Simulation-to-Flight (STF-1) Proposal

In Response to the Announcement of CubeSat Launch Initiative

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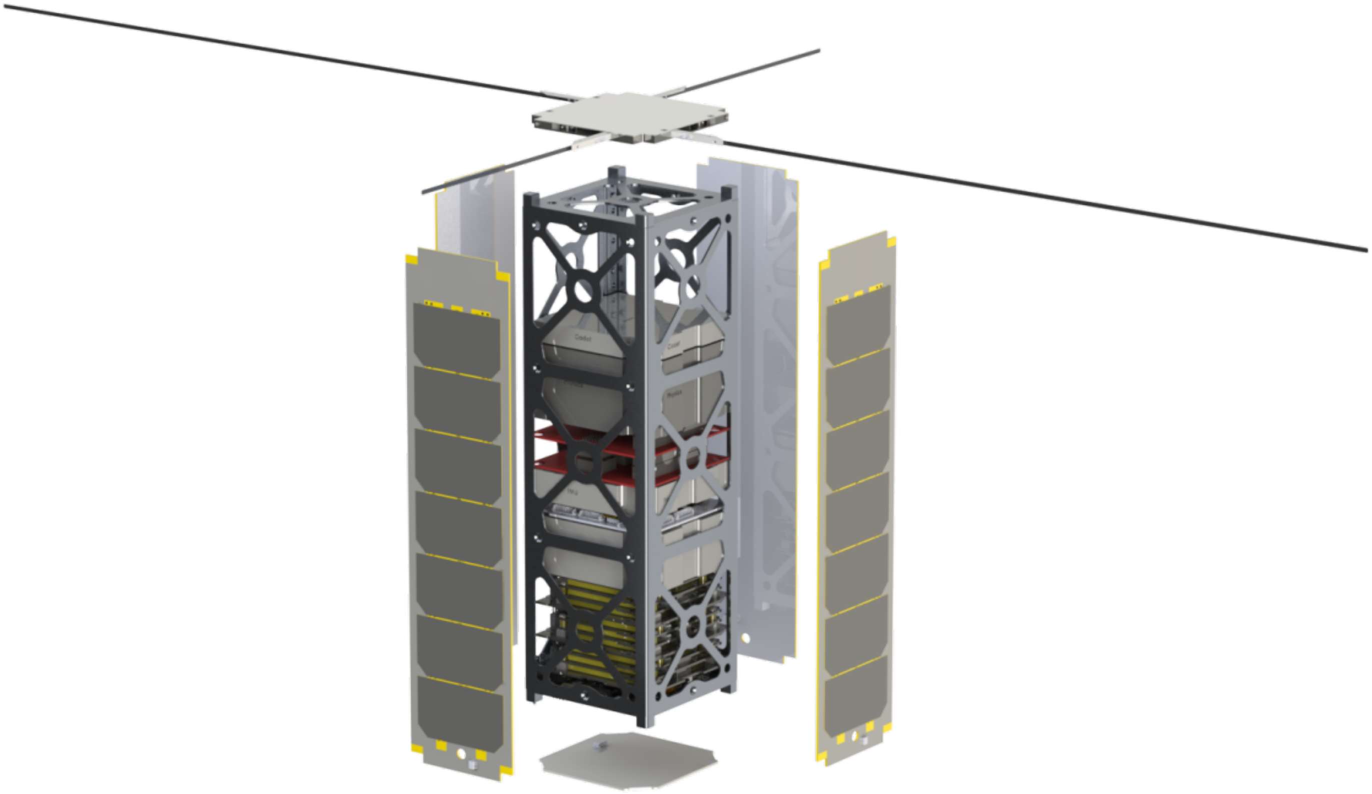

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NASA West Virginia
Space Grant Consortium

TMC² TECHNOLOGIES

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Simulation-to-Flight (STF-1) Proposal

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STF-1 Mission Parameters							
Mission Name	Mass	Cube Size	Desired Orbit	Acceptable Orbit Range	400 km @ 51.6 degree incl. Acceptable – Yes or No	Readiness Date	Desired Mission Life
STF-1	<4Kg	3U	Altitude 350-800 km	Any	Yes	09/13/2016	6 Months
			Inclination 70-85°	Any			

STF-1 Project Details						
Focus Area(s) (e.g. science, technology, education)	Student Involvement Yes or No	NASA Funding		Sponsoring Organization (s)	Collaborating Organization(s)	
		Yes or No	Organization		List	International - Yes or No
Science and Technology	Yes	Yes	IV&V	NASA IV&V / GSFC	WV Space Grant Consortium NASA WFF WVU WVSGC TMC Tech	No

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Abstract

The NASA Independent Verification and Validation (IV&V) Program's Independent Test Capability (ITC) team has developed a set of simulation technologies, called NASA Operational Simulator (NOS), which demonstrate a paradigm shift in the resources required for embedded software development. NOS technologies promote reusability of software simulation products across multiple missions, reducing mission cost and schedule risk. NOS technologies provide a means to simulate hardware in a software environment, enabling advanced verification and validation activities. NOS technologies have been utilized in the testing of several large spacecraft systems and subsystems to include the James Webb Space Telescope, Global Precipitation Measurement, Juno, and Deep Space Climate Observatory missions. On these missions, the technologies have demonstrated significant value to several user groups: software development, mission operations, verification and validation, test procedure development and check-out.

The primary objective of this mission, Simulation-to-Flight 1 (STF-1), is to demonstrate the utility of the NOS technologies across the CubeSat development cycle, from concept planning to mission operations. The STF-1 mission will demonstrate a highly portable simulation and test platform that allows seamless transition of mission development artifacts to flight products. This environment will be highly portable and will decrease the development time of future CubeSat missions by lessening the dependency on hardware resources.

The secondary objective of this mission is to advance engineering and physical-science research currently being developed at West Virginia University. Specifically, the STF-1 mission has three science goals in the areas of navigation, magnetosphere-ionosphere coupling and space weather, and the performance and durability of III-V Nitride-based materials.

As part of the science objective, the first goal of the STF-1 mission proposes to advance CubeSat navigation systems. This will be accomplished by demonstrating a new concept for inertial sensing that promises to enable a new class of inertial navigation performance by combining the output of many low-cost Microelectromechanical Systems (MEMS) Inertial Measurement Units (IMUs) to approximate the performance of a higher quality IMU. Additionally, the STF-1 mission will be equipped with a Fast, Orbital, Total Electron Content (TEC), Observables and Navigation (FOTON) software-defined multi-frequency Global Navigation Satellite Systems (GNSS) space receiver that promises to significantly improve the Precise Orbit Determination (POD) on CubeSat platforms.

The second STF-1 science goal is to measure dynamic properties of the ionospheric plasma system and verify the ionospheric coupling to the solar and magnetospheric drivers. The Earth's ionosphere is the natural plasma system nearest to Earth and has a large number of effects on telecommunications, navigation, defense, and other systems. Its two main drivers, solar and magnetospheric activity, strongly modulate the plasma environment in which the satellite operates. Plasma heating and particle acceleration involve a large number of mechanisms in plasma electrodynamics, many of which are not fully understood.

The final STF-1 science goal is to assess the performance and durability of III-V Nitride-based materials by developing a sensor platform with minimal shielding that improves and extends the sensing capability in the space environment. III-IV Nitride materials are known for their wide direct bandgaps and ability to form various alloys. These materials when synthesized along with apt combination of alloys are suitable semiconductors for a variety of applications in optoelectronics. These materials have high radiation hardness and can operate at extreme

temperatures, and as a result, these sensors are viable candidates for reliable materials and sensor platforms for future remote and automated space missions and applications.

The STF-1 mission will be the first CubeSat from the state of West Virginia and has adopted the slogan “The Time is Now! West Virginia in Space”. As a result, the STF-1 mission is motivated to inspire future generations in the areas of science, technology, engineering, and mathematics throughout the state. This will be accomplished primarily through partnerships with the West Virginia Space Grant Consortium and West Virginia University.

In order to realize all the STF-1 mission objectives, the STF-1 mission team will leverage proven COTS and GOTS technologies developed and lessons learned from other on-going CubeSat missions. Particularly, the STF-1 mission will be closely aligned with Goddard Space Flight Center’s (GSFC) Dellingr mission, a current CubeSat mission with similar mission characteristics and components. The STF-1 team will also utilize NASA Wallops Flight Facility environmental testing facilities, ground support equipment and resources to ensure proper check-out and operation of the CubeSat. Coupling these partners and resources with the development of a demonstrated CubeSat simulation and test platform and cutting-edge science yields a low-risk, high-impact next-generation CubeSat mission, Simulation-to-Flight 1.

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1 STF-1 Overview

The NASA Independent Validation and Verification (IV&V) Program, in collaboration with the West Virginia Space Grant Consortium (WVSGC) and West Virginia University (WVU) Departments of Physics, Computer Science and Electrical Engineering, and Mechanical and Aerospace Engineering, proposes to build the first CubeSat from West Virginia to be launched under the NASA CubeSat Launch Initiative (CSLI). The primary goal of Simulation-to-Flight 1 (STF-1) is to demonstrate the capabilities of the software-only simulation environments developed at NASA IV&V. The IV&V Independent Test Capability Team (ITC) team specializes in software-only-simulations of spacecraft. These simulations model hardware such that unmodified flight software (FSW) binaries can be tested in a test-as-you-fly “digital twin” simulator. This technology is beneficial to the NASA CubeSat/SmallSat community because it allows for software development and testing earlier in the project lifecycle, when access to the hardware is limited. Multiple developers and testers are able to use the ITC “digital twin” simulation environments simultaneously, whereas the hardware only allows for a single user. ITC developed simulators have demonstrated significant value for projects such as Global Precipitation Measurement (GPM) and the James Webb Space Telescope (JWST) projects. Lessons learned and technologies developed from ITC will be leveraged to produce a CubeSat simulation environment.

1.1 Areas of Focus

The **primary focus** area for this proposal will be a **technology demonstration** to prove that the STF-1 flight software (FSW) developed and tested in software-only-simulation will execute comparably during orbit. A basic STF-1 simulator will be developed and the flight software and its interfaces will be executed and tested on this simulator. Generic CubeSat hardware models will be developed and integrated. For example, a Global Positioning System (GPS) and Inertial Measurement Unit (IMU) model will be integrated into the STF-1 Software Bus to behave equivalently to the GPS/IMU hardware. From the FSW perspective, it will behave exactly as if it was receiving hardware GPS/IMU data. The GPS/IMU hardware interface will be abstracted so that the hardware can simply be connected without FSW source code changes. Whenever possible, the STF-1 hardware models will be generalized and not hardware vendor specific. Similar to how the NASA Goddard Space Flight Center (GSFC) Dellingr mission hardware and software designs will be open to the wider-NASA-community, the STF-1 team plans to release a CubeSat simulator to the NASA community. A **secondary focus** area will be **science** with instruments being provided by the West Virginia University Department of Physics and Astronomy, Department of Mechanical and Aerospace Engineering (MAE), and Lane Department of Computer Science and Electrical and Engineering (CSEE). These science focus areas are explained in more detail in Section 1.4.

STF-1 Area Of Focus	Priority	Lead Organization
Simulation-to-Flight Software for C&DH – NASA Operational Simulator Engine (with hardware emulators) flight technology demonstration	Primary Focus	NASA IV&V Program
Science Objective 1: GPS and IMU Science Experiments	Secondary Focus	WVU Dept. Mechanical and Aerospace Engineering
Science Objective 2: Magnetosphere-Ionosphere Coupling and Space Weather	Secondary Focus	WVU Department of Physics and Astronomy
Science Objective 3: Performance & Durability of III-V Nitride-Based Materials	Secondary Focus	WVU Lane Dept. of Computer Science & Electrical Engineering

1.2 NOS Engine – Simulation-to-Flight (STF) Middleware

The ITC team is experienced in software-only-simulation and has supported numerous NASA projects including GPM, JWST, and Deep Space Climate Observatory (DSCOVR). The commonality between each of these simulators is the ITC developed middleware referred to as NOS Engine, or *NASA Operational Simulator Engine*. The ITC team determined that a re-usable mechanism to ensure consistent and correct data passing among distributed components of a simulation system was needed. Each component has a unique notion of time, and when communication is received by one component another component may expect it to perform some action or respond within some amount of time from the transmission. NOS Engine solves this problem by providing these communication pathways in a synchronous manner where the sender and receiver each use message delivery as a point of synchronization. To further aid in testing using anomaly injection, final destinations can be "intercepted" in order to change the data sent to and sent back from the final destination. NOS Engine allows subsystems to be integrated into a larger system (such as a spacecraft simulator) while maintaining consistent data and time synchronization throughout. NOS Engine currently supports MIL-STD-1553B and Spacewire communication protocols and will include future support for CubeSats by adding Universal Asynchronous Receive Transmit (UART), Serial Peripheral Interface (SPI) and Inter-Integrated Circuit (I^2C) protocols.

1.3 System Architecture

STF-1 is a 3U CubeSat based upon the Goddard Space Flight Center (GSFC) Dellingr mission. The NASA IV&V Program will leverage Dellingr hardware and software design and implementation for STF-1. In order to contribute to the CubeSat community, all data from STF-1 as well as the simulation components will be shared within NASA.

1.3.1 Command and Data Handling (C&DH)

The primary processor onboard STF-1 will be the same as the Dellingr mission. This will allow any software or models written for STF-1 to be reused for future missions that will utilize the Dellingr Bus. The processor board, GOMSpace Nanomind, has a history of flight success, and a very low power demand. With a very low power C&DH system, STF-1 will be able to dedicate more power to its science experiments.

