Title
UCI Satellite-II

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UCI Satellite-II

Mission Objective: To advance the development and application of solar radiation towards the purification of aqueous solution-based pollutants in order to facilitate extended space operations

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Project Manager: Geoffrey Chen.

Abstract

The principal idea involves the utilization of existing solar radiation to degrade model pollutants (midodrine and humic acid) in aqueous solution. The decomposition of said pollutants will be observed through a photochemical effect known as "fluorescence", whereby substances emit light after absorbing electromagnetic radiation. The experiment will be carried out on a Class 2U Cube Satellite; hence the designation of "UCISAT-2". In addition, UCISAT-2 will utilize an electric propulsion system coupled with a flight control system to achieve full attitude control and thus orient the payload (the experiment) towards the sun. The development of such a purification technology has direct economic and practical implications for the future of space exploration and missions. To give some perspective, the current International Space Station (ISS) water purification systems encompasses the size of four fully grown men and weights thousands of pounds. Furthermore, between 2000 and 2005, approximately $60 million was spent on sending fresh water up to the ISS. Therefore, it is clear that developing a solar-based purification system would affect tremendous savings in weight and cost, and ultimately advance the scope of space operations and future missions.

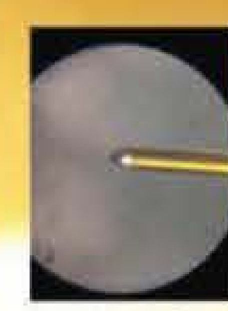
Propulsion

Propulsion has determined and selected a colloid electrospray thruster as the electric propulsion system of choice for UCISAT-2. After substantial research and materials selection, a preliminary prototype design has been developed. Currently, the thrusters are being fabricated using copper, plastic, and standard machining tools. It has also been decided to first test the prototype electrospray design on a 1U Cube Satellite (CubeSat) for uniaxial de-spin attitude control, before eventual integration onto UCISAT-2. To simulate realistic space conditions, the test 1U CubeSat shall be inserted into a vacuum chamber and be wirelessly controlled with a LabView algorithm and Arduino Uno R3 microcontroller. Both in-house components (resistors, MOSFETs, etc.) and externally-ordered electronics, such as the EMCO power transformer, ITG-3200 gyroscope, and Ni-Cd battery, shall also be installed within the test 1U CubeSat. We have selected ethylammonium nitrate (EAN) as the propellant of choice due to its low dynamic viscosity and high electrical conductivity.

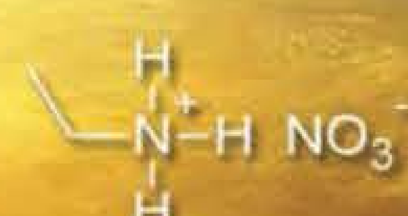
Members: Geoffrey Chen, Navin Timilsina.

prototype colloid thruster (N. Timilsina)

vacuum chamber (Gamero Lab, MAE)



electrospraying formaldehyde ethyl thertyl ammonium (G. Chen)



ethylammonium nitrate

Attitude Determination and Control Systems (ADCS)

ADCS has conducted detailed analyses into the attitude dynamics of UCISAT-2 using MATLAB and STK. In particular, the disturbance torques, orbital velocities, and de-spin characteristics were analyzed for all Low-Earth orbits (LEO). These calculations establish the basic constraints on the overall mission, and also define the fundamental requirements of the Propulsion system. Preliminary research has also revealed that a proportional-derivative (PD) controller be used for attitude control because of its inherent stability. In the future, such a flight control system shall be designed to work in conjunction with the Propulsion system to control the motion of the spacecraft.

Members: Geoffrey Chen, Gilberto Hernandez, Abdullah Tarif, Scott Walter.

UCISAT-2 prototype (A. Patel)

Structures

Structures has been designing the chassis, face plates, payload, and thrusters for system integration into UCISAT-2. The primary thrust of this quarter has been focused on an integrated payload module design. We have selected Aluminum 6061 T6 as the material of choice for the primary structure, due to its excellent combination of formidable mechanical and thermal properties, coupled with its economical attributes. Currently, there is much work into improving an existing preliminary design – with the eventual intention of manufacturing an actual prototype to facilitate further modifications. This preliminary design must comply with CubeSat standards, while also endure the various environments encountered in storage, launch, and orbital injection/space. To this end, computational and theoretical analyses have been implemented in order to study the viability of various designs.

Members: Geoffrey Chen, Leann Kempley, Kevin Lasquete, Akash Patel.

Thermal

The Thermal subsystem is responsible for the research and design of UCISAT-2's temperature control and heat rejection/retainment system, a variable-emissivity radiator. A preliminary design has thus far been completed, which has led to the construction of a prototype. In particular, fabrication of various components has initiated - such as the thermocouples, radiator/cold plates, and coolant tubing. Aluminum has also been selected as the candidate material for the plates, due to its simplicity, strength, and economy. We are also using STK and COMSOL to simulate the physics and response of the prototype thermal system. Once this preliminary prototype design is complete and fully tested, a flight-ready prototype can be designed to be integrated with UCISAT-2. Ultimately, such a system will render the harsh environment of space operable, and therefore enable UCISAT-2 to carry out its mission.

