NC STATE UNIVERSITY

Department of Mechanical and Aerospace Engineering

Rubble Attachment and Conveyance CubeSat

Aerospace Engineering Capstone Senior Design 2022-2023
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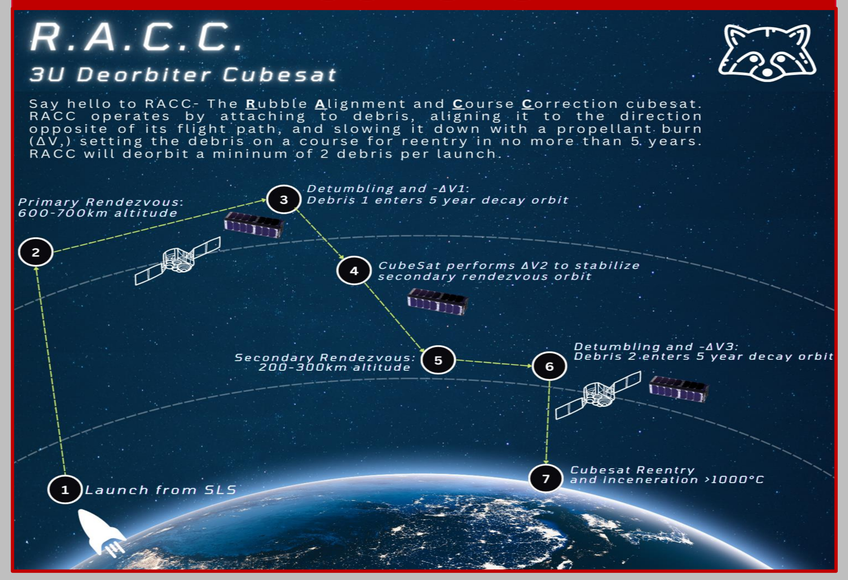
Mission Overview

- The RACC will attach to space debris and using its own propulsion, deorbit the debris.
- RACC will:
  - Rendezvous with a chosen piece of debris
  - Use the target detection and analysis system and a harpoon to attach to debris
  - Use its own thrust to deorbit the debris

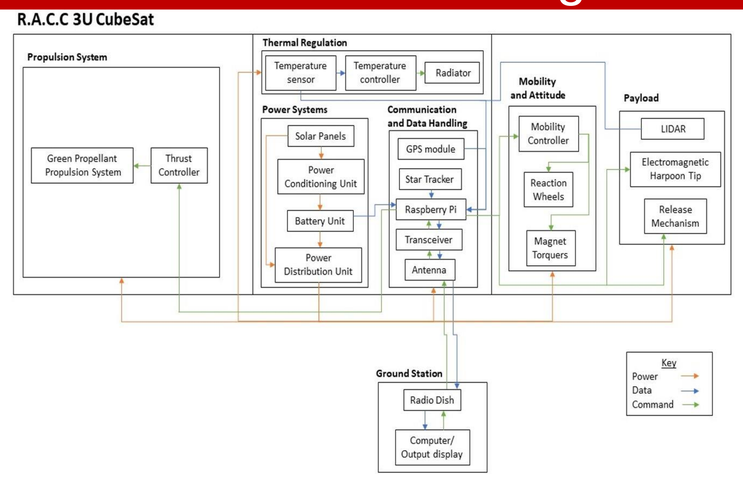
Space Debris Background

- There are 36,000+ objects larger than 10cm
- Potential damage to spacecraft necessitates LEO cleanup
  - Even small objects can cause massive damage
  - Need an efficient and cost-effective cleanup method

