From SmallSat to CubeSat: Reducing Mass Size and Cost

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Introduction

- The NEOSat SmallSat concept was born from a space mission architecture class last Fall
- The final project for the course was to create a spacecraft design compliant with the U.S. Air Force University NanoSat Program that could be submitted to the upcoming UNP solicitation
- The original SmallSat-size concept was completed during this course and refined over several months subsequent to this

Transition to 6U CubeSat

Why did we downsize?

- Suggestions from the UNP staff about the ease of getting a USAF launch
- The possibility of receiving a launch from NASA ELaNa if our spacecraft wasn't down-selected by UNP
- A realization that the 6U form factor could perform most of what we wanted to do

NEOSat Goals

Mission Statement

Earth Impactors (EI) may pose a significant threat to life on Earth. In order to mitigate such a threat, the physical characteristics of the potential EI must be established. Using a small spacecraft to make in-situ measurements of a potential EI can offer a low-cost option for obtaining data necessary for threat assessment as well as for the development of mitigation strategies.

Prior to an actual EI rendezvous mission proof of concept for the required technologies needs to be demonstrated. A student/faculty designed mission, EI Technology Demonstrator, will investigate and demonstrate technologies that can be used for a future EI rendezvous mission.

Material from: NEOSat: An Architecture for Small Interplanetary Spacecraft Development and Earth Impactor Threat Mitigation

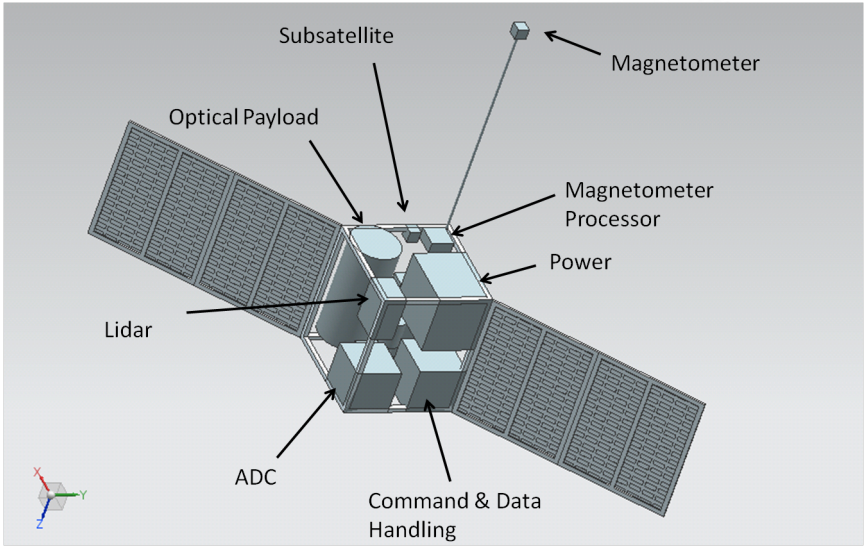
NEOSat Goals (cont.)

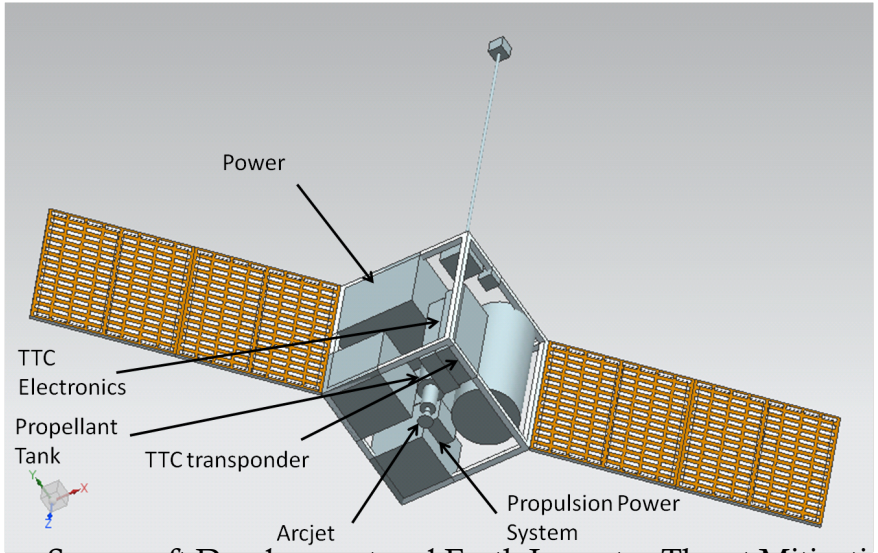
Primary Objective
Perform observations of a target object to evaluate technologies for a future EI rendezvous mission.

