NC STATE UNIVERSITY
Department of Mechanical and Aerospace Engineering

Waste Allocation Load Lifter - Space Class

WALL-S

Aerospace Engineering Capstone Senior Design 2022-2023

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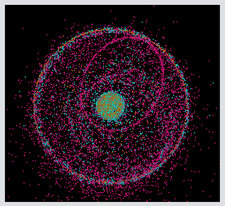
WALL-S Mission Overview

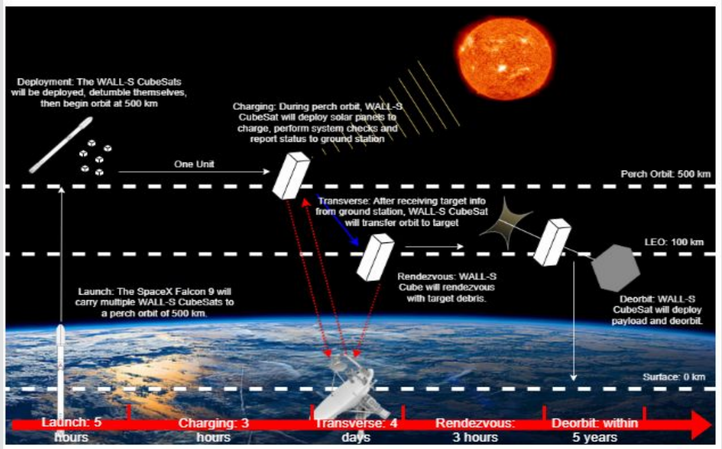
- More than 27,000 pieces of debris are actively being tracked
  - Many are too small to be tracked
- Space debris travels at speeds up to 17,500 mph
  - Even small debris can cause significant damage
- Missions requiring the destruction of debris in orbit create more particles
  - Kessler Syndrome



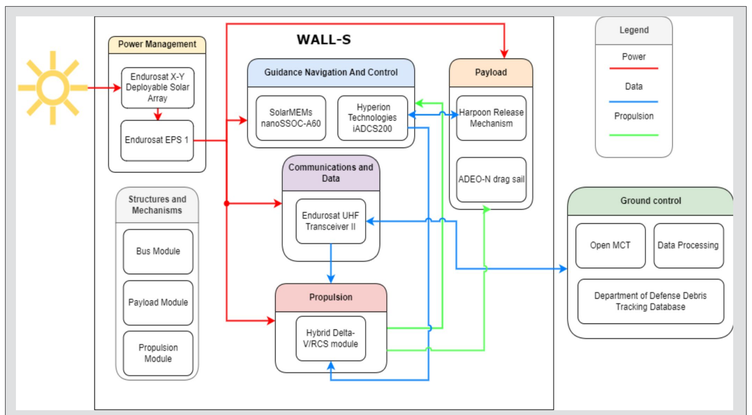
The WALL-S Mission

As humanity continues to launch vehicles into the atmosphere and into space, there is a growing need for a method of removing debris in order to protect the space commons and future missions.

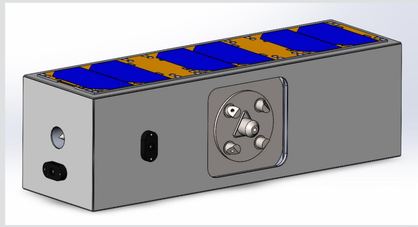
Concept of Operations



Functional Block Diagram



Design Solution



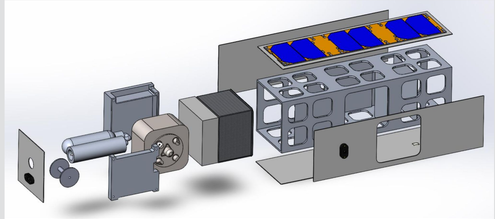
The WALL-S CubeStat is a 3U CubeSat designed to be launched as part of a constellation of satellites and deployed at 500 km where its mission will begin.

The WALL-S Design Solution is divided into 8 subsystems, each with their own design choices for the WALL-S CubeSat.

