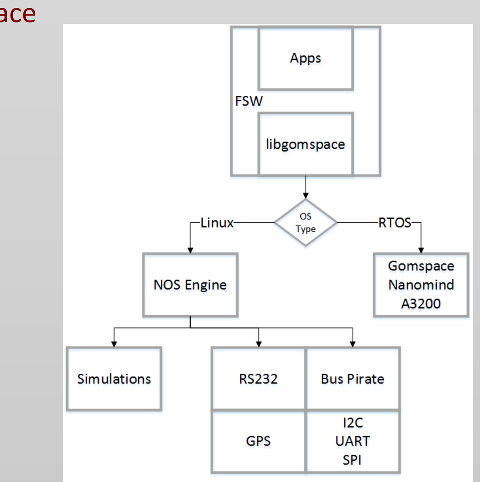
NASA IV&V ITC

Flight Software (FSW)
- Core Flight Executive (cFE) was chosen due to proven flight heritage
- cFE was originally developed at Goddard Space Flight Center (GSFC)
- Operating System Abstraction Layer (OSAL) enables FSW to execute in an environment such as Linux in a manner comparable to the flight hardware
- External satellite components over UART, SPI, or I2C are not included

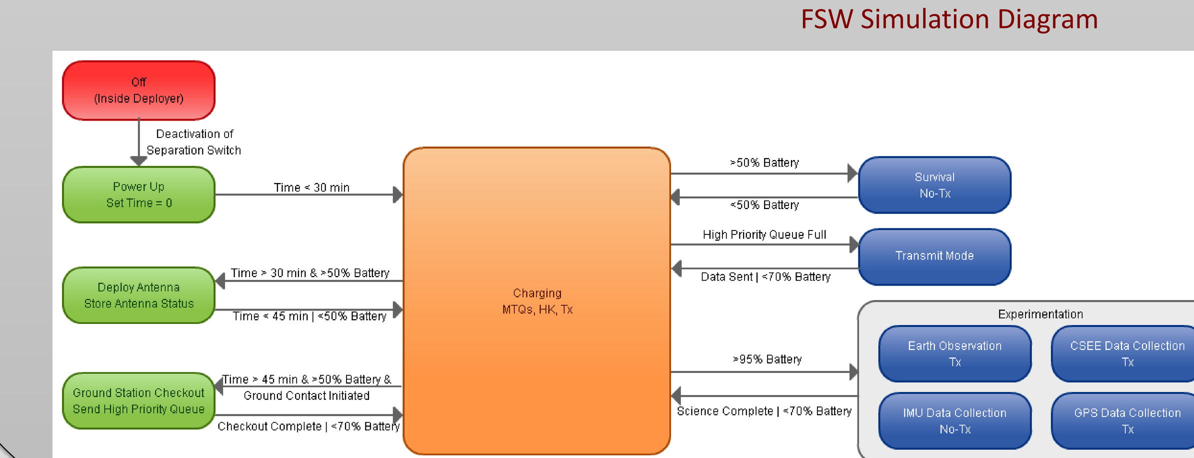


HW/SW Interface

NASA Operational Simulator (NOS)
- Cleanly mimics protocols required by these components in a software-only abstraction layer
- Allows for external component modeling in both full simulation and in Hardware-in-the-Loop (HWIL)
- Easily linked to FSW using default build system
- Changes required for simulation remain unknown to the FSW



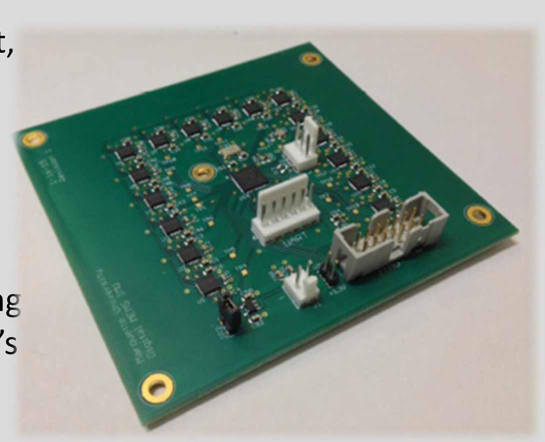
FSW Simulation Diagram



Operating Modes

WVU MAE

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)
- Gen2 IMU Cluster to fly on sounding rocket in late 2015 as part of NASA's Undergraduate Student Instrumentation Program (USIP)
- STF-1 version will be custom-built for the CubeSat form-factor



GEN2 IMU Cluster

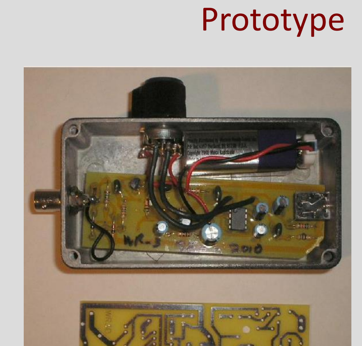
GNSS Receiver and Precise Orbit Determination
- Cornell University and the University of Texas at Austin have developed the Fast, Orbital, Total Electron Content (TEC), Observables and navigation (FOTON) software-defined multi-frequency GNSS space capable receiver
- Donated to STF-1
- Focus to develop and assess estimate strategies that will maximize POD accuracy form data obtained during duty-cycled operations
- Post processing using NASA JPL's GIPSY-OASIS package

