Small Spacecraft Technology Program 2016 Selections

Topic: Power generation, energy storage, and thermal management systems for small spacecraft

Lightweight Structural Battery Systems for Cubesats

PI: Ryan Kakkainen
University of Miami

Partners: NASA Kennedy Space Center and NASA Glenn Research Center

Brief Summary: This effort proposes to develop a lightweight 1U cubesat that utilizes improved and fully integrated structural battery materials for mission life extension of 200 to 300 percent, larger payload capability, and significantly reduced mass. With structural elements being comprised of graphitic and carbon fiber electrodes in an electrolytic polymer, the multifunctional capacitive energy system can serve as both a lightweight load bearing structure and an electrochemical battery system. Multifunctional material will reduce mass and increase electrical power in highly integrated small spacecraft.

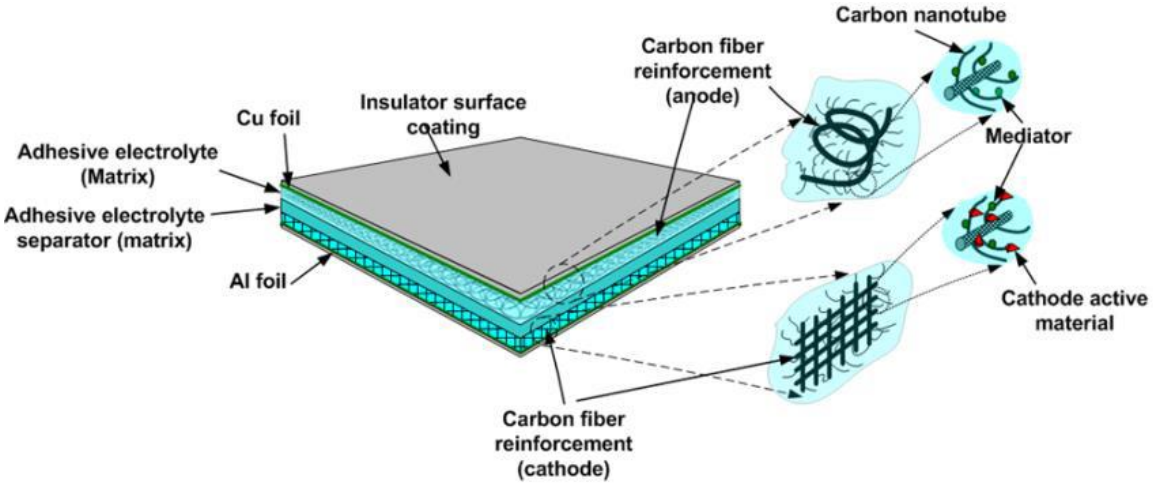


Illustration of multifunctional material

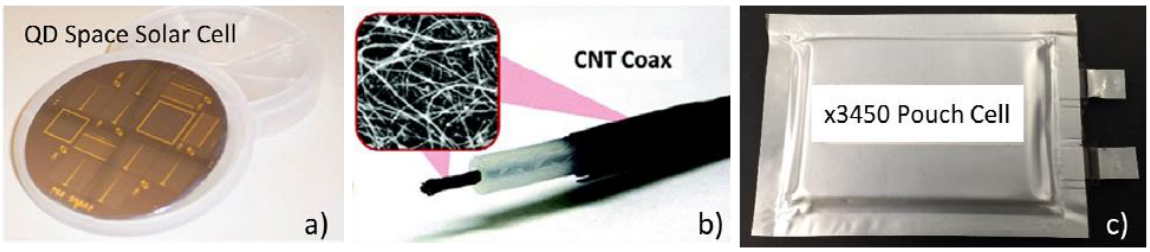
Topic: Power generation, energy storage, and thermal management systems for small spacecraft

Demonstration of a Nano-Enabled Space Power System

PI: Ryne Raffaelle
Rochester Institute of Technology

Partner: NASA Glenn Research Center

Brief Summary: The objective of this proposal is to demonstrate the successful space flight of a nanomaterial-enabled space power system. This project will integrate bandgap-engineered quantum dot/quantum well solar cells, metal-free carbon nanotube-based conductors, high energy-density lithium ion batteries, and thermal electric heat management devices into a cubesat.