1.3.2 Power System

Solar panels will be mounted on each of the sides and bottom of the 3U structure. Each of the panels includes a coarse sun sensor (CSS) and three of the panels will include magnetorquers (MTQs), which will be discussed in Section 1.3.3. The 3U solar panels can provide up to 7.3W of power in direct sunlight and will be used to charge a Lithium-Polymer (LiPo) battery array. Three 30Whr batteries will be used to provide a total of 90Whr of power for all of the components within STF-1. The batteries each have their own microprocessor controlled heating system designed to maintain their nominal temperature range. A Commercial-Off-The-Shelf (COTS) electrical power system (EPS) will be used to control the charging of the batteries via the solar panels. This EPS will also provide power control of the individual science payloads, monitor over current and over/under voltages of the batteries, and provide a means to hard reset of all components on the spacecraft if necessary.

1.3.3 Attitude Determination and Control (ADC)

As previously mentioned, the solar panels provide embedded magnetorquers (MTQs) for attitude control and CSSs to aid in attitude determination. The MTQs take up no valuable space within the 3U structure, and are controlled via the processor board. A GPS receiver and an experimental IMU, specifically designed for the CubeSat platform, will be included for orbit measurements and attitude determination.

1.3.4 Communications

STF-1 will communicate with the CubeSat Ground Station Network at Wallops Flight Facility (WFF) over a government licensed UHF band. The system will include a flight-proven COTS UHF transceiver, the L3 Cadet, along with a deployable antenna mounted on the top of the 3U structure. This transceiver is half duplex, in which a command will be sent from Wallops to trigger a downlink, and has a data rate up to 3.0Mbps while consuming only 12W transmitting, 0.3W receiving, and 0.05W in standby mode. A “store and forward” function is also available allowing the 4GB memory buffer to be used to store data until a primary link is established. It is anticipated that National Telecommunications and Information Administration (NTIA) frequency licensing will be required; GSFC personnel experienced with the licensing process will assist with acquiring the required licenses in order to utilize the WFF Ground Network.

1.4 Science Objectives and Instrumentation

This section provides an introduction, goals, and plans for the three STF-1 science objectives. When appropriate, ancillary information such as images, timeline, budgets, and references are found in the appendices.

1.4.1 Science Objective 1: GPS/IMU Experimentation

1.4.1.1 Introduction

Like all CubeSat missions, STF-1 is characterized by tight constraints on mass, power, and volume. Despite these constraints, many CubeSat missions are demanding improved navigation performance as they attempt to accomplish more ambitious objectives. This has created a need for better inertial navigation capability on the CubeSat platform. Unfortunately, CubeSats are too small to support the conventional tactical grade Inertial Measurement Units (IMUs) that one might hope to fly, leading most CubeSat missions to fly Microelectromechanical Systems (MEMS) sensors. While small enough to fit within a CubeSat’s mass, power, and volume budget, MEMS IMUs have relatively poor performance and quickly become a limiting factor in navigation system performance. To help address this pervasive problem, the STF-1 mission proposes to demonstrate a new concept for inertial sensing that promises to enable a new class of inertial navigation performance on the CubeSat platform.

Moreover, while current state-of-the-art Global Positioning System (GPS) Precise Orbit Determination (POD) for Low-Earth Orbiting (LEO) spacecraft has achieved 1-cm level accuracy [1], POD of a CubeSat platform has only been demonstrated at the 1-10 meter level. As more advanced CubeSat instruments with rigorous scientific objectives are matured, there is a need for advancing the accuracy of GPS POD on the CubeSat platform. In 2008, the first CubeSat mission to demonstrate dual-frequency GPS tracking was the CanX-2 mission [3]. Can-X2 flew a COTS Novatel OEM4-GL receiver, and was unable to retrieve useable carrier-phase tracking data. Nonetheless, CanX-2 successfully demonstrated meter-level post-processed orbit determination on a constrained nano-sat platform. Acknowledging the need for a space hardened CubeSat Global Navigation Satellite Systems (GNSS) receiver, 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 receiver that is specifically designed for the CubeSat form factor (0.5U volume) [4]. The FOTON receiver has recently successfully demonstrated dual-frequency carrier-phase tracking on a sounding rocket flight [4]. STF-1 will be flying a FOTON that has been donated to the mission.

1.4.1.2 Research Goals

The fundamental idea behind the prototype IMU system is that the output of many low-cost MEMS IMUs may be combined to approximate the performance of a higher quality IMU. The technology underlying the IMU cluster board that will be flown on STF-1 was matured through a NASA SmallSat Technology Partnership between WVU, Marquette University, and NASA Johnson Space Center [5]. Austin Satellite Design, a small business, which now commercially sells the FOTON GPS receiver, has agreed to contribute a FOTON for integration in the STF-1 mission. Furthermore, WVU researchers have years of experience with using JPL's GPS Inferred Positioning System and Orbit Analysis and Simulation Software (GIPSY-OASIS) for GPS POD, and have been granted a source-code software license for academic research use. Thus, the STF-1 mission provides an excellent opportunity to advance the state-of-the-art CubeSat POD by leveraging both the FOTON receiver and existing expertise with GIPSY-OASIS.

1.4.1.3 Plan and Instrumentation

The current version of the IMU board has an approximate mass of less than 70g and requires 1.9 W. As part of an on-going effort, the team is working to reduce both the mass and power of this new system. A second generation of the IMU board is presently under development and should be ready for testing later in early 2015. Thus, the goal of this IMU experiment is to mature the technology associated with processing large clusters of redundant MEMS IMUs on the CubeSat platform. The FOTON GPS receiver has been acquired by WVU and requires no further hardware development.

1.4.2 Science Objective 2: Magnetosphere-Ionosphere Coupling and Space Weather

1.4.2.1 Introduction

The Earth's ionosphere is the natural plasma system nearest to Earth and has a large number of effects on telecommunications, navigation, defense, and other systems. Its two main drivers, solar and magnetospheric activity, strongly modulate the F-region, the satellite's plasma and electrodynamic environment. Plasma heating and particle acceleration involve a large number of mechanisms in plasma electrodynamics many of which are not well understood. The STF-1 mission provides an environment where fundamental ionospheric physics mechanisms can be tested and compared with direct measurements of a complex plasma system. At the same time, measuring particle and wave properties is essential for understanding the spacecraft's charged-particle environment.

1.4.2.2 Research Goals

Auroral and Polar Regions: The most important electro-dynamic interactions take place at high geomagnetic latitudes (65-75°) where the ionosphere couples directly to the dayside magnetosphere and the plasma sheet.
<u>Plasma Effects:</u> Quiet convection and storm-time activity determine the plasma thermodynamic properties. By mapping these properties in geomagnetic coordinates the dynamic changes in ionospheric convection and heating can be determined [6]. In addition these diagnostics will be used to monitor the spacecraft's immediate plasma environment.
<u>High-energy Particle Precipitation</u>*:* Electron flux at keV energies is used to quantify particle precipitation into the auroral region. The intensity of precipitation intensity and its spatial patterns are extremely useful for understanding the interaction of the ionosphere with the dayside magnetosphere and the plasma sheet. Particle acceleration in auroral arcs is a characteristic signature of energetic events such as magnetic storms, convection, and substorms [7]. Correlating ionospheric activity and distribution with the solar-wind and magnetospheric activity measured in space and from ground arrays is a powerful technique which will be used to quantify the ionospheric coupling and understand fundamental mechanisms of ionospheric energization [8].
Radiation Belts and Space Weather: At lower geomagnetic latitudes (40-65°) the ionosphere-plasmasphere system couples to the inner magnetosphere and its radiation belts. Relativistic electrons in the outer belt can produce surface charging and debilitating effects on spacecraft electronics. Space weather effects result in single-event upsets and phantom commands in spacecraft. Thus the energy content, spatial distribution and dynamics of the relativistic electron flux is crucial in understanding how the plasma environment produces these space weather effects. Ultra-low-frequency and very-low-frequency waves' scatter energetic electrons in pitch angle resulting in enhanced precipitation in the form of microbursts [9], [10]. The intensity and spatial distribution of microbursts is a

major research question [11], and has important applications in spacecraft design. The time-dependence of electron acceleration and loss has been correlated with larger-scale events such as the recovery phase of magnetic storms [12]. By comparing energetic particle precipitation and its spatial distribution with simultaneous solar wind and magnetospheric activity the properties and dynamic response of the microbursts to the large-scale solar wind driving and the excitation of low-frequency waves will be measured [13], [14].

1.4.2.3 Plan and Instrumentation

The four instruments below will be utilized to monitor Magnetosphere-Ionosphere Coupling and Space Weather. *(1) Plasma density and temperature.* A Langmuir probe has been built, tested, and flown in the RockSat-C 2014 sounding rocket mission. *(2) Plasma waves.* A radio sounder has been built and tested. The transmitter can excite plasma and cyclotron resonances at F-region altitudes to provide plasma density and magnetic field measurements. An early version of the sounder was flown in the RockSat-C 2012 mission. *(3) Precipitating electron flux.* An array of 3 particle counters with energy thresholds of 20, 50, and 100 keV will be used to measure the electron precipitation due to auroral acceleration or radiation-belt loss. The 50-keV detector has been flown annually in sounding rocket missions from 2009 to 2014. *(4) Sodium and iron airglow narrowband emissions.* Sporadic metal layers of the upper atmosphere modify its electrical and thermal conductance. Dust-plasma interactions are important for the mesosphere and thermosphere. A COTS photometer will be used to measure emissions of the sodium and iron dust layers and map their geographic distributions. The experiment was flown on an E-region sounding-rocket mission in June 2014.

1.4.3 Science Objective 3: Performance and Durability of III-V Nitride-Based Materials

1.4.3.1 Introduction

With the increasing demand for remote and automated missions to be carried out in space and for space applications, reliable materials and sensor platforms are required. An optoelectronic sensor module is envisioned that can generate and detect a wavelength of light that can be used in such automated missions in space environment. The advancements in material sciences and optoelectronics have propelled the use of novel materials for generation and detection of various wavelengths of light. The wavelength range best for this sensor is 380 - 450 nm [15], as it is sufficiently close to the edge of the solar spectrum to avoid signal saturation. These wavelengths of light in the visible spectrum are usually considered the hardest to generate.

III-V nitride materials are known for their wide direct bandgaps and the ability to form various alloys [16]. These materials, when synthesized along with apt combination of alloys, show promise to generate blue light [17], [18] and are suitable semiconductors for a variety of applications in optoelectronics. The reason behind choosing the family of III-V Nitride materials like gallium nitride (GaN), indium gallium nitride (InGaN), etc. in comparison to off the shelf components involving silicon based technology is due to their high radiation hardness and the ability to operate at extreme temperatures [19], [20], [21]. The ability to engineer their bandgaps over the entire range of the visible range of the electromagnetic spectrum makes these materials suitable semiconductors in making a variety of optoelectronic devices. Due to harsh radiation and extreme temperatures observed in space environment, the sensors need to be shielded appropriately for reliability and functionality of the devices [22]. In most cases, the shielding helps protect the underlying electronics and prolong their usage in space. However, the shielding for an optoelectronic sensor involving light-emitting diodes (LEDs) and photodiodes (PDs) acts more like an obstruction to the path of light and does not help in accurate detection of the signals. Thus, a sensor platform is proposed with minimal shielding that improves and extends the sensing capability in the space environment. With this CubeSat launch, the intent is to test the durability of the materials used in the sensor (GaN, InGaN etc.) and also the performance of the core components of the sensor (LEDs and PDs) at various conditions of space atmosphere.

1.4.3.2 Research Goals

(1) Develop sensors with minimal shielding for space applications using III-V nitride materials. (2) Track the characteristic changes in III-V nitride material properties (current-voltage characteristics (IVs), Optical Power) (3) Test the effects of harsh temperature and radiation exposure on the materials (IVs and Optical Power) (4) Test the functionality of the devices under various conditions (LEDs – ON/OFF, Transistors – Switching, Sensor performance) (5) Compare the performance of the devices with commercial components (6) Study the effect of space environment with various configurations of shielding on III-V nitride materials (none, minimal and normal)

1.4.3.3 Plan

The technical plan for testing the durability and performance of the devices is to utilize III-V nitride materials for fabricating the core elements of the sensor (LEDs, PDs, etc.). West Virginia University (WVU) has extensive research experience in the growth of high-quality epitaxial substrates using metal-organic vapor phase epitaxy (MOVPE) [23], [24], [25]. The fabrication of a variety of optoelectronic device structures is carried out in the state-of-the-art cleanroom environment managed by shared research facilities (SRF) at WVU. Previous efforts in the growth, fabrication and characterization of LEDs and PDs have helped to precisely produce reliable materials and devices [26]. Because of WVU's experience in research and development in LEDs and PDs, it is planned to utilize existing growth and fabrication methods to test LED and PD modules in this CubeSat launch. The plan is to send arrays of LEDs and PDs grown and fabricated at WVU along with selection circuitry containing high electron mobility transistors (HEMTs).

2 Eligibility and Reviews

2.1 Relevance to NASA Strategic Goals and Objectives

The STF-1 team has identified relevance with the NASA strategic goals/objectives and technology areas as shown in the table below. The areas of focus below were evaluated based on their benefit to NASA and their relevance to the NASA Strategic Goals during the Merit review.