Secondary Objectives
1. *Collect mission data pertaining to the target object(s).* 2. *Provide meaningful real-world space mission experience for students.* 3. *Demonstrate that students and faculty at the University of North Dakota can successfully design, build, test, and launch a small spacecraft.*

Material from: NEOSat: An Architecture for Small Interplanetary Spacecraft Development and Earth Impactor Threat Mitigation

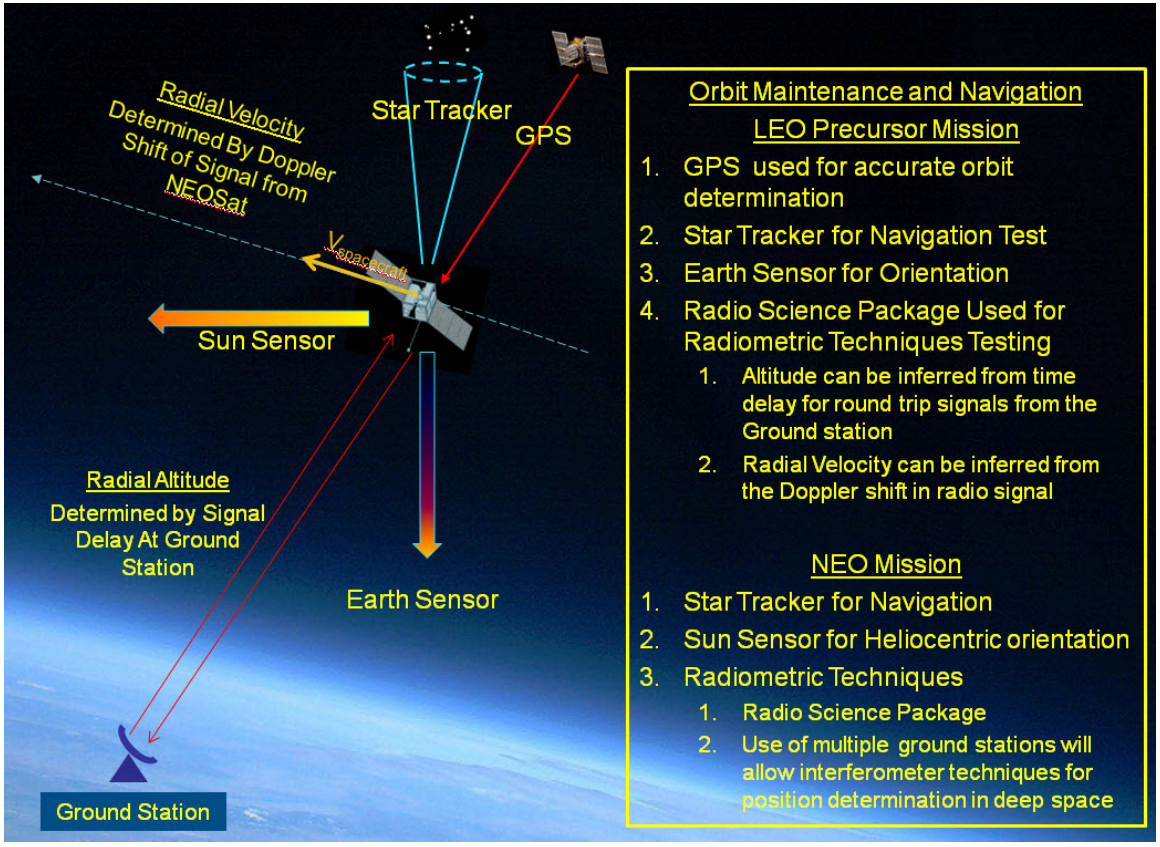
The Original SmallSat





Material from: NEOSat: An Architecture for Small Interplanetary Spacecraft Development and Earth Impactor Threat Mitigation