Photographs of nano-enabled quantum dot solar cells (a), carbon nanotube conductive wiring (b), and, carbon nanotube enhanced lithium ion pouch cell (c)

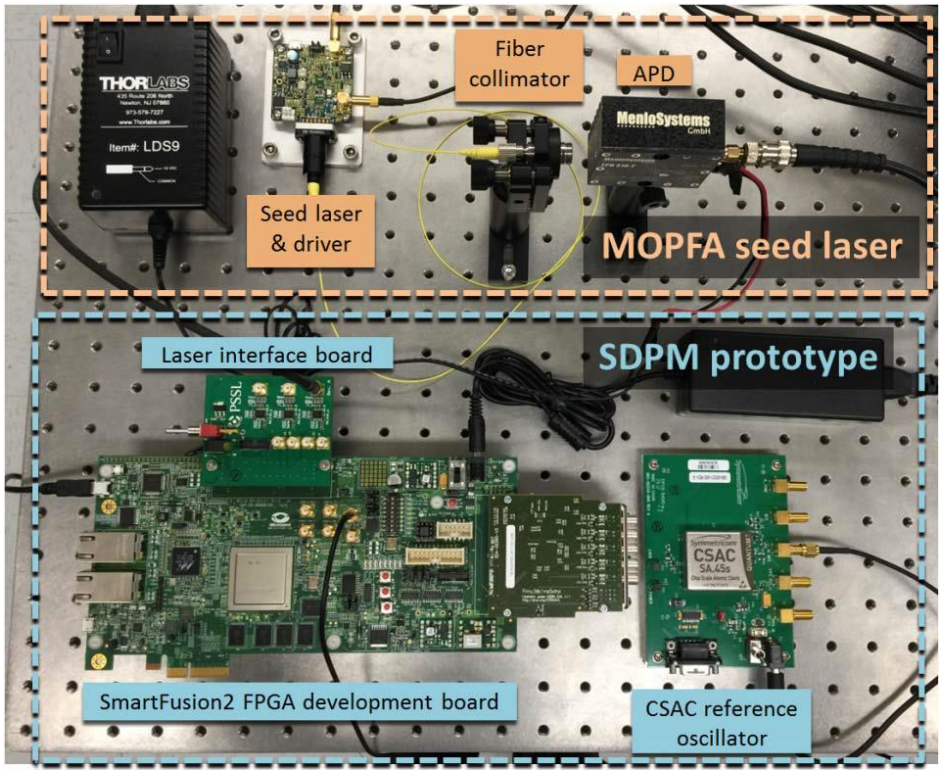
Topic: Crosslinking Communications Systems

Fast, Power-Efficient Pulse Modulator For Optical Crosslinks

PI: John Conklin
University of Florida

Partner: NASA Ames Research Center

Brief Summary: We will develop a software-defined pulse modulator and integrated seed laser for optical communications between small spacecraft, including cubesats, using pulse position modulation. This technology can generate less than 1 nanosecond 1550 nm optical pulses with 50 picosecond timing accuracy. Since the pulse timing is generated using programmable delays within a field-programmable gate array, it does not require a power hungry gigahertz slot clock or processor. Instead, a low power 10 megahertz chip-scale atomic clock is used to continuously calibrate the timing delay chain. The modulator will be paired with a photo-receiver and tested for a future flight demonstration on a cubesat bus.