Area of Focus	NASA Strategic Goals	Technology Areas	Details
STF-1 Software for C&DH – NASA Operational Simulator (NOS) Engine	Strategic Goal 1.7 Strategic Goal 3.3	TA 11: Modeling, Simulation, Information Processing	The STF-1 mission will result in the development of a C&DH functional simulator that will be functionally identical to the STF-1 hardware/software & provide a V&V environment. The STF-1 team plans to release this simulator to the NASA community.
Science Objective 1: GPS and IMU Hardware & Science Experiments	Strategic Goal 1.4 Strategic Goal 2.3 Strategic Goal 3.3	TA-05: Communication and Navigation Systems	The GPS and IMU payloads both offer an increased level of science fidelity at the CubeSat form factor.
Science Objective 2: Magnetosphere-Ionosphere Coupling	Strategic Goal 2.2	TA-08: Science Instruments, Observatories, and Sensor Systems	Earth's geomagnetic environment is intimately coupled to near-Earth space and to the upper atmosphere of the planet. Plasma, energetic-particle, and wave experiments on a polar-orbiting spacecraft can measure key properties of the coupling mechanisms.

Science Objective 2: Space Weather	Strategic Goal 1.4	TA-08: Science Instruments, Observatories, and Sensor Systems	The daily and seasonal variations of the planet's space environment are often dramatic and difficult to forecast. By comparing plasma measurements with statistical space weather models we can improve our understanding and predictions of the state of the ionosphere.
Science Objective 3: Performance and Durability of III-V Nitride-Based Materials	Strategic Goal 1.7	TA 10: Nanotech and TA 4: Robotics	From this research, novel nano-scale optoelectronic devices will aid towards the development of advanced electronic and sensor technologies for space applications.
Education Objective 1: STEM	Strategic Goal 2.4	N/A	WVU will involve graduate and undergraduates in the development of the STF-1 mission. IV&V is coordinating with the WV Space Grant.

2.2 Merit Review

The merit review for the STF-1 mission was held 11/7/2014, via electronic submission from each of the reviewers. Electronic submission was necessary due to the distributed locations of the review committee. Reviewers were provided with a review packet including, pertinent information from this document, a presentation of technical data, and a review template. The presentation and template are included in the appendix.

Proposal Assessment Factors	Details and Responses
Merit review process	The review committee was selected based upon the qualifications of each member. Information on the STF-1 mission was provided to each reviewer, and responses were collected throughout the following week. Based on the review, a selection was made at the IV&V program to support the STF-1 mission.
Competitive or non-competitive	The review was non-competitive, as the mission will be the first of its kind from the IV&V program
Review committee members and qualifications	Marcus Fisher – Associate Director, NASA IV&V Program (Merit Review Lead) Mike Johnson – Chief Technologist AETD, NASA GSFC Tom Johnson – NASA GSFC/WFF Small Satellite Manager
Merit assessment factors	The mission was assessed based on the strength of the proposed mission concepts, with regards to scientific and technical quality, as well as the overall alignment of the mission in addressing the science and technology objectives identified in the NASA Strategic Plan. In addition, the mission was evaluated based on relevance to the NASA IV&V Program and the NASA GSFC CubeSat community.
Outcome of the merit review	The review committee determined that the mission was properly aligned with the goals defined in the NASA Strategic Plan, and that each of the mission objectives provided a key scientific and/or technological benefit. Based upon responses for this review, the NASA IV&V program, under advisory of the merit review lead, agreed to contribute $100,000 in support of the STF-1 mission.
Respondent actions	Due to the outcome of the merit review no actions were required

2.3 Feasibility Review

The feasibility review for the STF-1 mission was held 11/7/2014, via electronic submission from each of the reviewers. Electronic submission was necessary due to the distributed locations of the review committee. Reviewers were provided with a review packet including, pertinent information from this document, a presentation of technical data, and a review template. The presentation and template, which were provided to the committee, are included in the appendix.

Proposal Assessment Factors	Details and Responses
Feasibility review process	The review committee was selected based upon the individual expertise of each member. Information on the STF-1 mission was provided to each reviewer, and responses were collected throughout the following week. Based on the review the STF-1 mission team made adjustments to the mission budget and schedule to properly address the concerns of the reviewers. All risks and design implementation suggestions were documented and will be addressed for future design reviews.
Review committee members and qualifications	Tom Johnson – NASA GSFC/WFF Small Satellite Manager (Feasibility Review Lead) Alan Cudmore – NASA GSFC CFS & Dellingr C&DH Mark Suder & Steve Yokum – Systems Engineers, NASA IV&V Program Cinnamon Wright – Aerospace Engineer, Navigation and Mission Design NASA GSFC Damon Bradley – DSP Tech Lead, NASA GSFC Darryl May – Aerospace Engr., NASA JSC Brenda Dingwall – Technology PM, NASA WFF Douglas Rowland – Astrophysicist, NASA GSFC
Feasibility assessment factors	The technical implementation of the STF-1 mission was assessed based on the feasibility, resiliency, and probability of success. In addition the feasibility of the mission was assessed based upon the proposed schedule and cost estimates.
Mission organization and team assessment	The organization of the team leverages each members own expertise, whereas each science objective is led by experts in research and education, and the CD&H, power, and communications systems are led by NASA IV&V. Reviewers note that it would be useful to have a CubeSat expert as part of the team, however the shadowing of the GSFC Dellingr mission and support from WFF will mitigate this risk. (The appendix provides an illustration of the team's organization.)
Technical development risk assessment	The committee's concerns with technical development were the need for engineering test units (ETUs) and better power generation. To address these concerns, the team added ETUs for the C&DH system and a plan for scheduling of science experiments is being developed. In the event of further donations, deployable solar panels can be added for greater power generation and the science experiments schedule can be improved.
Technology development risk assessment	The mission plans to leverage as many COTS components as possible, however the science experiments will be in-development. The concern is a problem with one experiment offsetting the schedule or affecting the budget of the entire mission. To address this concern, de-scoping plans are being developed such that a secondary objective can be minimized or lost and the mission can still succeed. This is also mitigated by the fact that each of the technologies being included have been in development before this mission was proposed. That means instead of starting from the initial development phase, the technology only needs to be adapted to the CubeSat environment.

Probability of success assessment	The consensus of the committee is that the mission is deemed feasible. Certain reviewers voiced concerns that too many secondary objectives are included; however, the failure of a secondary objective will not hinder the success of the mission's primary objective. Each secondary objective's definition of success has been reassessed. In addition, the experiments were initially selected by the IV&V team based on need for orbital testing, as well as a high probability of success.
Financial support assessment	Cost estimates were provided to all reviewers. As previously mentioned, ETUs were not included; however there was still sufficient funding in the budget. Reviewers mentioned that the cost estimates were conservative in that spare parts were not included. The reserve in the budget will cover individual spares as necessary. The STF-1 team is still receiving funding commitments from other parties.
Outcome of feasibility review	Upon receipt of all review committee responses, the STF-1 team held a meeting on 11/17/2014 to address the comments and concerns in the review. Since the mission was deemed feasible by the committee, and had passed merit review, risk assessment and detailed design meetings have been scheduled to continue work on the mission. The team will continue detailed design in preparation of selection for the CSLI.
Respondent actions	One concern of the review committee was that the proposed schedule was too aggressive when relying on COTS components, and custom designed components such as those being developed for the III-V Nitride experiment. To address this concern the schedule was adjusted to account for lead time in acquiring/developing these components. A de-scoping plan is being developed to ensure mission success in the event of a single objectives failure

2.4 Conformance to Launch Services Requirements

STF-1 plans to be to be launched as a secondary payload on a launch vehicle (LV) or deployed from the International Space Station (ISS) upon selection for the CubeSat Launch Initiative. STF-1 will comply with all launch services requirements as specified in *LSP-REQ-317.01*. The 3U structure of STF-1 will contain all components and wiring, and will not exceed the size requirements of 34cmx10cmx10cm, with a total weight less than 4kg. All materials used will be selected in accordance with *NASA-STD-6016*. STF-1 will have no propulsion system, no pressurized vessels, no radioactive materials, and no explosive devices. All electrical systems will be powered off until the deactivation of a separation switch when deployed from the dispenser. The antenna on STF-1 will be deployed 30 minutes after the on orbit deployment, although no transmission will occur until after 45 minutes. Environmental testing will be performed in accordance with *LSP-REQ-317.01* and *MIL-STD-1540C* at Wallops Flight Facility.

3 Mission Details

3.1 Development Schedule

The following table captures the projected milestones and dates for the STF-1 mission. The STF-1 mission team will conduct a series of reviews to evaluate the progress of the STF-1 development and receive feedback on overlooked issues, alternate approaches, and risks. A more detailed schedule is provided in the Appendix.

Milestone	Dates
Project Start	03/02/2015
Design Review	04/27/2015
System Table Top Review	04/19/2016
Integration and Test	04/19/2016 – 08/15/2016
Pre-Environmental Table Top Review	08/16/2016
Launch Ready / Pre-Ship Review	09/13/2016

3.2 Mission Parameters and Project Details Tables

Please reference Page i for mission parameters and project details tables. An inclination in the range of 70-85°would be preferred to improve data collected for Science Objective 2, although any launch opportunity will be acceptable. Orbit altitude and inclination will not affect the success of any objective.

3.3 Budget

3.3.1 Operating Budget

Items	Cost
Chassis (3U)	$3,050.00
Power Systems (Battery, Solar Panels, EPS)	$48,050.00
C&DH (including 1 ETU)	$12,100.00
Communications	$35,000.00
Miscellaneous (Wire, Connectors, Shielding)	$3,000.00
Environmental Testing Facility Operation (Wallops)	$15,000.00
Science Objective 1: FOTON GPS and MEMS IMU Hardware (FOTON provided no-cost)	$3,000.00
Science Objective 2: Particle Precipitation and Space Weather	$3,900.00
Science Objective 3: Performance and Durability of III-V Nitride-Based Materials	$750.00
Total	$123,850.00
Available Budget	$175,000.00
Reserve	$51,150.00

3.3.2 In-Kind Contributions

The following items are labeled as "in-kind" contributions. These represent existing hardware, software, and services that will be provided to the STF-1 team at no cost.

Items	Purpose	Impact
Funding Commitments (Letters Provided in Appendix)	STF-1 Components	Provides funding for all needed CubeSat components
Fabrication Supplies (Mask set, chip carriers, epoxies, etc.)	Science Objective 3	Cost Reduction
Core Flight System and Dellingr Core Flight System (CFS) software applications	C&DH Subsystem Support	Foundation for C&DH subsystem; Reduces schedule risk; Cost Reduction
NOS Engine Development	C&DH Subsystem Support	Foundation for simulation technology & reduces schedule risk; Cost Reduction
Space Hardened FOTON GPS	Science Objective 1	Cost Reduction