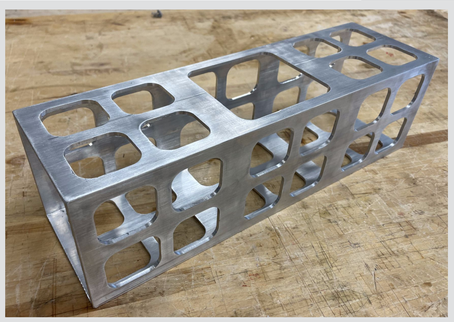
1. Structure:
   - 3U Modular Chassis Design made of Aluminum 6061-T6.
2. Thermal:
   - Two-part passive regulation system of surface coating and MLI blanket.
3. Power and Electrical:
   - Solar panel, battery, distribution system.
4. Data and Communication:
   - UHF transceiver and Monopole antenna.
5. Ground Station:
   - Multiple ground station locations centered around the equator.
6. GNC:
   - External Sun-sensors, ADCS and RCS system.
7. Propulsion:
   - ADN-based green propulsion system with an integrated cold gas RCS.
8. Payload:
   - Harpoon and drag sail system.

Design Solution Power Breakdown:

- Battery Capacity: 20.4 Wh
- Solar Generation: 16.8 W
- Antenna Power: 1 W
- GNC System: 4.5 W
- RCS: 11 W
- Flight Computer: 1 W
- Thrusters: 6 W



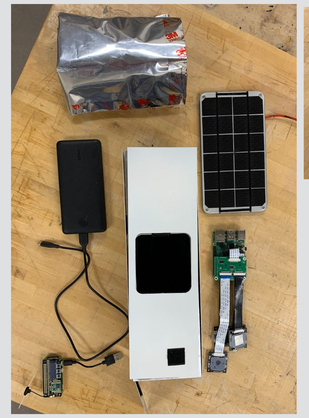
Manufacturing



1. The chassis structure above was modified from the ideal, modular design for ease of construction for the prototype. It was cut from rectangular tubing. It is made of Aluminum 6063-T6.
2. The harpoon structure above was lathe cut from an aluminum rod to be used for verification testing. The damage to the tip seen above is due to puncture testing.
3. The thermal blanket seen left was constructed by layering aluminum foil and thermal insulation packaging.

More details on the manufacturing process of the WALL-S prototype may be accessed through the QR code above.

Final Prototype



Due to budget, time, and experience constraints, the WALL-S prototype was constructed in order to verify that the design solution chosen would be a viable option for deorbiting space debris.

Seen above is the fully assembled prototype bus. This prototype is 11 lbs or 4.9895 kg.

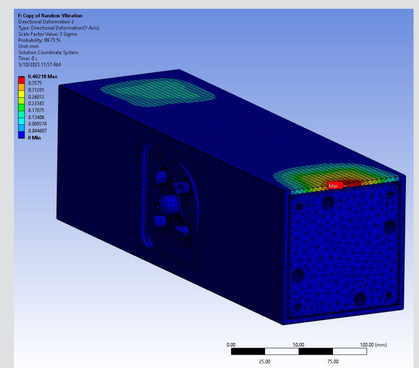
Seen left is the disassembled prototype with its battery, communication transceiver and antenna, camera system, solar panel, and thermal blanketing.

The battery used in the prototype provides 20,000 mAh or 100 Wh to the system. This is much larger than the battery to be used, but this effect is balanced by the less efficient solar panels. Also seen above is the white paint representative of the magnesium-oxide surface coating, part of a two-part system for thermal regulation.

Prototype Power Breakdown:

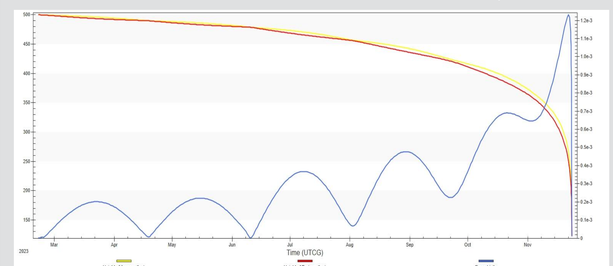
- Battery Capacity: 100 Wh
- Solar Generation: 6 W
- Raspberry Pi: 0.4 to 5.1 W
- Sun Sensors: 0.5 W ea.
- Transceiver: 0.25 W

Verification & Validation Testing



Individual tests for each subsystem were performed to verify their performance. The entire prototype was then assembled and tested to determine the full capabilities of the WALL-S prototype and how it compared to the full scale model.

1. The rendering seen left is the simulation of stress during launch and its effect on the WALL-S CubeSat prototype design. This simulation was performed in SOLIDWORKS
2. The plot seen below shows the length of time required for a drag sail to deorbit a 100 kg piece of debris from an altitude of 500 km. This simulation was performed in ANSYS STK.



More details on the testing process of the WALL-S prototype may be accessed through the QR code above.