The software-defined pulse modulator and seed laser prototype undergoing testing in the Precision Space Systems Lab at the University of Florida

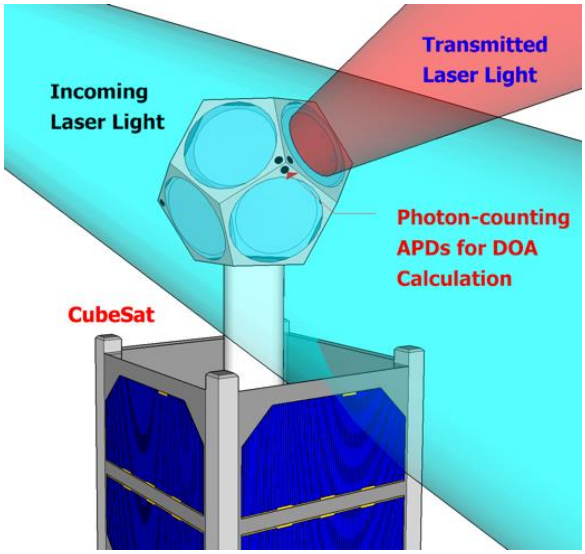
Topic: Crosslinking Communications Systems

Omnidirectional Inter-satellite Optical Communicator

PI: Ozdal Boyraz
University of California, Irvine

Partner: NASA Jet Propulsion Laboratory

Brief Summary: Advanced omnidirectional inter-satellite optical communicator is being proposed to enable high bandwidth (1Gb/s) full-duplex optical communication between small spacecraft that are separated by over 200 km distance. In particular, the proposal aims at space, power and performance challenges pertinent to cubesat missions. The project will adapt dodecahedron geometry that can fit inside a cubesat-scale block and utilize avalanche photo detector arrays and gimbal-less MEMS scanning mirrors for direction of arrival calculation and beam steering. When it is built, the proposed communicator will be integrated into small spacecraft to enable data transfer, data relay and relative navigation control.



Proposed inter-satellite optical communicator dodecahedron geometry

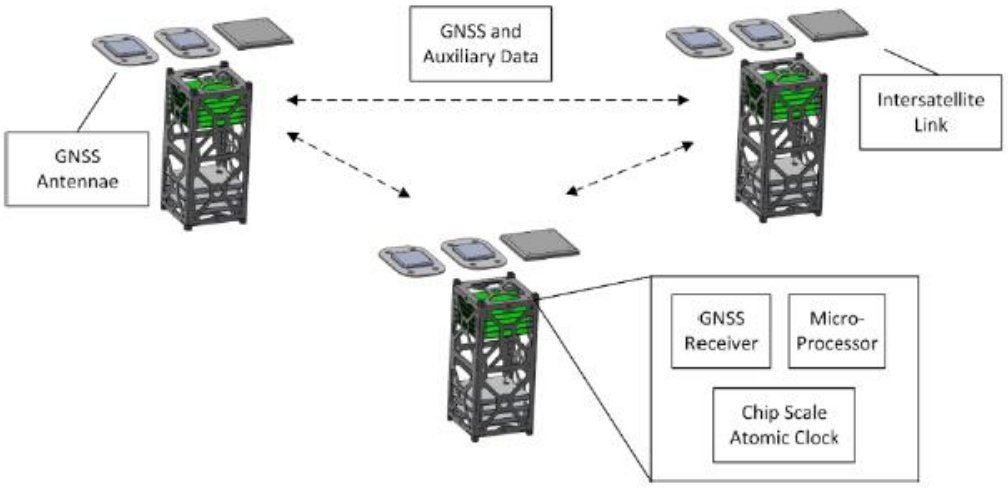
Topic: Relative Navigation for Multiple Small Spacecraft

Precision Global Navigation Satellite System Relative Navigation for Multiple Nanosatellites

PI: Simone D'Amico
Stanford University

Partners: NASA Goddard Space Flight Center and Tyvak Nano-Satellite Systems

Brief Summary: We propose the development and demonstration of a distributed multi-Global Navigation Satellite System (GNSS) timing and localization system to enable future distributed mission concepts. The goal is to provide unprecedented precision real-time absolute and relative navigation capabilities to formations of nano-satellites using signals offered by modern Global Navigation Satellite Systems. The proposed system consists of a plug-in-ready hardware/software unit capable of integration with most satellites to provide peer-to-peer decentralized navigation accuracy at the centimeter-level over separations up to hundreds of kilometers. The size of the device is 0.5 cubesat units. The project leverages algorithms and software developed by the proposing team and demonstrated on formation-flying missions such as PRISMA and MMS.