4 Appendix: References

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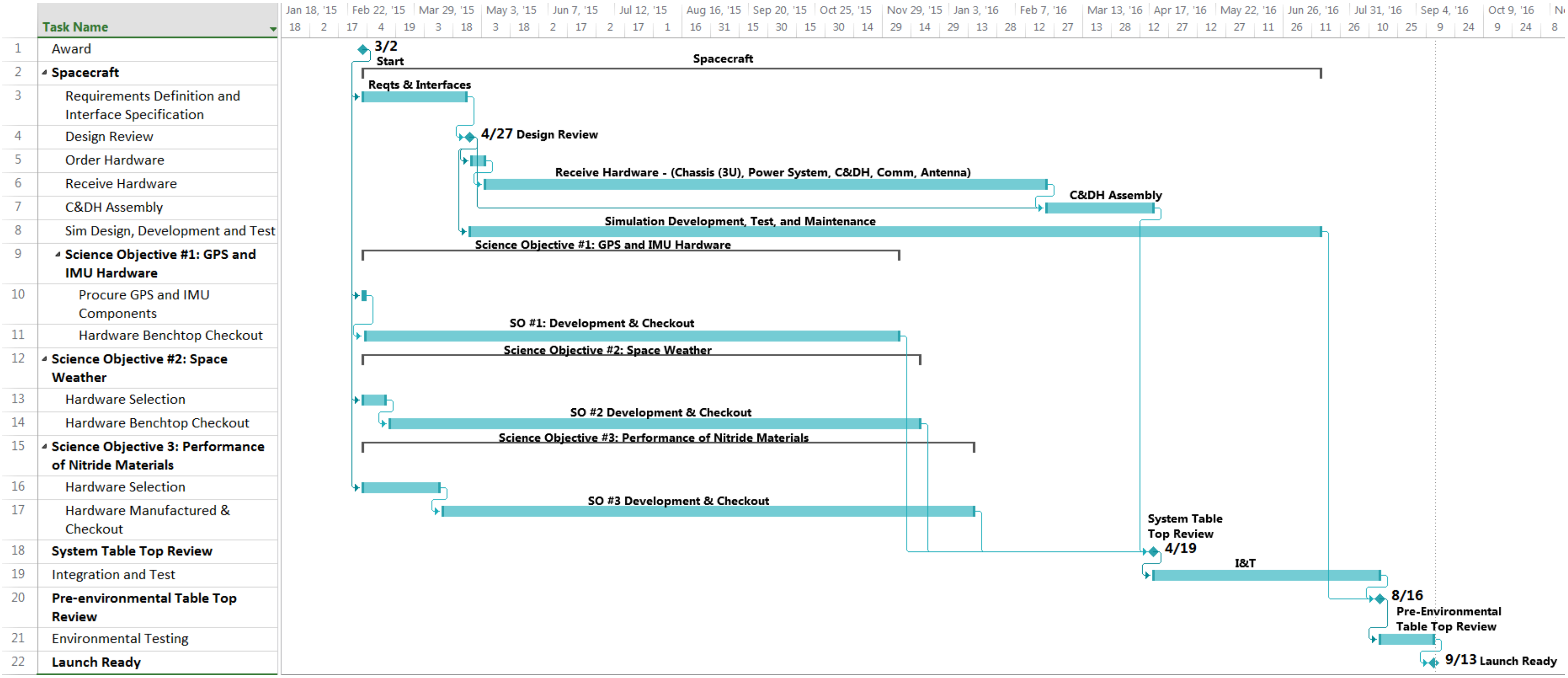
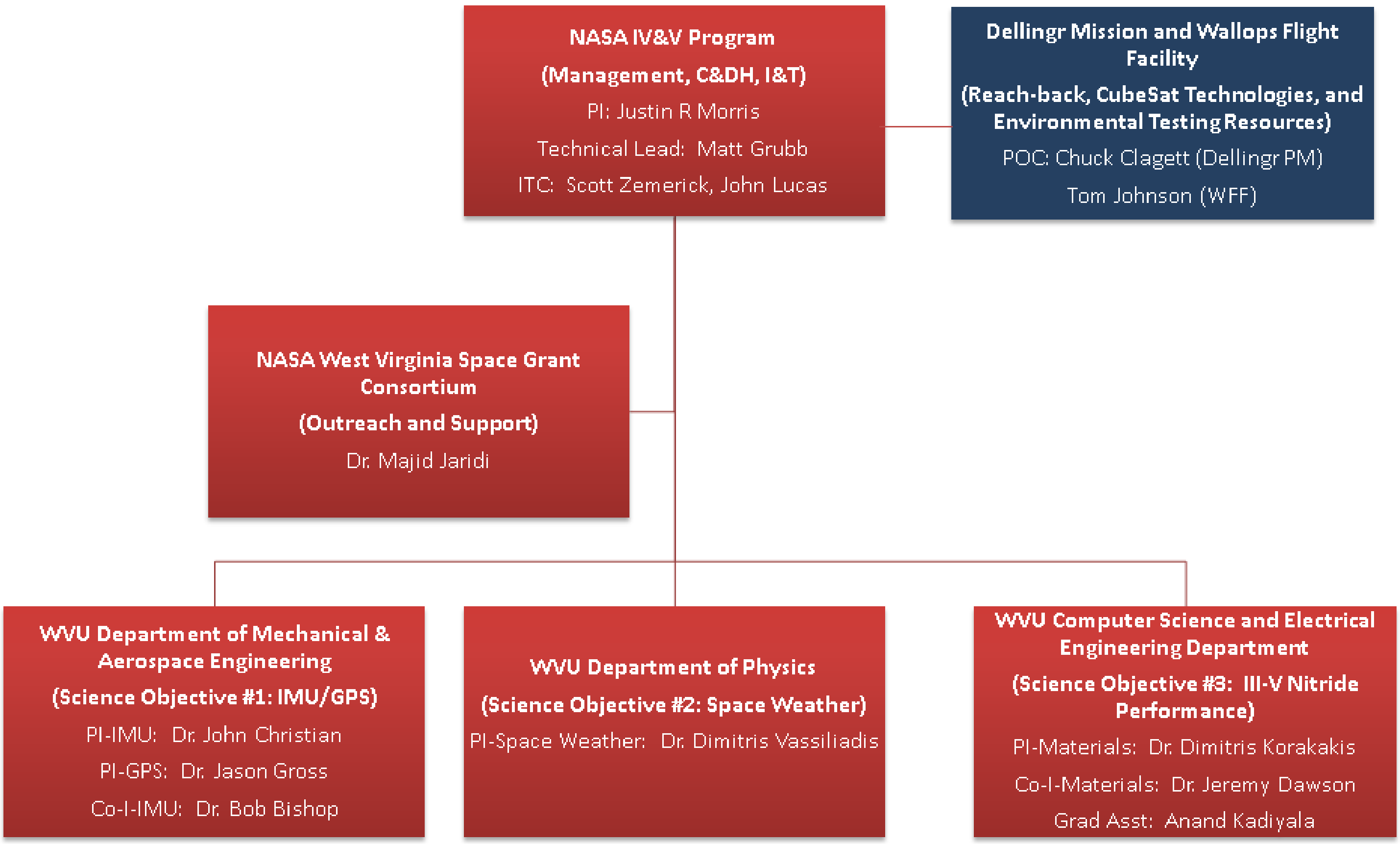
5 Appendix: Acronym List

ADC	Altitude Determination and Control
CSEE	Computer Science & Electrical Engineering
CSS	Coarse Sun Sensor
C&DH	Command & Data Handling
COTS	Commercial-off-the-Shelf
DSCOVR	Deep Space Climate Observatory
EPS	Electrical Power System
FSW	Flight Software
GaN	Gallium Nitride
GOTS	Government-off-the-Shelf
GPM	Global Precipitation Measurement
GPS	Global Positioning System
GSFC	Goddard Space Flight Center
HEMTs	High Electron Mobility Transistors
JWST	James Webb Space Telescope
LEDs	Light-Emitting Diodes
LV	Launch Vehicle
IMU	Inertial Measurement Unit
InGaN	Indium Gallium Nitride
ITC	Independent Test Capability
IV	Current-Voltage Characteristics
IV&V	Independent Verification & Validation
I2C	Inter-Integrated Circuit
MAE	Mechanical and Aerospace Engineering
MTQs	Magnetorquers
NOS	NASA Operational Simulator
PDs	Photodiodes
SPI	Serial Peripheral Interface
STF-1	Simulation to Flight - 1
TMC	TMC Technologies
UART	Universal Asynchronous Receiver/Transmitter
UHF	Ultra High Frequency
VHF	Very High Frequency
ULF	Ultra Low Frequency
VLF	Very Low Frequency
WFF	Wallops Flight Facility
WVSGC	West Virginia Space Grant Consortium
WVU	West Virginia University

6 Appendix: STF-1 Mission Schedule



7 Appendix: STF-1 Mission Team Organization



8 Appendix: Letters of Commitment

National Aeronautics and
Space Administration
Goddard Space Flight Center

NASA IV&V Facility
100 University Drive
Fairmont, WV 26554

November 21, 2014

SUBJECT: Proposal entitled, "Simulation-to-Flight (STF-1) Proposal"

REFERENCE: NASA Announcement of CubeSat Launch Initiative, dated July 31, 2014

The NASA Independent Verification and Validation (IV&V) Program is pleased to support the "Simulation-to-Flight Proposal". The primary objective of the proposal is to demonstrate that flight software developed and tested in software-only simulation environment will execute comparably during orbit. The NASA IV&V Program is fully committed to allowing the use of the JSTAR laboratory as well as $100,000 in funding for goods and services.

If you have any questions, please feel free to contact me at (304) 367-8387.

Sincerely,

Gregory Blaney
Director, NASA IV&V Program

NASA
West Virginia Space Grant Consortium
G-68 Engineering Sciences Building
West Virginia University, PO Box 6070
Morgantown, WV 26506-6070
(304) 293-4099 www.wvspacegrant.org

TO: Dr. Eugene Cilento, Dean, Statler College
Dr. Jacky Prucz, Chair, Mechanical and Aerospace Engineering
Dr. Brian Woerner, Chair, Lane Dept. of Computer Science and Elec. Eng.

FROM: Majid Jaridi MJ

SUBJECT: CubeSat Proposal

DATE: November 10, 2014

I am writing to confirm the financial commitment provided by the Statler College, Mechanical and Aerospace Engineering Department, and the Lane Department of Computer Science and Electrical Engineering in support of the proposal entitled "Simulation to Flight (STF-1)" being submitted by a team from WVU and NASA IV & V Facility in response to the NASA announcement of CubeSat Initiative number NNH14HEOMD001L.

Our commitment of resources will take effect once the WV proposal is accepted by NASA and the work of designing and building of the CubeSat starts.

Thank you.

Source	Faculty Release Time and Graduate Student Support	Cash (Supplies and Travel)	Signature
LCSEE Dept.	$23,966	$12,500	Brian D. Woerner
MAE Dept.	$59,000	$12,500	[signature]
Statler College		$25,000	Eugene V. Cilento 11/10/14
WV SG Consortium		$10,000	Majid Jaridi
TOTAL	**$82,966**	**$60,000**	

WestVirginiaUniversity
OFFICE OF THE ASSOCIATE VICE PRESIDENT FOR RESEARCH

November 10, 2014

Majid Jaridi, Ph.D.
Director, NASA WV Space Grant Consortium/NASA WV EPSCoR Professor,
Industrial Engineering Department
G-68 Engineering Sciences Building
West Virginia University
Morgantown, WV 26506-6070

Dear Majid:

If funded by NASA, the Office of Research will provide $10,000 in support of your proposal entitled "'Simulation to Flight (STF-1)" being submitted by a team from WVU and NASA IV & V Facility in response to the NASA announcement of CubeSat Initiative number NNH I4HEOMD00IL.

Sincerely, Earl Scime
Interim Associate Vice President for Research

Department of Physics
West Virginia University
Eberly College of Arts and Sciences

Res. Assoc. Prof. Dimitris Vassiliadis
WVU Department of Physics and Astronomy
135 Willey St., Campus Box 6315
Morgantown, WV 26506-6315

November 2, 2014

Mr. Justin Morris
NASA IV&V Independent Test Capability
100 University Dr.
Fairmont, WV 26554

Dear Mr. Morris,

I am writing in support of your proposal to NASA entitled *Simulation-to-Flight* and prepared in response to the CubeSat Launch Initiative (announcement NNH14HEOMD001L). As part of this collaboration, and provided the proposal is accepted, we will make the following available:

- $5,000 for components and testing equipment dedicated to the plasma experiments.
- A call to graduate and STEM undergraduate students to participate in the development team, including participants in previous spaceflight projects.
- Scheduled use of a state-of-the-art helicon device in the WVU Plasma Lab directed by Prof. Earl Scime. The device provides a range of relevant density and temperature environments. The WVU-IV&V cubesat team may use the space plasma simulation chamber to test plasma instrumentation for ionospheric missions in coordination with the lab staff.
- High-quality machine shop services for components and structures.
- Lab space for payload integration and testing used for student projects flown on ionospheric missions. The payload lab includes a 5-ft chamber for plasma and wave tests.
- Development equipment available from previous flights.

The WVU plasma groups look forward to working with IV&V and West Virginia Space Grant, and I wish you the best for your endeavors in this project.

Sincerely,

Dimitris Vassiliadis

Cc: Prof. E. Scime, Prof. M. Jaridi

Telephone: (304) 293-4920 Fax : (304) 293-5732 E-mail : dimitris.vassiliadis@mail.wvu.edu

National Aeronautics and Space Administration
Goddard Space Flight Center
Greenbelt, MD 20771

November 18, 2014

Reply to Attn of: 596

SUBJECT: Proposal entitled, "Simulation-to-Flight (STF-1) Proposal"

REFERENCE: NASA Announcement of CubeSat Launch Initiative, dated July 31, 2014

The new features and enhancements being made to GSFC's Core Flight System (CFS) and other CubeSat development activities in support of the Dellingr CubeSat mission will help reduce schedule risk on the Simulation-to-Flight (STF-1) CubeSat mission. In addition, the work proposed by the STF-1 mission team will help future CubeSat efforts with respect to development, integration and test activities.

If you have any questions, please feel free to contact me at (301) 286-2438.

Sincerely,

Charles E. Clagett

Charles E. Clagett
Dellingr Project Manager

9 Appendix: Merit Review Approval Letter

From: Marcus S. Fisher
Sent: Thursday, November 20, 2014 12:28 PM
To: Justin R. Morris
Cc: Matthew D. Grubb
Subject: RE: Simulation to Flight (STF-1) Merit Review

Yes, they look to be addressed, please move forward
--Marcus

Marcus S. Fisher
Associate Director

NASA IV&V Program
100 University Dr.
Fairmont, WV 26554

O: +1 (304) 367-8337
C: +1 (304) 612-4993
F: +1 (304) 367-8203

From: Justin R. Morris
Sent: Wednesday, November 19, 2014 3:06 PM
To: Marcus S. Fisher
Cc: Justin R. Morris; Matthew D. Grubb
Subject: RE: Simulation to Flight (STF-1) Merit Review

Marcus,

Please find attached an updated copy of the CSLI proposal which addresses both the merit and feasibility reviewer comments. Particularly, these are addressed in Sections 2.2 and 2.3. Please let us know if you feel that the team has properly addressed all of the communicated risks and approve moving forward with the STF-1 proposal submission.