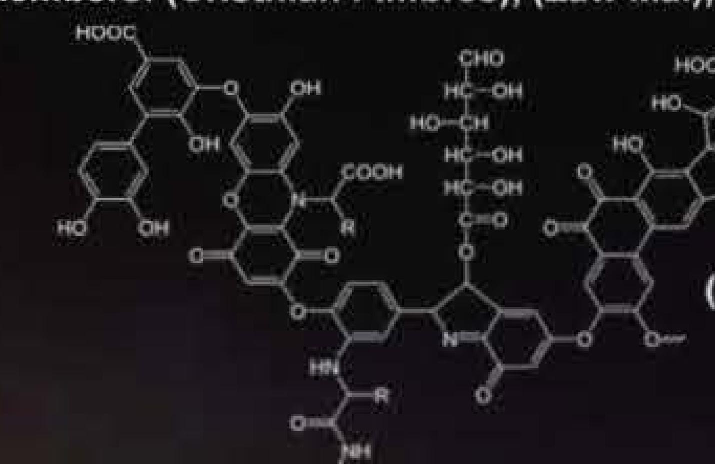
Members: (Andrea Antonello), Amy Dunford, Akash Patel, Ross Deason.

prototype variable-emissivity radiator (A. Antonello, A. Patel)

Payload

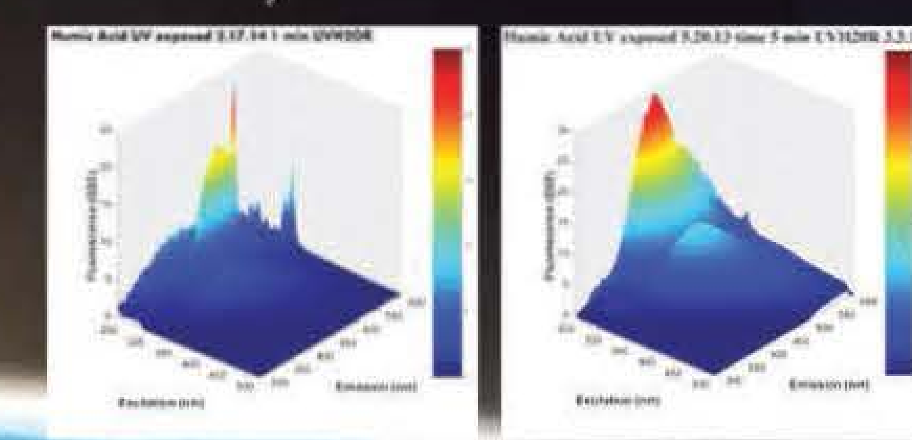
Payload has researched the technology and designs available that will facilitate the execution of the experiment. In particular, they are working with Structures to design an integrated shutter/photodiode system that will both expose the vials to solar radiation and enable measurement of the experiment's success. The determination and subsequent experimental verification that both pollutants obey first-order kinetics significantly simplifies calculations. Consequently, we have verified many of the experimental results from previous quarters, and thus there has been an emphasis on resolving the remaining theoretical problems. These problems are primarily the problem of the entire solar spectrum extrapolation, dynamic pollutant solution flow extrapolation, quantum yield extrapolation, and general scaling issues due to the differences between laboratory and spacecraft (UCISAT-2) environments. Once these problems are fully resolved, the experiment can be fully defined, and flight-ready.

Members: (Cristhian Fimbres), (Zaw Mai), Diane Phung.

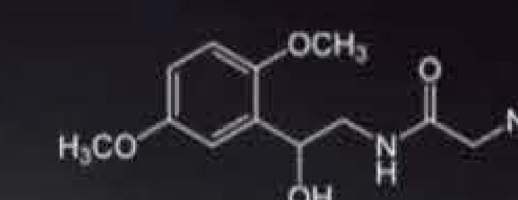


humic acid (general structure)

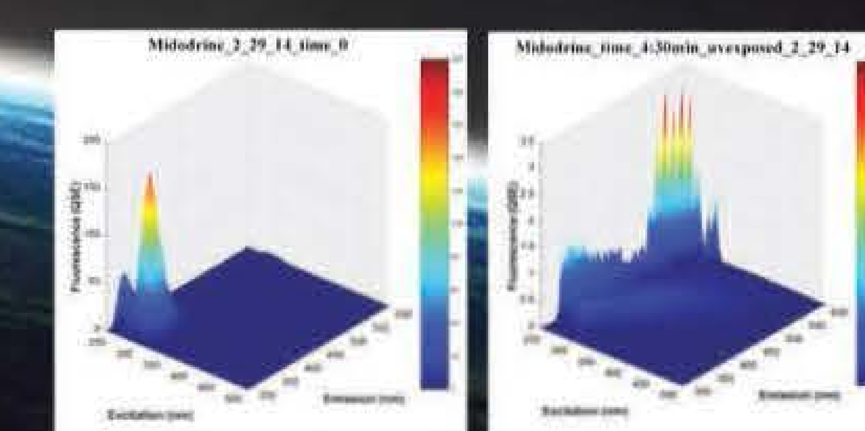
fluorometer (Cooper Lab, CEE)



humic acid fluorescence intensities (C. Fimbres, Z. Mai, D. Phung)



Midodrine



Midodrine fluorescence intensities (C. Fimbres, Z. Mai, D. Phung)