SmallSat Operations



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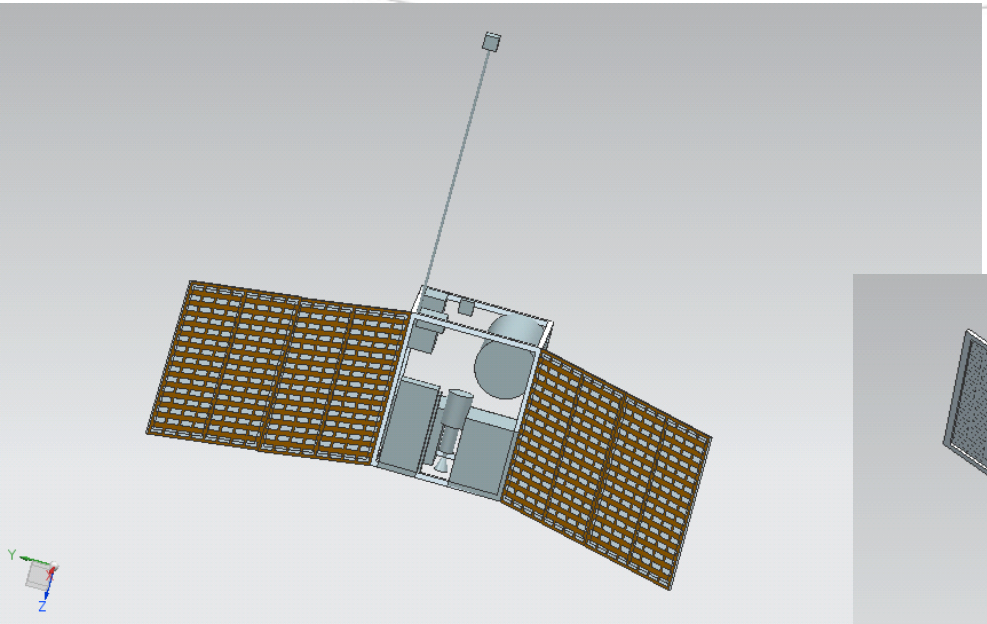
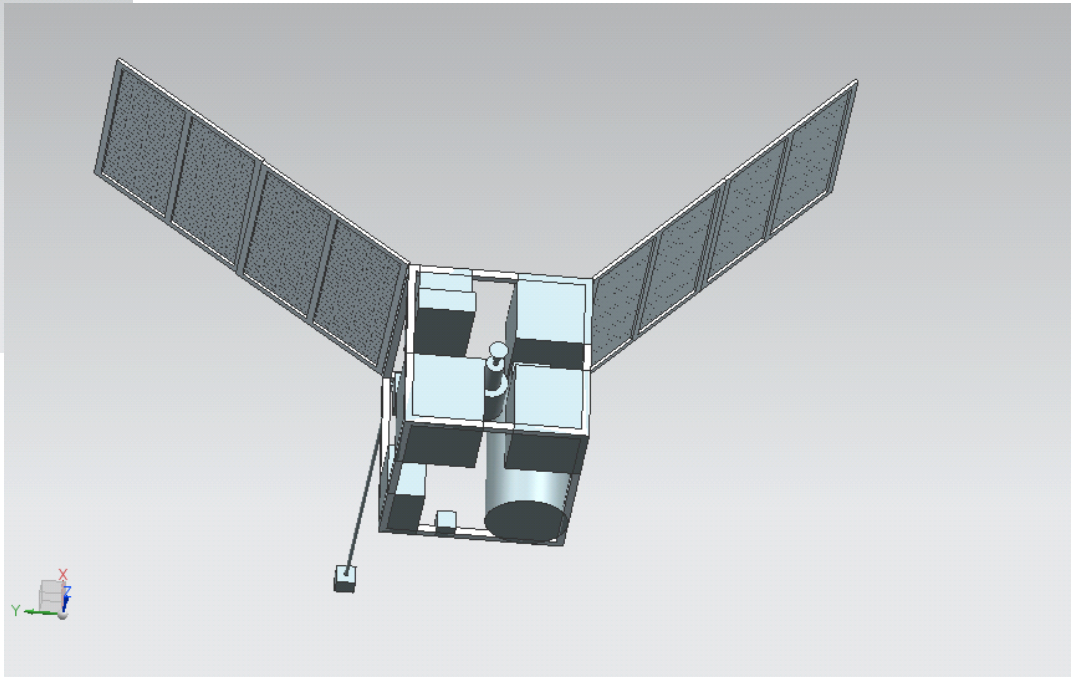
Minor Revisions