Thank you!
Justin

Justin R Morris
Computer Engineer
Phone: (304)367-8260
Mobile: (304)376-3754

10 Appendix: Merit and Feasibility Review Templates

STF-1 Merit Review **Date:**

1. **Reviewer Details:**

   Name and Title:
   Expertise:

2. **Please provide your assessment of the strength of the proposed mission concepts with regards to scientific and technical quality.**

3. **Please provide your assessment of the overall alignment of the mission in addressing the science and technology objectives identified in the NASA Strategic Plan (www.nasa.gov/sites/default/files/files/2014_NASA_Strategic_Plan.pdf)**

4. **Please provide your assessment of the technical design feasibility within the proposed cost and schedule.**

5. **Please provide any additional thoughts or recommendations on the STF-1 mission.**

STF-1 Feasibility Review

Date:

1. **Reviewer Details:**
   Name and Title:

   Expertise:

2. **Please assess the technical feasibility, risk and probability of success of the proposed mission.**

3. **Please assess the preliminary schedule and cost estimates in regards to ability to support the proposed mission.**

4. **Please assess the teams' roles, experiences, and expertise as well as organization structure of the mission team.**

5. **Please identify any technical development risks and/or concerns**

6. **Please identify any critical technology development areas in regards to flight readiness. (Note: Team plans to utilize proven CubeSat technologies for this mission as well as leverage Dellingr architecture and CFS applications developed to support Dellingr)**

7. **Identify any areas that reduce the probability of mission success (technical, managerial, financial)**

8. **Please provide any additional thoughts or recommendations on the STF-1 mission.**

11 Appendix: Resumes

Justin R Morris

NASA IV&V Program
100 University Drive, Fairmont, WV 26554
Justin.R.Morris@nasa.gov
304-367-8260

Education

M.S. Electrical Engineering, West Virginia University, 2011
B.S. Computer Engineering, Summa Cum Laude, West Virginia University, 2006
B.S. Electrical Engineering, Summa Cum Laude, West Virginia University, 2006

Professional Experience

NASA Independent Verification and Validation (IV&V) Program, 2008-Present
Independent Test Capability (ITC) Project Manager

- Lead software testing research and development team to provide the IV&V Program with the capability to perform dynamic analysis on NASA software systems.
- Responsible for the planning and execution of the development and maintenance of spacecraft simulators acquired, developed, and deployed to NASA IV&V users
- Served as NASA IV&V Project Manager on the GRACE-FO mission
- Familiar with IV&V processes and procedures and have performed IV&V on two NASA missions (Juno and Hubble Space Telescope Service Mission 4)

West Virginia University, 2007-2008
Lecturer

- Taught digital logic and microcontroller systems laboratories
- Authored and implemented curriculum for the microcontroller systems laboratory

NASA Independent Verification and Validation (IV&V) Program, 2006-2007
Computer Engineering Intern

- Conducted research project focused on performing fault injection on real-time operating systems

WVHTF Consortium, 2005
Software Engineering Intern

- Developed a Change Request System for Research and Development Team

Marion Electric Company, 2003-2005
Draftsman

- Created power system schematic drawings using Computer Aided Design software
- Wired power cars and belt starters

Honors and Awards

- NASA Group Achievement Award, Independent Test Capability
- NASA Group Achievement Award, Juno IV&V Team
- NASA Group Achievement Award, HST SM4 Servicing Mission Implementation Team
- NASA Special Act Award, Procurement Activity Team
- NASA Early Career Achievement Award
- 2012 NASA Software of the Year Honorable Mention, GPM Operational Simulator
- NASA Space Grant Scholar
- Tau Beta Pi Scholar

Matthew D. Grubb

NASA IV&V Program (ITC)
100 University Dr. (681)753-5363
Fairmont, WV 26554 matthew.d.grubb@nasa.gov

Education:
MS Electrical Engineering, West Virginia University, Expected May 2015
BS Computer Engineering, West Virginia University, May 2012

Relevant Experience:
NASA IV&V Program (Jacobs Engineering/TMC Technologies)
Software Systems Engineer, 2013 - present

- Support the development and maintenance of spacecraft simulators acquired, developed, and deployed to NASA IV&V
- Research simulation technologies for new hardware platforms such as FPGA, ASIC

West Virginia University
Course Instructor, 2013 - 2014

- Taught Microprocessor interfacing, Digital logic design, Electrical Circuit Analysis
- Updated course curriculums for new technologies

Electrical and Software Systems Team Lead (NASA Robotic Mining Competition 2014)

- First Place in Mining, Educational Outreach, and Joe Kosmo Excellence Award
- Led the development of electrical and software systems for the teams entry to RMC
- Developed autonomous mining algorithms
- Supported fabrication of custom designed components

Electrical and Software Systems Team Lead (PISCES Robotic International Space Mining Competition 2014)

- First Place in Mining, First Place in Operations
- Led the development of electrical and software systems for the teams entry to PRISM

Team Member (NASA/RASCAL Robo-Ops 2014)

- First place in competition
- Supported electrical and software design, and fabrication

Team Member (NASA RMC and RASCAL Robo-Ops 2013)

- Supported electrical, mechanical, and software design and development

US Army Corps of Engineers
Field Force Engineering, 2010 - 2012

- Support FEST (Forward Engineering Support Teams) both in the US and abroad
- Establish satellite communications for FEST in remote areas
- Test and deploy the newest software and equipment to FEST teams

Scott A. Zemerick

Education

Ph.D Computer Engineering, West Virginia University, In Progress, Started 2011
M.S. Electrical Engineering, West Virginia University, 2002, 4.0 GPA
B.S. Computer Engineering, Magna Cum Laude, West Virginia University, 2000

Professional Experience

TMC Technologies, NASA Contractor, 2011-Present
Chief Technology Officer (CTO) and Task Lead, Fairmont, WV

- Familiar with all aspects of Verification and Validation (V&V) and mission assurance activities related to unmanned systems and spacecraft.
- Responsible for spacecraft simulator design and development to support mission critical software Verification and Validation (V&V) activities.
- Familiar with many spacecraft ground systems

Intergraph, Inc. (acquired Augusta Systems) 2005-2011
Systems Engineer, Morgantown, WV

- Supported unmanned aerial vehicle (UAVs) flights at Wallops Flight Facility and responsible for simultaneous ground-to-air-to-ground communications between UAVs and unmanned ground vehicles (UGVs) by deploying a wireless mesh network. Designed, acquired, and deployed the wireless equipment hardware.

Titan Corporation: GE Aircraft Engines Contractor 2004 – 2005
Systems Engineer, Fairmont, WV

- Participated in the design and implementation of a novel control system for the GE Aircraft Engines (GEAE) F136 DEMO STOVL (Short Take-Off, Vertical Landing) jet engine for the Joint Strike Fighter (JSF) F-35. Team of three in Fairmont, WV was responsible for the design, software implementation, modeling, and verification of the STOVL control system.

Titan Corporation: NASA Contractor, IV&V Team Member 2002 – 2004
Associate Systems Engineer, Fairmont, WV

- Performed IV&V and systems reverse-engineering support for NASA's Advanced Air Transportation Technologies (AATT) project. Performed C, C++, and Java code analysis using automated static analyzers. Reverse-engineered source code to produce design documentation using UML. Researched methods for improving IV&V and its processes, specifically related to nontraditional IV&V projects.

West Virginia University – Advanced Power Engineering Research Center
Graduate Research Assistant, Morgantown, WV 2001 – 2002

- Performed a funded research investigation into designing and implementing a microprocessor-controlled PSVC (personal static var compensator) that helps AC motors run more efficiently by dynamically correcting their power factor.

National Radio Astronomy Observatory (NRAO) 1999
Summer Intern/Programmer, Green Bank, WV

- Designed and developed a GUI/control application for the 40FT Educational Radio Telescope that is used by educators and students at Green Bank, WV. Interfaced the software application to existing telescope software/hardware, and was responsible for testing movement control of the telescope.

John P. Lucas

NASA IV&V ITC, Building-2 C240 John.P.Lucas@ivv.nasa.gov
100 University Dr., Fairmont WV, 26554 (304)-367-5219

Education

B.S., Computer Engineering, West Virginia University, 2014
B.S., Electrical Engineering, West Virginia University, 2014
M.S., Electrical Engineering, West Virginia University, In Progress

Academic and Professional Experience

Electronics Shop Professional Technician Intern, West Virginia University, MAE, May 2013-Aug 2014
Resident Assistant, West Virginia University, Lincoln Hall, August 2012-May 2013
Robotics Team, West Virginia University, LCSEE, Aug 2012-Present
Student Programmer, West Virginia University, Anatomy Department, May 2013-August 2014
Systems Engineer Year Round Internship, NASA IV&V ITC, Aug 2014-Present
Teaching Assistant, West Virginia University, LCSEE, Aug 2014-Present

Awards, Honors, and Memberships

A.C.E., Bechtel Engineering Mentorship Program Team Leader, 2008-2010
Association for Computing Machinery, ACM, 2011-Present
Eta Kappa Nu, Computer and Electrical Engineers Honors Fraternity, IEEE, 2012-Present
leadWELL WVU Mentor Program, 2010-2011
Society of Automotive Engineers, SAE, 2010-2011
Sigma Alpha Pi, Society of Leadership and Success 2011-Present

Selected Publications

Article/Publication Submitted for Peer-reviewed:
-Klinkhachorn, P.S., J.B. Battin, J.P. Lucas, M.K. Radow, J.P. Hogg, R.J. Tallaksen, J.A. Altemus, and P. Klinkhachorn, Angiographic Anatomy of the Head and Neck, Submitted to MedEdPORTAL ID# MEP-2013-0433, Nov 2013
http://anatomyresources.hsc.wvu.edu/klinkweb/hnangiography

Invited presentations in 2013:
-Klinkhachorn, P.S., J.B. Battin, J.P. Lucas, M.K. Radow, and P. Klinkhachorn, Educational Scholarships: Examples of Teaching and Learning Clinical Anatomy, Invited Faculty Development Seminar Presentation at Oman Medical College, Dec 2013

Majid Jaridi

West Virginia Space Grant Consortium, G-68 ESB majid.jaridi@mail.wvu.edu
West Virginia University, Morgantown, WV, 26506 304-293-4099

Education

PhD, Industrial and Operations Engineering, the Univ. of Michigan, Ann Arbor, MI, 1983
MS Eng., Industrial Engineering, Asian Institute of Technology, Bangkok, Thailand, 1975
BS, Industrial Engineering, Sharif University of Technology, Tehran, 1973

Academic and Professional Experience

Professor, Industrial and Management Systems Engineering Department, 1995 – Present
Director, NASA WV Space Grant Consortium/NASA WV EPSCoR, 1991 – Present
Associate Professor, Industrial Engineering Department, WVU, 1988 – 1995
Assistant Professor, Industrial Engineering Department, WVU, 1984 – 1988
GRA, TA, the University of Michigan, Ann Arbor, 1978 – 1983
Lecturer, Tehran Polytechnic University, 1975 – 1978

Honors and Awards

Outstanding Advisor, West Virginia University, College of Engineering
Leadership Award, West Virginia University, College of Engineering
Outstanding Graduate Professor, West Virginia University, College of Engineering
Alpha Pi Mu - Industrial Engineering Honorary

Recent Publications

Ning, X., Zhou, J., Dai, B., Jaridi, M., (2014). The assessment of material handling strategies in dealing with sudden loading: the effects of load handling position on trunk biomechanics. Applied Ergonomics, 45(6), pp. 1399-1405.

Muniswamy, A., Gopalakrishnan, B., Chaudhari, S. Jaridi, M., Crowe, E., Gupta, D., (2014) A computer-based total productive maintenance model for electric motors. International Journal of Productivity and Quality Management, 13(2), pp. 178 – 200.

Nimbarte, A.D., Sun, Y., Jaridi, M., Hsiao, H., (2013) Biomechanical loading of the shoulder complex and lumbosacral joints during dynamic cart pushing task. Applied Ergonomics, 44(5), pp. 841-849.

Chowdhury, S.K., Nimbarte, A.D., Jaridi, M., Creese, R.C., (2013) Discrete Wavelet Transform Analysis of Surface Electromyography for the Fatigue Assessment of Neck and Shoulder Muscles. Electromyography and Kinesiology. 23(6), pp. 995-1003.

Chengcheng Xiang, Feng, Y., Ming L., Jaridi, M., and Wu, N., "Experimental and Statistical Analysis of Environmental Fate of Surface-Functionalized Titanium Dioxide Nanoparticles in Aquatic System," *Journal of Nanoparticle Research (NANOA)*, (2013), 15:1293 DOI 10.1007/s11051-012-1293-7.

Ashish D. Nimbarte, Yun Sun, Majid Jaridi, Hongwei Hsiao, "Biomechanical loading of the shoulder complex and lumbosacral joints during dynamic cart pushing task," *Applied Ergonomics*, (2013) Vol. 1, No. 9.

Nimbarte, A., Chapman, M., Sivak-Callcott, J., Ning, X., Jaridi, M., "Biomechanical evaluation of surgical loupes," Proceedings of the 2013 Industrial Engineering Annual Research Conference, San Juan, PR., May 2013.

Dr. Dimitris Vassiliadis

Department of Physics and Astronomy, White Hall 205 dimitris.vassiliadis@mail.wvu.edu
135 Willey St., Morgantown, WV, 26505 304-293-4920

Education

Ph.D., Space Plasma Physics, University of Maryland, College Park, 1992
M.Sc., Physics, University of Maryland, College Park, 1989
B.S., Physics, with honors, University of Thessaloniki, Greece, 1986

Academic and Professional Experience

Research Associate Professor, West Virginia University, Dept. of Physics, Aug 2007-present
Research Scientist, ST at NASA/Goddard Space Flight Center, Jan 2005-Jul 2007
Space Scientist, USRA at NASA/Goddard Space Flight Center, May 1994-Dec 2004
Resident Research Associate, National Research Council, NASA/GSFC, May 1992-April 1994
High-Performance Computational Sciences Summer School, NASA/GSFC, 1991
Research Assistant, University of Maryland, College Park, Sep 1988-May 1992
Teaching Assistant, University of Maryland, College Park, Sep 1986-May 1988

Honors and Awards

National Research Council Associateship, NASA/Goddard Space Flight Center, 1992-1994
Fulbright Foundation Fellowship, Exchange Graduate Student Program, 1986-1991
National Merit Scholarship, Hellenic Republic, 1984-1985

Selected Publications

Vassiliadis, D., Stormtime dynamics of the relativistic electron flux in Earth's radiation belts, in: Vassiliadis, D., X. Shao, S.F. Fung, I.A. Daglis, and J. Huba (eds.), *Modern Challenges in Nonlinear Plasma Physics*, AIP Conference Proceedings 1320, American Institute of Physics, Melville, NY, 2010.

Vassiliadis, D., I. Mann, S. Fung, X. Shao, Ground Pc3-Pc5 Wave Power Distribution and Response to Solar Wind Velocity Time Variations, *Planet. Space Sci.* 55, 743-754, doi:10.1016/j.pss.2006.03.012, 2007.