Distributed multi-GNSS timing and localization system

Topic: Relative Navigation for Multiple Small Spacecraft

Smoothing-Based Relative Navigation and Coded Aperture Imaging

PI: Alvar Saenz Otero
Massachusetts Institute of Technology

Partners: NASA Jet Propulsion Laboratory and NASA Ames Research Center

Brief Summary: This project will develop a time-windowed smoothing algorithm for estimation of the relative poses and velocities between multiple, small, and potentially differently instrumented spacecraft. The smoothing algorithm will obtain the most probable estimate of the relative states between the spacecraft by using all available sensor information. It will be portable between different satellite platforms with different onboard sensors, adaptable in the case that one or more satellites become inoperable, and tolerant to delayed measurements or measurements received at different frequencies. It will be matured from technology readiness level 3 to 6 using the SPHERES-VERTIGO microgravity test platform on the International Space Station.

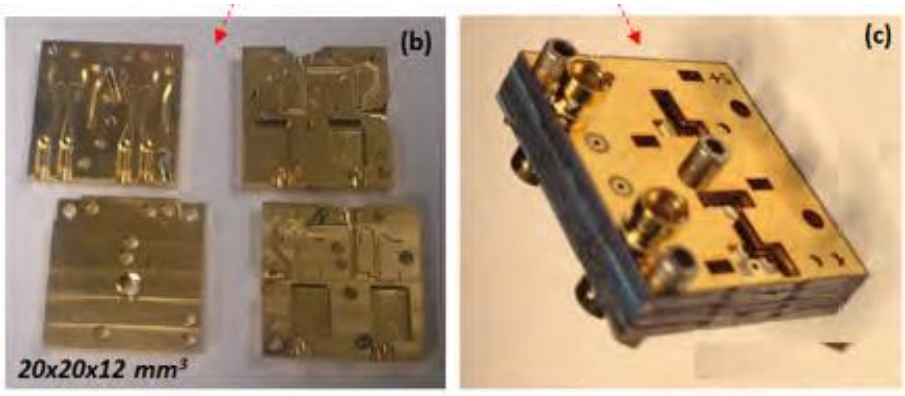
Topic: Instruments and Sensors for Small Spacecraft Science Missions

Terahertz Receiver for Small Satellite Remote Sensing

PI: Christopher Groppi
Arizona State University

Partners: NASA Jet Propulsion Laboratory, Sierra Lobo Inc.

Brief Summary: Recent advances in small satellite technology now allow us to consider their use for astrophysics and remote sensing. Water and atomic oxygen render Earth's atmosphere opaque in most of the terahertz (THz) band, but those very species are of intense interest to astrophysicists, planetary scientists and Earth scientists. We propose to advance the state of the art Schottky diode receiver technology to develop THz receivers suitable for cubesats. We will take advantage of Arizona State University's strength in micromachining to repackage JPL's state of the art modular receivers into integrated systems that minimize mass and volume to a level suitable for cubesats while preserving performance.



Very thin, stacked metal plates machined at Arizona State University can reduce the size of the receiver

Topic: Instruments and Sensors for Small Spacecraft Science Missions

Magnetometers for Small Satellites

PI: Mark Moldwin

University Of Michigan
Partner: NASA Goddard Space Flight Center

Brief Summary: We propose to develop and test a new boom-less magnetometer for use in cubesats. This involves the development and test of new algorithms and procedures to fly boom-less magnetometers. Undergraduate engineers and graduate space systems engineers will actively be involved with the designing, building and testing of the new sensors and algorithms. The Partnership leverages existing complimentary efforts at UM and NASA GSFC.

University of Michigan undergraduate students building the MCUBED satellite (left) and students testing a system in microgravity (right)