NEOSat: The 6U Version

Goals for 6U Design:

- Retain mission statement
- Retain primary & secondary objectives
- Maximize utilization of craft volume

Design Trades

Removed:

- LIDAR (though we actually added this back in)
- Magnetometer
- Sub-satellite
- Propulsion (though we actually added this back in)

Added:

- Additional onboard computing capabilities

Design Trades (cont.)

Degraded:

- Communications
- Radio Science
- Power Generation

Enhanced:

- Ground Station Capabilities

Design Trades (cont.)

Reduced:

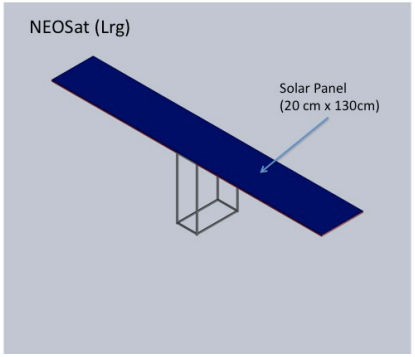
- Cost
- Mass
- Volume
- Schedule

Increased:

- Risk
- Complexity

Communications Subsystem

- Deployable phased-array antenna's surface area was significantly reduced: 12,000 cm^2 to 2,400 cm^2
- Solar panel surface area (on reverse of phased array) was similarly reduced
- Dramatic decrease in gain & power
- Poses significant constraints on system operation

