Feb 3rd, 8:00 AM - 12:30 PM

A Constellation of CubeSats for the Measurement of Thermospheric Density

Kimberly Wright
Old Dominion University

James Flynn
Old Dominion University

Susannah Miller
Old Dominion University

A Constellation of CubeSats for the Measurement of Thermospheric Density
Spring 2018 - Old Dominion University - Aeternitas

Robert Bossinger[1], Jordan Byrd[1], Zachary Campbell[1], Mariano Chacon[1], Charles Chiou[1], Avery Corbett[1], Thomas Crouse[1], James Flynn[2], Justin Hernandez[1], Samuel Jensen[1], Garland Johnson[1], Christopher Life[2], Westin Messer[1], Susannah Miller[1], Cody Steele[1], Braxton Vangundy[2], Joseph Vogel[1], Kimberly Wright[1], Wade Yeary[1]

Faculty Advisors: Dr. Robert Ash[1] and Dr. Dimitrie Popescu[2]

[1]Mechanical and Aerospace Engineering Department and [2]Electrical and Computer Engineering Department | Old Dominion University, Norfolk, VA USA

INTRODUCTION

The ODU CubeSat is part of a multi-university collaborative project that is building a constellation of three small satellites, with the dimensions of each at 10 x 10 x 10 cm, that will be deployed in Low Earth Orbit (LEO) to study the variation of the thermosphere density while in orbit. Variations lead to uncertainties in current atmospheric drag models, which constitute a major source of error in orbit prediction for most LEO satellites and contribute to flaws in atmospheric density models of the thermosphere.

Sponsored through the Virginia Space Grant Consortium (VSGC) the project brought together students from Hampton University (HU), Old Dominion University (ODU), the University of Virginia (UVA), and Virginia Tech (VT) to form the Virginia CubeSat Constellation (VCC), a first of its kind for undergraduate small satellite research projects in Virginia. The VCC mission has been manifested and given a delivery date of July 2018, for a launch between Q4 2018 and Q1 2019 with an optimal launch in late December of 2018.

ODU, UVA, and VT built the three satellites that will be simultaneously deployed from the International Space Station (ISS). Each satellite will collect and transmit GPS coordinates, Inertial Measurement Units (IMU) and attitude data, which will be compiled and analyzed by HU.

Among the constellation CubeSats, the one built by ODU has a unique design and will implement a deployable drag brake to accelerate its de-orbit. The mechanical side of the project has completed the design and fabrication of their CubeSat chassis, drag brake, and antenna system; while integrating the much needed electrical hardware and software components. The ODU CubeSat houses a stack of four PCBs; Electrical Power System (EPS), processor board, radio board, and the GPS board.

For each of the universities launching, these CubeSats will hopefully be the first of many more to come.

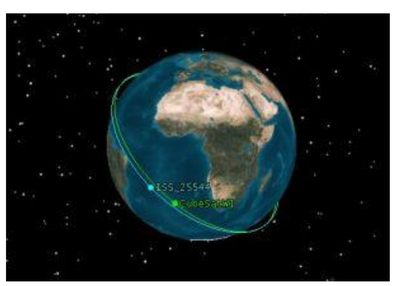

Figure 1: System Tool Kit (STK) results of projected orbit

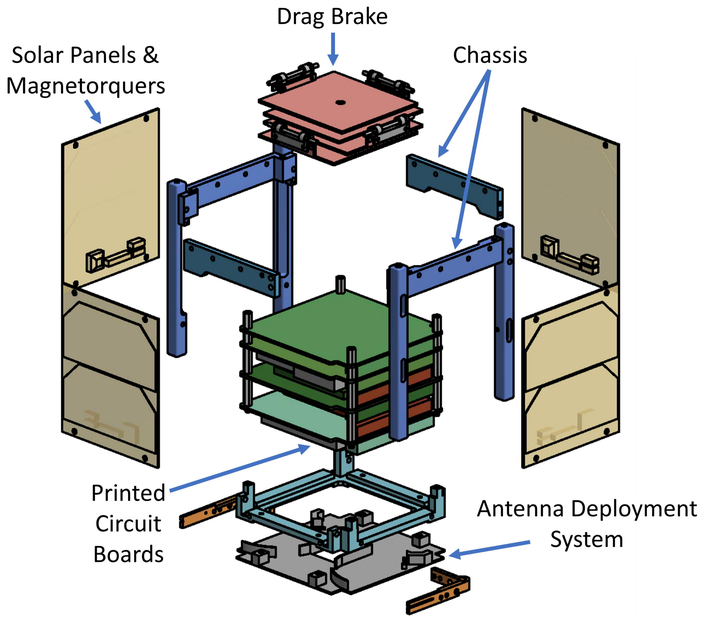

Figure 2: ODU CubeSat Assembly

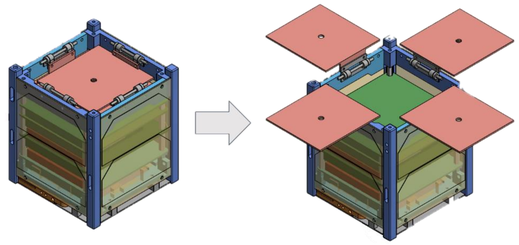

Figure 3: Pre- and Post-Drag Brake Deployment

RESULTS & CONCLUSIONS

- CubeSat will be handed over to NanoRacks and NASA in July 2018
- Deployment from the International Space Station (ISS) in Q4 2018 or Q1 2019
- Chassis structure fabricated
- Completion of drag brake hinge FEA and hinges fabricated
- ADCS algorithms developed, testing and code implementation complete
- Temperature exposure range (-80C to 150C) calculated from orbit path with reference to ISS orbit determined
- Lifetime analysis for different launch windows determined

VIRGINIA CUBESAT CONSTELLATION MISSION

METHODS

The mechanical and electrical engineering teams collaborated to create the internal and exterior functions of the ODU CubeSat, as well as across the constellation.

Structure

- Chassis structure complete
- Antenna assembly plate complete

Payload

- Drag-brake hinge design iterations, Finite Element Analysis (FEA), prototyping and fabrication complete

Attitude Determination and Control System (ADCS)

- Research and algorithm development for pointing, finding earth, sun sensor complete

Power, Environmental and Thermal

- Modeled different parameters the satellite will be subjected to while in orbit; including radiation and temperature differences, inertial and fixed accelerations, ground station coverage, and range of dates for optimal launch

Communications

- Design and antenna deployment mechanism testing complete
- Integration of radio antennae, sun and temperature sensors, Remove Before Flight (RBF) pin, and burn-wire

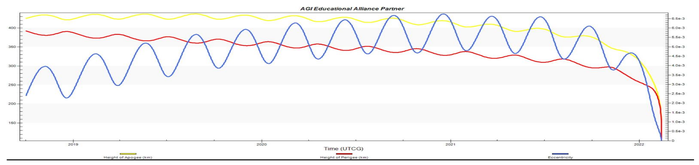

Figure 4: Lifetime analysis of the ODU CubeSat

REFERENCES

- J.T. Emmert, "Thermospheric mass density: A Review", Advances in Space Research, Vol. 56, pp. 773-824, 2015.

ACKNOWLEDGEMENTS

- Electrical and Computer Engineering student team members
- The Virginia CubeSat Constellation (VCC) partner universities: Hampton University, University of Virginia and Virginia Tech
- NASA Wallops Flight Facility
- Virginia Space Grant Consortium (VSGC)
- Old Dominion University Research Foundation
- BECTeam and Tom Friend