CONOPS

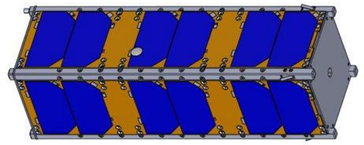


Functional Block Diagram

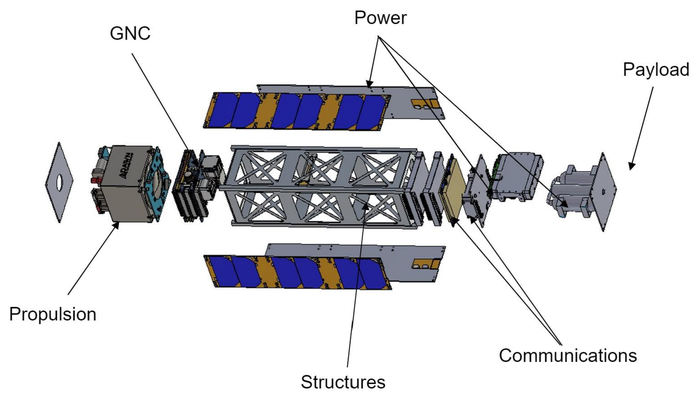


Design Solution

The RACC is unlike any other CubeSat in space today. This is due to its unique mission and functional requirements which has not been accomplished by any other group. The RACC consists of state-of-the-art propulsion and GNC systems for precision attitude control and maneuvers. Also on board is a target detection and analysis system which will allow the CubeSat to successfully connect to the space debris. The most innovative part of the RACC is the payload, which is a fully customized powder actuated harpoon system which is strong enough to pierce through space grade metal and make a rigid connection with the CubeSat.



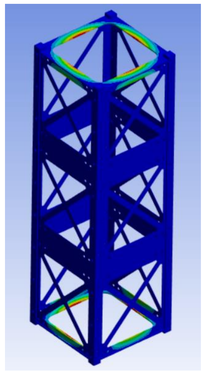
Subsystem	Component
Structure	Custom Al 7075-T6 Structure
GNC	CubeADCS 3-Axis Small
Propulsion	Dawn 1U
Power	EXA Battery Array, ISIS 3U Solar Panels, and ISIS EPS
Ground Station	Amazon AWS Ground Station Network
Communication & Data Handling	EnduroSat Onboard Computer, S-Band Transceiver, and S-band Planar Antenna
Thermal	Silver Second-surface FEP Tape, Phase Change Unit, Copper Thermal Strap
Payload	Custom firing mechanism and harpoon rod
Target Detection & Analysis	2 Cameras and 2 LiDAR Sensors



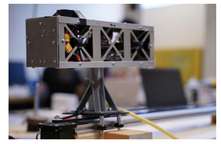
VV&T

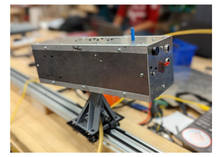
Harpoon Test

Vehicle Simulations



Vehicle Test





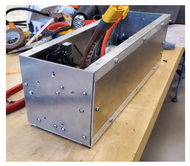
Manufacturing

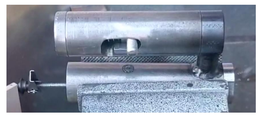
The R.A.C.C. CubeSat prototype is constructed from many components that had to be manufactured. These pieces are the steel custom made powder harpoon, the PLA 3D printed air bearing, the brass reaction wheels, the aluminum 7705 and 6061 3U structure, and the electrical system.

The Air bearing consists of two 3D printed parts, the support bowl, and the ball structure that connects to the chassis.

The Harpoon system was manufactured from W-1 tool steel cut into several pieces. These pieces are two threaded caps, a spring loaded and lever action firing system, the harpoon itself which consists of a conic tip with flanged bit to catch material and threaded shaft, and a firing tube connected to a powder charge holder by a weld.

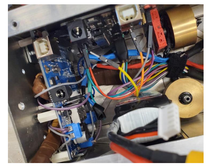
The structure was constructed by 2 sheets of aluminum 7705 and 6601 and L Brackets. The sheets were cut with a waterjet. Aluminum 6601 formed the support panels and 2 square panels. The L brackets secured the support panels by screwing them together. Aluminum 7705 formed the rectangular outer panels.

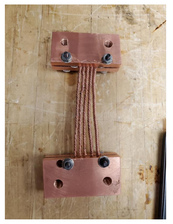




The reaction wheels are made of solid brass wheels connected to BLDC motors; The brass wheels were cut from a piece of Hexagonal brass rod. The motors are connected to 3 electronic speed controllers (ESC), and the ESCs are connected to an Arduino where the code for the control modes were uploaded.

The electrical system is made up of the battery, wires, connectors, Arduinos, and ESCs.





The Thermal strap was constructed from a 2" x 3" x ½" bar of copper and braided 2mm wire. The bar was cut into 2 ends with a horizontal cut, and 4 holes. Wires were fitted into the rectangular cut of each end which were then screwed together using two of the holes pinching the wires in place.

A Linear track driven by a motor and toothed belt was built to simulate propulsion. This was done by sawing the track to the correct length and properly assembling it.