Vassiliadis, D., Systems theory for geospace plasma dynamics, *Reviews of Geophysics* 44, doi: 10.1029/2004RG000161, 2006.

Vassiliadis, D., S.F. Fung, and A.J. Klimas, Interplanetary and magnetospheric state parameters for the radiation belt electron flux, J. Geophys. Res. 110, A4, Art. No. A04201, 2005.

Vassiliadis, D., A.J. Klimas, R. S. Weigel, D. N. Baker, E. J. Rigler, S. G. Kanekal, T. Nagai, S. F. Fung, R. W. H. Friedel, and T. E. Cayton, Structure of Earth's outer radiation belt inferred from long-term electron flux dynamics, Geophys. Res. Lett. 30 (19), 2015, doi:10.1029/2003GL017328, 2003.

Vassiliadis, D., A. J. Klimas, S. G. Kanekal, D. N. Baker, R. S. Weigel, Long-term average, solar-cycle, and seasonal response of magnetospheric energetic electrons to the solar wind speed, *J. Geophys. Res.*, doi:10.1029/2001JA000506, 2002.

Vassiliadis, D. System identification, modeling, and predictions for space weather environments, IEEE Trans. for Plasma Phys. 28, 6, 1944-1955, 2000.

Dr. Jason N. Gross - GPS Payload Lead

Jason N. Gross, Ph.D.
Department of Mechanical and Aerospace Engineering (MAE)
West Virginia University (WVU)
Morgantown, WV 26506/6106 P: 304-293-3770
Email: *Jason.Gross@mail.wvu.edu* , Web: *http://www2.statler.wvu.edu/~gross/*

Professional Preparation

West Virginia University	Aerospace Engineering,	Ph.D., 2011
West Virginia University	Aerospace Engineering,	B.S., 2007
West Virginia University	Mechanical Engineering,	B.S., 2007

Academic/Professional Experience

West Virginia University, Assistant Professor, January 2014-Present
California Institute of Technology, NASA Jet Propulsion Laboratory, Near Earth Tracking Applications Group, Section 335, Research Technologist, 2011-2014
West Virginia University, Graduate Research Assistant, 2007-2011
NASA GSFC, NASA Academy Internship, Research Associate, Summer 2007
NASA GSFC, Summer Internship Program, Summer 2005

Honors and Awards

NASA Group Achievement Award, AirMoss Instrument Team: *"For achievement in developing P-band polarimetric imaging radar capability*" 2013

NASA Academy Robert H. Goddard Outstanding Research Award, 2007

Relevant Publications (Selected)

Bertiger W., Bar-Sever Y., Bokor, E., Butala, M., Dorsey, A., **Gross, J.**, Harvey, N., Lu, W., Miller, K., Miller, M., Romans, L, Sibthorpe, A., Weiss, J.P, Jones, M. Holden, J., Donigan, A., Saha, P. "First Orbit Determination Performance Assessment For The OCX Navigation Software In An Operational Environment" Institute of Navigation Fall GNSS+ Meeting, Nashville, TN, Sept. 2012.

Gross, J., Gu, Y., Rhudy, M., Gururajan, S., Napolitano, M. "Flight Test Evaluation of Sensor Fusion Algorithms for Attitude Estimation" IEEE Transactions on Aerospace Electronic Systems, Vol. 48 Is. 3, July, 2012.

Gross, J., Gu, Y., Rhudy, M., Barchesky, F., Napolitano, M. "On-line Modeling and Calibration of Low-Cost Navigation Sensors", AIAA Modeling and Simulation Technologies Conference, Portland, OR, August 2011.

Desai, S, Haines, B., **Gross, J.**, Stowers, D. "Verification and Validation of the GNSS Stations at the Prototype Core Site for NASA's Next Generation Space Geodesy Network" Submitted to American Geophysical Union 2013 Fall Meeting.

John A. Christian, Ph.D.

Department of Mechanical and Aerospace Engineering (MAE)
West Virginia University (WVU)
Morgantown, WV 26506/6106 P: 304-293-3263
Email: John.Christian@mail.wvu.edu, Web: http://asel.mae.wvu.edu

Professional Preparation

University of Texas at Austin	Aerospace Engineering,	Ph.D., 2010
Georgia Institute of Technology	Aerospace Engineering,	M.S., 2007
Georgia Institute of Technology	Aerospace Engineering,	B.S., 2005

Role on Proposed Mission

Dr. Christian will be responsible for IMU cluster board design, integration, and data analysis.

Academic/Professional Experience

West Virginia University, Assistant Professor, January 2013 – Present
Aerospace Engineer, NASA Johnson Space Center, August 2010 – December 2012
  *NASA JSC Exceptional Software Award, September 2012
  *NASA Group Achievement Award, August 2012
  *NASA Orion MPCV Excellence Award, November 2011
Assistant Instructor / Graduate Teaching Assistant, UT-Austin, August 2007 – May 2010
  *Class of 1942 Endowed Graduate Fellowship in Engineering
  *Texas Space Grant Consortium Fellow
Engineering Co-Op, NASA Johnson Space Center, 2002-2009 (eight rotations)
  *NASA Group Achievement Award, April 2006
Graduate Teaching Assistant, Georgia Institute of Technology, August 2006 – May 2007
  *AIAA Willy Z. Sadeh Graduate Award in Space Systems and Space Sciences

Relevant Publications (Selected)

- Bittner, D.E., Christian, J.A., and Bishop, R.H., “Development of an Alignment Technique for a Large Number of Redundant Inertial Measurement Units,” 65th International Astronautical Congress, Toronto, ON, 29 September - 3 October 2014.
- Greenheck, D.R., Bishop, R.H., Jonardi, E.M., and Christian, J.A., “Design and Testing of a Low-Cost MEMS IMU Cluster for SmallSat Applications,” 28th Annual AIAA/USU Conference on Small Satellites, Logan, UT, 2-7 August 2014.
- Bittner, D.E., Christian, J.A., Bishop, R.H., and May, D., "Fault Detection, Isolation, and Recovery Techniques for Large Clusters of Inertial Measurement Units," ION/IEEE/AESS Position, Location, and Navigation Symposium (PLANS), Monterey, CA, 5-8 May 2014.
- Zanetti, R., Ainscough, T., Christian, J.A., and Spanos, P.D., “Q-Method Extended Kalman Filter,” AAS/AIAA Space Flight Mechanics Conference, Kauai, HI, 10-14 February 2013.
- Christian, J.A., Hinkel, H., D’Souza, C.N., Maguire, S., and Patangan, M., “The Sensor Test for Orion RelNav Risk Mitigation (STORRM) Development Test Objective, AIAA Guidance, Navigation and Control Conference, Portland, OR, 8-11 August 2011.
- Christian, J.A., and Lightsey, E.G., “Sequential Optimal Attitude Recursion Filter,” Journal of Guidance, Control, and Dynamics, Vol. 33, No. 6, 2010, pp 1787-1800.

Robert H. Bishop, Ph.D., P.E.

4202 E. Fowler Ave., ENB 118 — Office: (813) 974-3780
University of South Florida, Tampa, FL 33620-5350 — Email: robertbishop@usf.edu

EDUCATION:

Rice University	Electrical & Computer Engineering	PhD, 1990
Texas A&M University	Aerospace Engineering	MS, 1980
Texas A&M University	Aerospace Engineering	BS, 1979

PROFESSIONAL REGISTRATION: Registered, State of Texas

ACADEMIC AND PROFESSIONAL EXPERIENCE:
Dean & Professor, University of South Florida, Department of Electrical Engineering, 2014 – present
Dean & Professor, Marquette University, Department of Electrical and Computer Engineering, 2010 – 2014
Chairman, Aerospace Engineering & Engineering Mechanics, The University of Texas at Austin, 2003 – 2009
Professor, Aerospace Engineering & Engineering Mechanics, The University of Texas at Austin, 2001 – 2010
Associate Chairman, Aerospace Engineering & Engineering Mechanics, The University of Texas at Austin, 1995 – 2000
Associate Professor, Aerospace Engineering & Engineering Mechanics, The University of Texas at Austin, 1995 – 2001
Assistant Professor, Aerospace Engineering & Engineering Mechanics, The University of Texas at Austin, 1990 – 1995

SELECTED HONORS AND AWARDS:
AAS Dirk Brouwer Award (for significant technical contributions to space flight mechanics and astrodynamics), 2013
Elected AAS Fellow, 2009
Elected AIAA Fellow, 2007
Joe J. King Professorship in Engineering, Endowed Position, 2005 – 2010
Elected to the UT Academy of Distinguished Teachers, 2002
Myron L. Begeman Fellowship in Engineering, Endowed Position, 1997 – 2005
ASEE/AIAA John Leland Atwood Award, 1999
Lockheed Martin Award for Excellence in Engineering Teaching, 1997

SELECTED PUBLICATIONS:

1. R. Zanetti and R. H. Bishop, "Kalman Filters with Uncompensated Biases," *AIAA Journal of Guidance, Control, and Dynamics*, Vol. 35, No. 1, 2012, pp. 327-330.
2. DeMars, K. Bishop, R. H., and Jah, M., "Entropy-Based Approach for Uncertainty Propagation of Nonlinear Dynamical Systems," *AIAA Journal of Guidance, Control, and Dynamics*, Vol. 36, No. 4, 2013, pp. 1047-1057.
3. Crain, T., Bishop, R. H., and Brady, T., "Shifting the Inertial Navigation Paradigm with MEMS Technology," AAS 10-043, *AAS Guidance and Control Conference*, Breckenridge, CO, 2010.
4. Escobar-Alvarez, H., Akella, M., and Bishop, R. H., "Geometrical Configuration Comparison of Redundant Inertial Measurement Units," AAS 11-258, *AAS Space Flight Mechanics Meeting*, New Orleans, LA, 2011.
5. Bittner, D. E., Christian, J. A, Bishop, R. H., and May, D., "Fault Detection, Isolation, and Recovery techniques for large clusters of Inertial Measurement Units," *Position, Location and Navigation Symposium - PLANS, 2014 IEEE/ION,* 2014.
6. Greenheck, D. R., Bishop, R. H., Jonardi, E. M., and Christian, J. A., "Design and Testing of a Low-Cost MEMS IMU Cluster for SmallSat Applications," SSC14-III-6, 28TH Annual AIAA/USU Conference on Small Satellites, Logan, UT, 2014.

Dimitris Korakakis

Dimitris Korakakis, Ph. D.
745 Engineering Sciences Building
West Virginia University
P.O. Box 6109
Morgantown, WV 26506-6109

Phone: 304.293.9697
E-mail: dimitris.korakakis@mail.wvu.edu
Fax: 304.293.8602

a. Professional Preparation

London University	Theoretical Physics	B. S. 1986
Boston University	Manufacturing Engineering	M. S. 1994
Boston University	Electrical Engineering	Ph. D. 1998

b. Appointments

2014-present	Professor, Lane Department of Computer Science and Electrical Engineering, West Virginia University
2008-2014	Associate Professor, Lane Department of Computer Science and Electrical Engineering, West Virginia University
2002-2008	Assistant Professor, Lane Department of Computer Science and Electrical Engineering, West Virginia University
2000-2002	Research Assistant Professor, Department of Physics, West Virginia University
1997-2000	Research Associate, School of Physics and Astronomy and School of Electrical and Electronic Engineering, University of Nottingham, UK

c. Selected Publications

Anand Kadiyala, Kyoungnae Lee, L. E. Rodak, Lawrence A. Hornak, Dimitris Korakakis, and Jeremy M. Dawson, "Improvement in the Light Extraction of Blue InGaN/GaN-Based LEDs Using Patterned Metal Contacts", IEEE Journal of the Electron Devices Society, 10.1109/JEDS.2013.2289308 (2014).

Ronak Rahimi, Alex Roberts, V. Narang, Vamsi Krishna Kumbhama and D. Korakakis, "Study of the effect of the charge transport layer in the electrical characteristics of the organic photovoltaics", Optical Materials **35**, 1077-1080 (2013).

Ronak Rahimi, Alex Roberts, V. Narang and D. Korakakis, "Investigate the role of the active layers' structures and morphology in the performance of the organic solar cell devices", Appl. Phys. Lett. **102**, 073105 (2013).

Joshua Justice, Kyoungnae Lee, and D. Korakakis, "Harmonic Surface Acoustic Waves on Gallium Nitride Thin Films", IEEE Trans. Ultrasonics Ferroelectrics and Frequency Control **59**, 1806 (2012).

K. Lee, H. Yalamanchili, L.E. Rodak, A. Kadiyala, J. Dawson, D. Korakakis, "Large-scale fabrication and observation of self-assembled silica nanospheres on GaN", Microelectronic Engineering **96**, 45 (2012).

L. E. Rodak and D. Korakakis. "Influence of the interface on growth rates in AlN/GaN short period superlattices via metal organic vapor phase epitaxy," Appl. Phys. Lett. **99**, 201903 (2011).

L. E. Rodak and D. Korakakis, "Properties of Aluminum Gallium Nitride Digital Alloy Growth via Metal Organic Vapor Phase Epitaxy," J. Electron. Mater. **40**, 388-393 (2011).