WVU Physics and Astronomy

Magnetosphere-Ionosphere Coupling
- Depends primarily on electromagnetic and convective stresses from the magnetosphere on the ionosphere resistivity
- A solid-state detector will be used to measure the flux of electronics precipitating from the plasma sheet
- Over the polar caps, the detector will effectively measure solar energetic particle fluxes
- Accuracy relies on IMU and magnetometer data

Space Weather
- A Langmuir probe will be used to measure electronic density and temperature of the ionosphere
- These measurements will be compared to the total electron content (TEC) derived from the GPS receiver
- Effects of the space environment on technologies such as spacecraft are collectively called space weather
- High fluxes of precipitating particles and high-temperature plasma can produce surface and deep dielectric charging on a CubeSat
- Measuring these at times of intense solar and/or ionospheric activity is the goal for research and education programs at WVU

Particle Detector Prototype



VLF detector to be miniaturized

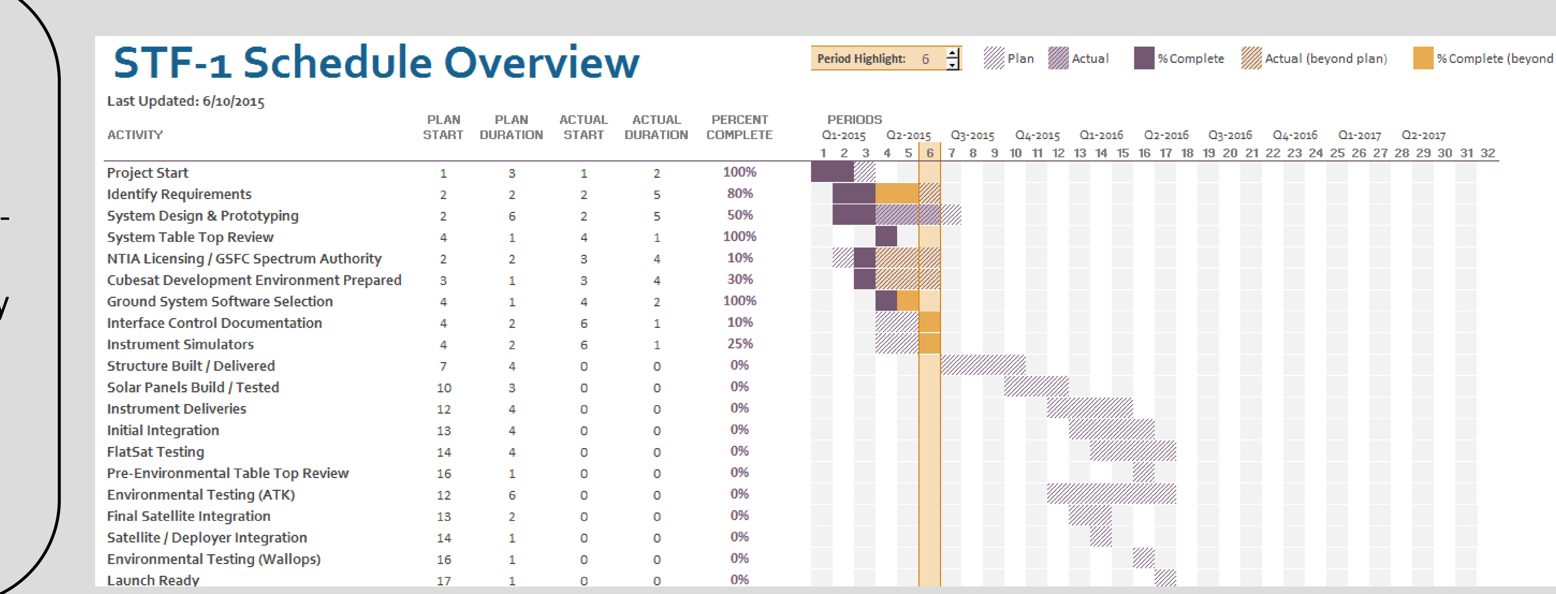
WVU LCSEE

III-V Nitride-Based Materials
- A precision optoelectronic sensor module containing arrays of light-emitting diodes (LEDs) and photodiodes (PDs) can be used for short-range distance measurement and shape rendering
- Utilizing materials known for their radiation hardness and the ability to operate at extreme temperatures
- Due to the harsh environment of space, shielding is usually needed to ensure reliability and functionality
- Less shielding allows for better range of measurement
- Levels of shielding will be tested over time to determine the optimum amount to extend capability in the space environment

WVSGC

Statewide Outreach Plans and Programs
- Educator's Guide for teachers of K-16 students
- Brochures and education material on general space related topics
- Guide and activity books on CubeSats
- 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)

STF-1 Schedule Overview



STF-1 Team
- NASA IV&V Program
- Orbital ATK (WV)
- TMC^2 Technologies
- WVU LCSEE
- WVU MAE
- WVU Physics and Astronomy
- WVSGC

JSTAR

Jon McBride Software Testing & Research Lab