Jeremy M. Dawson

Lane Department of Computer Science and Electrical Engineering
West Virginia University
Morgantown, WV 26506
Tel: 304.293.4028
jeremy.dawson@mail.wvu.edu

A. Education:
West Virginia University - Electrical Engineering B.S. - 1997
West Virginia University - Electrical Engineering M.S. - 1999
West Virginia University - Electrical Engineering Ph.D. - 2002

B. Academic and Professional Experience:
5-/2007 to Present - Research Assistant Professor, WVU/LCSEE
11/2003 to 5/2007 - Materials Science Branch Supervisor/Scientist, ISR Inc./WVHTCF
5/2002 to 11/2003 - Postdoctoral Researcher, WVU/LCSEE
5/1997 to 5/2002 - Graduate Research Assistant, WVU/LCSEE

C. Selected Publications:

1. A. Kadiyala, K. Lee, L.E. Rodak, L.A. Hornak, D. Korakakis, and J.M. Dawson, "Improvement in the Light Extraction of Blue InGaN/GaN-Based LEDs Using Patterned Metal Contacts," *Electron Devices Society, IEEE Journal of the*, vol. 2, no. 2, pp. 16-22, (2014).
2. B. Hamza, M. Srungarapu, A. Kadiyala, J. Dawson, and L. Hornak, "Photonic Crystal Bioensors," in *Biosensors Based on Nanomaterials and Nanodevices (Chapter 8)*, CRC Press (2013).
3. B. Hamza, An. Kadiyala, L.A. Hornak, Y. Liu, and J.M. Dawson, "Direct Fabrication of Two-dimensional Photonic Crystal Structures in Silicon Using Positive and Negative Hydrogen Silsesquioxane (HSQ) Patterns," *Microelectronic Engineering*, 91, p. 70 (2012).
4. K. Lee, H. Yalamanchili, L.E. Rodak, A. Kadiyala, J. Dawson, and D. Korakakis "Large-scale fabrication and observation of self-assembled silica nanospheres on GaN," *Microelectronic Engineering*, 96, p.45, 2012.
5. R. Goswami, J.R. Nightingale, J.A. Duperre III, M.S. Lim, J.M. Dawson, A. Timperman, D. Korakakis and L.A. Hornak, "Surface Loading Sensitivity Characterization of a Resonant Planar Optical Waveguide Stack," *IEEE Photonics Technology Letters*, 24 (9), p. 778, 2012.
6. B. Hamza, A. Kadiyala, C. Kilemi, Y. Liu, and J. Dawson, "Fluorescence Enhancement in a Polymer-based Photonic Crystal Biosensor," in *Proc. SPIE* 7888, p. 788804, 2011.
7. A. Kadiyala, J. M. Dawson, and L. A. Hornak, "Modeling of a 3-D tunable photonic crystal for camouflage coating," in *Proc SPIE* 7781, p. 77810U, 2010.
8. H. Yalamanchili, L. A. Hornak, D. Korakakis, and J. M. Dawson, "Bandgap tuning of photonic crystals on III-V nitride thin films," in *Proc. SPIE 7402*, p. 740212, 2009.
9. J.R. Nightingale, R. Goswami, J. Duperre, J.M. Dawson, L.A. Hornak, and D. Korakakis, "Use of ion beam assisted deposition and low temperature annealing for the fabrication of low loss, vertically stacked alumina waveguide structures, *J. Vac. Sci. Technol. B*, 26, p. 1813 2008.

Anand Kadiyala

Lane Department of Computer Science and Electrical Engineering anand.kadiyala@mail.wvu.edu
West Virginia University, Morgantown, WV, 26505 304-293-3478

Education

Ph.D., Electrical Engineering, West Virginia University, In Progress
B.E., Electronics and Communication Engineering, Osmania University, India, 2008

Academic and Professional Experience

Graduate Research Assistant, LCSEE, West Virginia University (Aug 2009 – Present)
Graduate Teaching Assistant, Creative Arts Center, West Virginia University (Jan 2009 – May 2009)

Honors and Awards

Eta Kappa Nu (HKN) - 2014

Research and Experience

- Research in the areas of Nano-Photonics, Photonic Crystals, Solid-State Lighting, III-V Semiconductors, Light-Emitting Diodes and Cleanroom fabrication techniques
- Experience in micro-/nano-fabrication tools like Electron Beam Lithography, Electron beam Evaporation, Scanning Electron Microscopy, Photolithography, ICP-RIE Etching, Packaging, etc.
- Developed and optimized several fabrication techniques to help aid in device integration of the photonic crystals
- Developed electrical and optical characterization techniques for UV, blue and green Light Emitting Diodes (LEDs) grown on (0001) sapphire and bulk GaN substrates
- Developed optical characterization techniques for characterizing photonic crystals fabricated on LEDs and other applications

Selected Publications

- A. Kadiyala, K. Lee, L.E. Rodak, L.A. Hornak, D. Korakakis, J.M. Dawson, "Improvement in the Light Extraction of Blue InGaN/GaN-Based LEDs Using Patterned Metal Contacts," Electron Devices Society, IEEE Journal of the , vol.2, no.2, pp.16,22, March 2014.
- B. Hamza, M. Srungarapu, A. Kadiyala, J. Dawson, and L. Hornak, “Photonic Crystal Biosensors,” in Biosensors Based on Nanomaterials and Nanodevices (Chapter 8), Taylor & Francis, pp. 179-207, 2014.
- J. Justice, A. Kadiyala, J. Dawson and D. Korakakis, “Group III-Nitride Based Electronic and Optoelectronic Integrated Circuits for Smart Lighting Applications,” MRS Proceedings, vol.1492, no. , pp. 123-128, 2013.
- K. Lee, H. Yalamanchili, L.E. Rodak, A. Kadiyala, J. Dawson, and D. Korakakis “Large-scale fabrication and observation of self-assembled silica nanospheres on GaN,” Microelectronic Engineering, vol.96, pp.45, 2012.
- K. Lee, A. Kadiyala, L. E. Rodak, V. Kumbham, B.A. Bearce, J. Justice, J. Peacock, J.M. Dawson, L.A. Hornak, and D. Korakakis , “Enhanced Emission from InxGa1-xN-based LED Structures Using III-Nitride based Distributed Bragg Reflector,” in MRS Proc., 1396, p. mrsf11-1396-o07-43, 2012.

12 Appendix: Science Objectives Additional Information

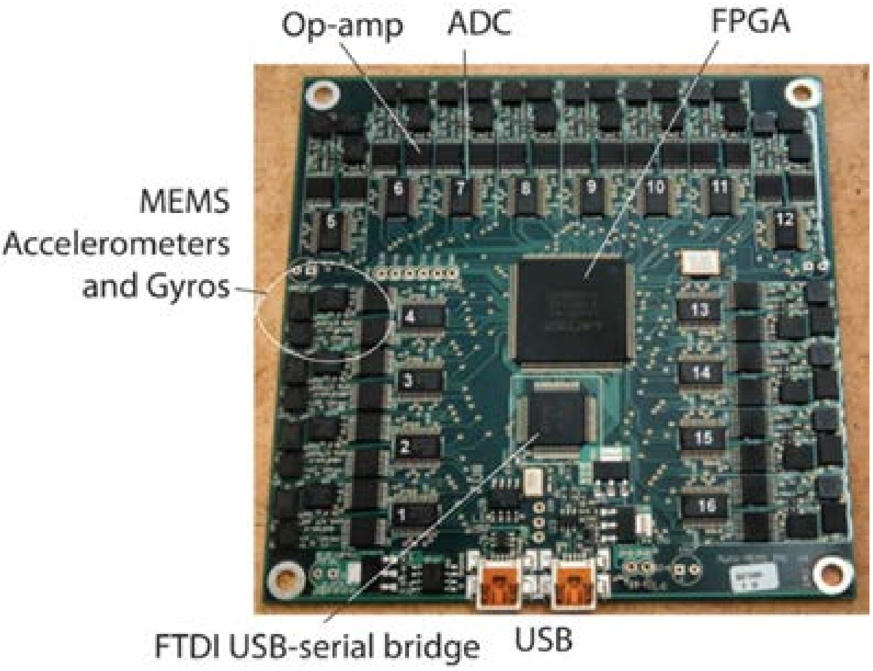


Figure 1 - First Generation IMU board designed for CubeSat platform

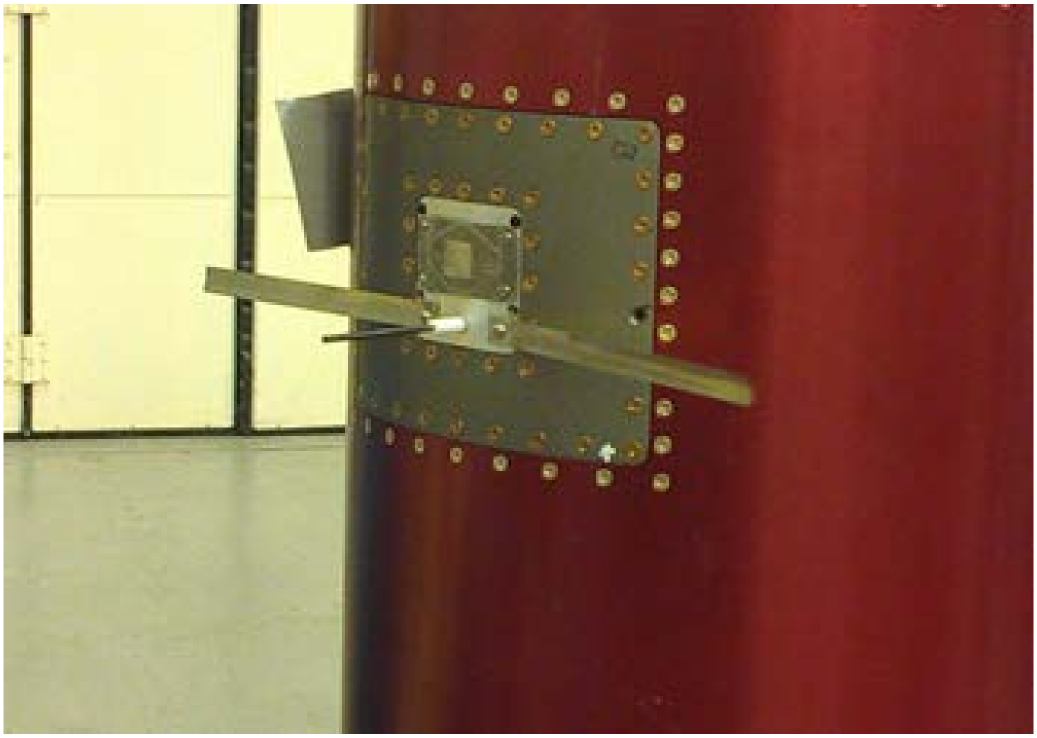


Figure 2 - Langmuir Probe and sounder patch antenna on RSC sounding rocket, June 2014

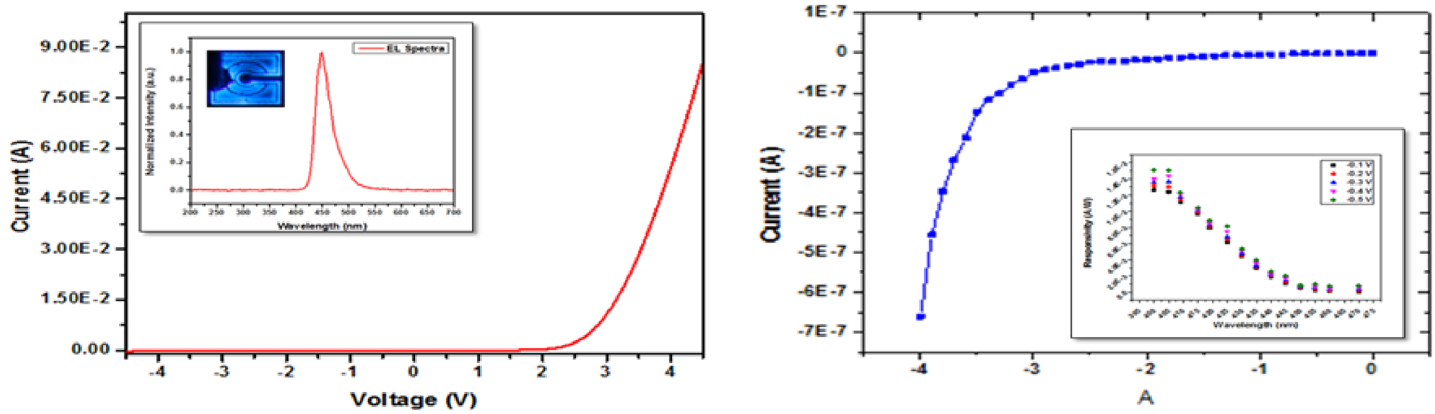


Figure 3 –(Left) Current Voltage characteristics of an LED (Right) Negative bias characteristics of a PD fabricated at WVU

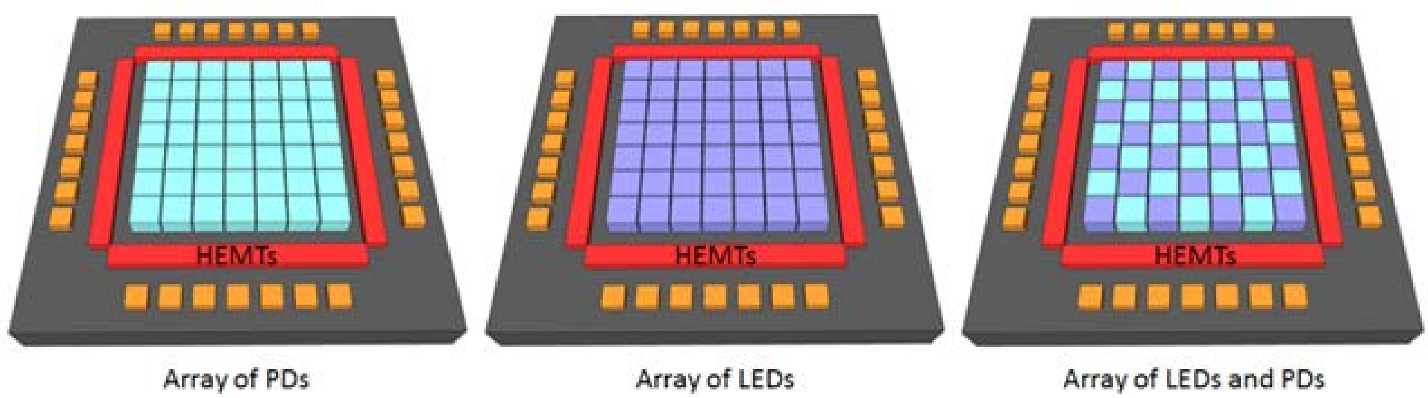


Figure 4 - Proposed arrays of III-V Nitride devices to be tested

13 Appendix: Review Supporting Materials

- Overview
- Expectations / Requirements
- STF-1 System
- Concept of Operations
- Mass/Height Overview
- Power Overview
- Hardware

Overview

- First West Virginia Satellite
- IV&V Investment in Simulation
  - Technology demonstration of IV&V simulation technologies on the CubeSat platform
- Strategies
  - Become integrated with GSFC CubeSat efforts
    - STF-1 will use same components as DELLINGR (GSFC CubeSat)
    - ICECUBE (Wallops Flight Facility/GSFC)
  - IV&V lead effort on C&DH and Integration
  - Leverage Wallops resources for environmental testing and launch integration services
  - West Virginia University partnership for scientific focus areas
    - MAE Dept. – GPS and IMU Experimentation
    - Physics Dept. – Magnetosphere-Ionosphere Coupling and Space Weather
    - CSEE Dept. – Performance and Durability of III-V Nitride-Based Materials

Key Requirements & Assumptions

- Successfully integrate multiple university science experiments with NASA IV&V developed C&DH
- Use simulation environment to aid in FSW development, integration, and testing
- Communication with Wallops Flight Facility CubeSat Ground Station Network

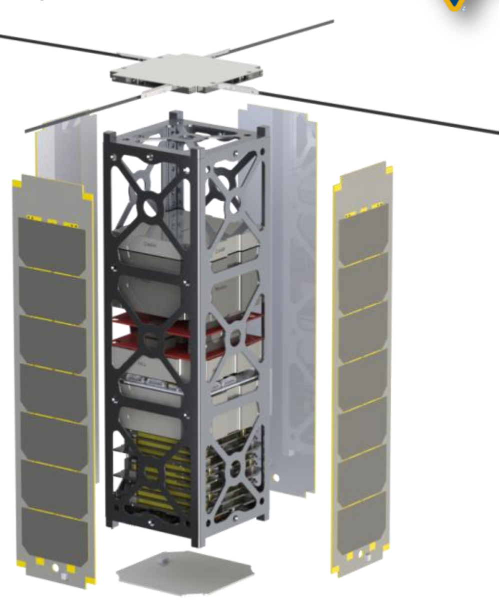
Key Requirements & Assumptions

- Instrument-derived overall requirements
  - Provide the following power rails: +3.3V, +5V, +8V, +12V
  - Max Current draw of 4.5A
  - 90Whr of battery storage (Should remain over 50% charged when not transmitting)
  - Science instruments should be designed to operate under these constraints
  - Store and transmit science data
- Comply with all Launch Services Requirements
  - No waivers necessary
- Comply with Cal-Poly PPOD Specifications
  - Use a remove before flight pin and a separation switch

3

STF-1 System

- Standard 3U Configuration
  - Skeleton Chassis
- Power Systems
  - 5 Solar Panels
  - ClydeSpace EPS
  - 90Whr Battery
- Communications
  - Four monopole antenna
  - L3 Cadet Radio
- C&DH
  - GOMSpace NanoMind



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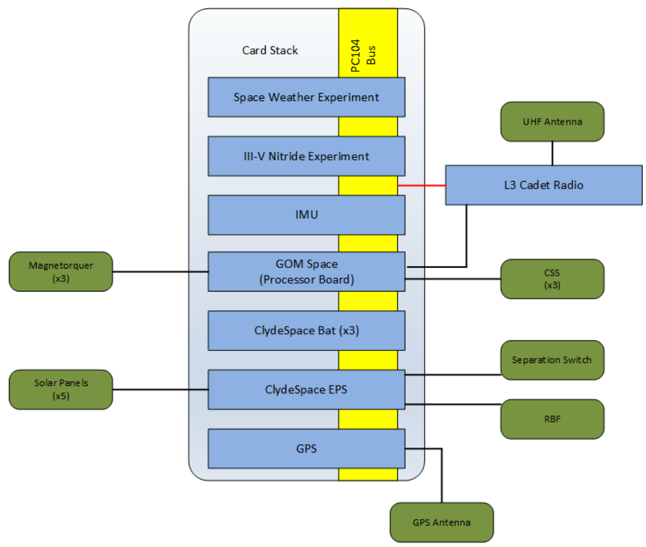
Hardware Block Diagram



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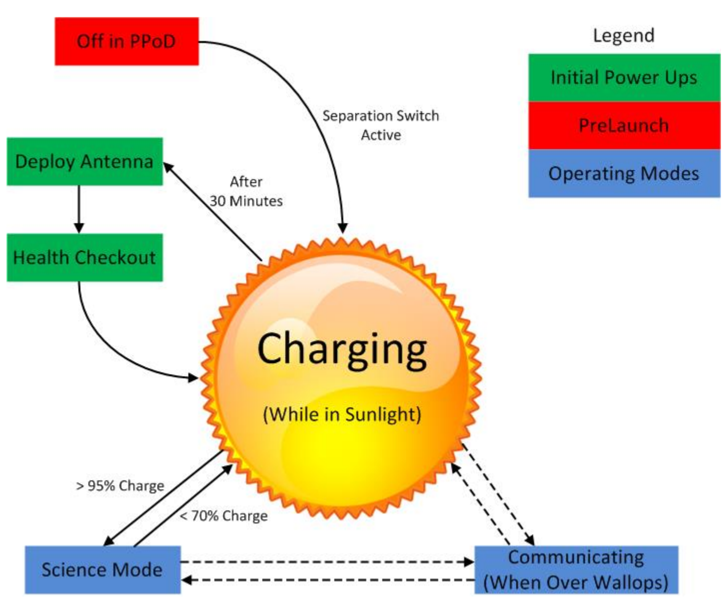
Concept of Operations / Modes



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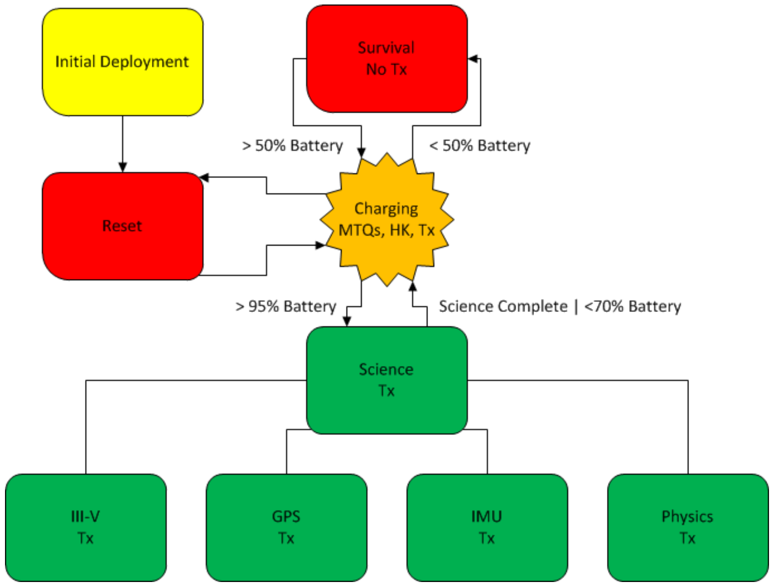
Mode Transitions

- Initial Sequence of Operations (Initiated upon release of Separation Switches)
- Start C&DH systems
  - begin House-Keeping(HK)
- After 30 Minutes deploy antenna
  - After 45 minutes turn on Cadet Radio
- Continue to charge batteries
- Perform C&DH checkout upon initial contact
- Transition to standard operating mode

Standard Operation Modes

- Charging
  - HK, Use Magnetorquers (MTQs), Transmit (Tx)
- Survival
  - Minimum consumption to remain powered until charged >50%
  - No MTQs, No TX
- Science Mode
  - Experiments scheduled and run until batteries reach 30% Depth of discharge (DoD)

Standard Operation Modes



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Mass / Height Budget

Total Height (mm)	265.22	Total Weight (g)	3245
Surplus Height (mm)	74.78	Surplus Weight (g)	755
Component	QTY	Weight (g, each)	Height (mm, each)
3U Structure - skeletonized	1	213	
3U Cover Plate Assembly	1	37	
3U Low-Profile Base Plate Assembly	1	49	
Midplane Standoffs	2	4	
3U Solar Panel	4	160	
1U Solar Panel	1	44	7
Solar Panel Clips	1	4	
Battery	3	256	20.44
EPS	1	88	15.3
GomSpace Processor Board	1	55	15.1
L3 Cadet	1	100	13.5
GPS - Foton w/ antenna	1	469	38
IMU - J.Christian	1	70	20
Antenna	1	100	7
CSEE III-V Nitride Exp	1	300	38
Physics	1	300	50

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Power Budget

Subsystem	Component	Power(W)	Survival Mode		Charging (Tx)		III-V Exp. (Tx)		GPS Exp. (Tx)		IMU Exp. (Tx)		Space Weather Exp. (Tx)	
			Total Whr/Orbit	2.2974	Total Whr/Orbit	5.029815	Total Whr/Orbit	11.029815	Total Whr/Orbit	11.374815	Total Whr/Orbit	7.989315	Total Whr/Orbit	16.579815
			Duty Cycle	Whrs Used / Orbit	Duty Cycle	Whrs Used / Orbit	Duty Cycle	Whrs Used / Orbit	Duty Cycle	Whrs Used / Orbit	Duty Cycle	Whrs Used / Orbit	Duty Cycle	Whrs Used / Orbit
C&DH	NanoMind	0.297	1	0.4455	1	0.4455	1	0.4455	1	0.4455	1	0.4455	1	0.4455
	Erasing Flash	0.0363	0	0	0.1	0.005445	0.1	0.005445	0.1	0.005445	0.1	0.005445	0.1	0.005445
	Writing Flash	0.0198	0	0	0.1	0.00297	0.1	0.00297	0.1	0.00297	0.1	0.00297	0.1	0.00297
Comm	L3 Cadet Tx	12	0	0	0.108	1.944	0.108	1.944	0.108	1.944	0.108	1.944	0.108	1.944
	L3 Cadet Rx	0.3	1	0.45	1	0.45	1	0.45	1	0.45	1	0.45	1	0.45
	Antenna	0.02	0	0	1	0.03	1	0.03	1	0.03	1	0.03	1	0.03
GNC	CSS (x5)	0	1	0	1	0	1	0	1	0	1	0	1	0
	Magnetorquer (x3)	0.3	0	0	0.1	0.045	0.1	0.045	0.1	0.045	0.1	0.045	0.1	0.045
	NanoMind (C&DH)													
Power	EPS	0.1	1	0.15	1	0.15	1	0.15	1	0.15	1	0.15	1	0.15
	Battery Consumption	0.3	1	0.45	1	0.45	1	0.45	1	0.45	1	0.45	1	0.45
	Battery Heater	5.346	0.1	0.8019	0.1	0.8019	0.1	0.8019	0.1	0.8019	0.1	0.8019	0.1	0.8019
Experiments	Physics	7.7	0	0	0	0	0	0	0	0	0	0	1	11.55
	IMU	1.973	0	0	0	0	0	0	0	0	1	2.9595	0	0
	GPS	4.7	0	0	0.1	0.705	0.1	0.705	1	7.05	0.1	0.705	0.1	0.705
	III-V Nitride	4	0	0	0	0	1	6	0	0	0	0	0	0

Power Generation Estimates

Worst Case Charging Scenarios				
Orbit Period	93	Mins		
Worst Case Sun Pointing	59	Percent		
Worst Case Sun/Orbit	54.87	Mins		
	Power		Probability (sun facing)	
3U Panel Power	7.3	Watts	0.666666667	
1U Panel Power	2.1	Watts	0.166666667	
Antenna	0	Watts	0.166666667	
Power Probability	5.216666667	Watts		
Power Generation Nominal	4.770641667	Whr / Orbit		
	Percentage			
EPS Losses	0.15			
Wiring Losses	0.05			
Net Power Generated / Orbit	3.816513333	Whr		
Net Power Generated / Day	59.0944	Whr		

Components Cost Breakdown

Component	Manufacturer	Price	QTY	subtotal
Chassis (3U)	Pumpkin Walls	2250	1	2250
	Pumpkin Base	425	1	425
	Pumpkin Cover	375	1	375
Power Systems				
Solar Panels	Clydespace 3U Front w/MTQ	6050	1	6050
	Clydespace 3U Side w/MTQ	6400	1	6400
	Clydespace 3U Side	6050	2	12100
	Clydespace Bottom w/MTQ	3000	1	3000
	Attachment Clips	450	1	450
EPS	Clydespace 3UEPS Harness	1800	1	1800
	Clydespace 3UEPS 3rd Gen	6700	1	6700
Battery	Clydespace 30Whr	3850	3	11550
C&DH				
Processor Board	Nanomind A712D	6050	2	12100
Transceiver				
UHF Radio	L3 Cadet	30000	1	30000
Attitude Control Systems				
GPS	Foton	0	1	0
IMU	John Christian	2500	1	2500
Miscellaneous				
Wire, Connectors, Solder, Sheilding (estimated)		3000	1	3000
Antenna		5000	1	5000
GPS Antenna	AntComm	500	1	500