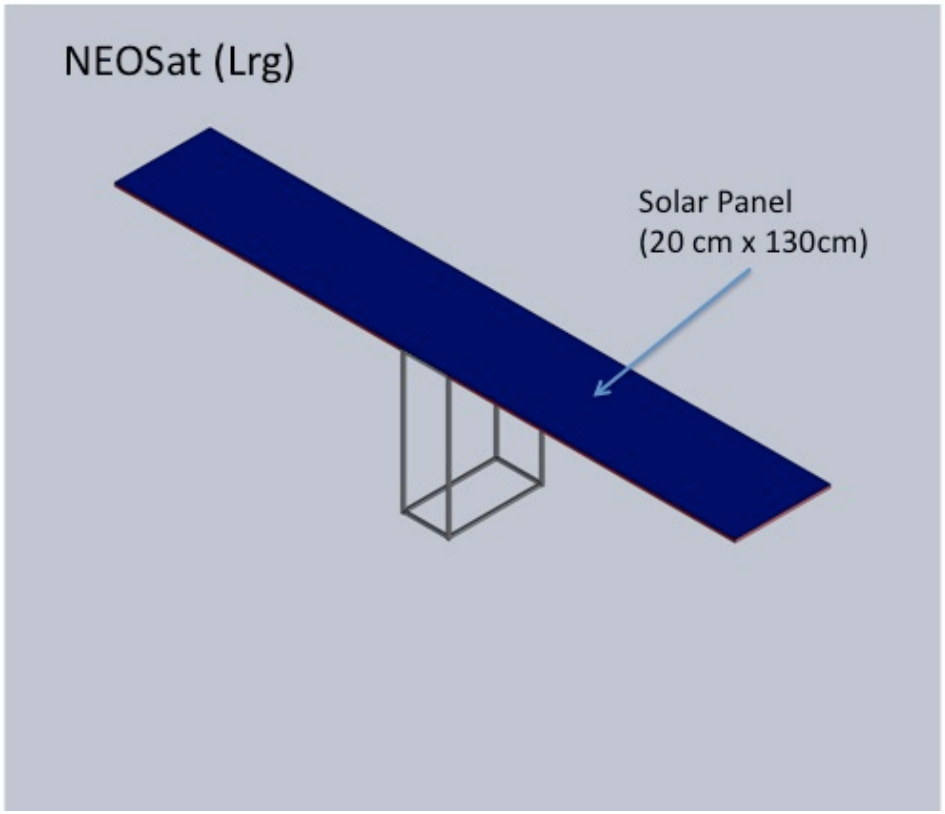


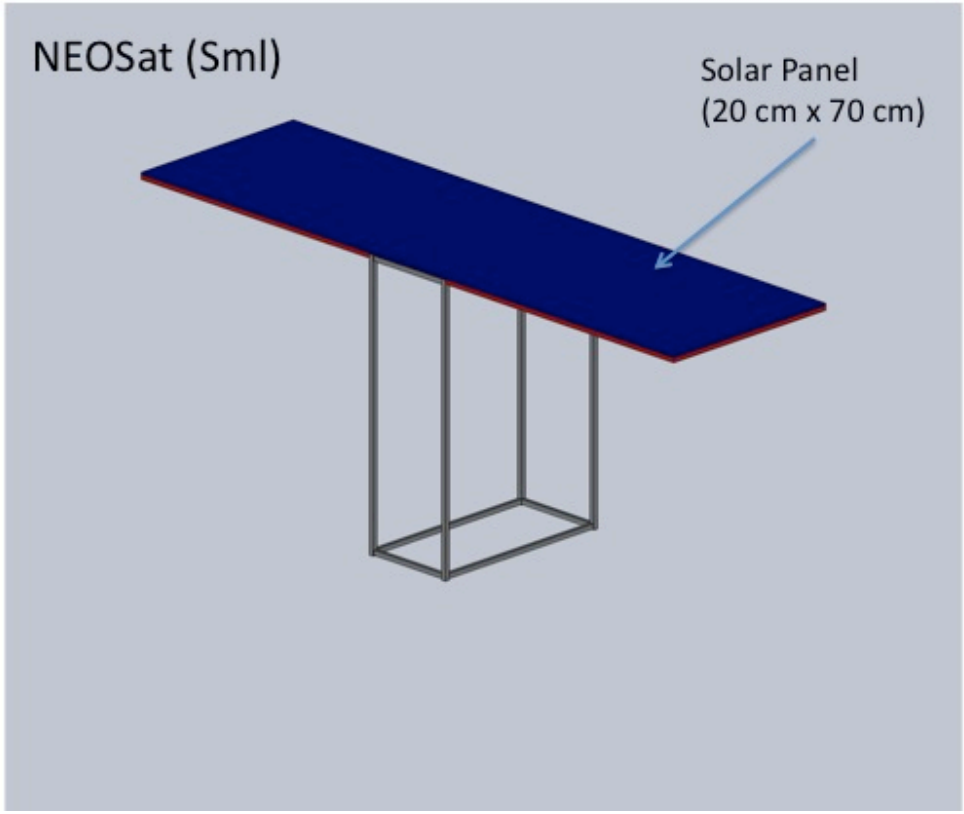
Comm System Considerations

Options considered:

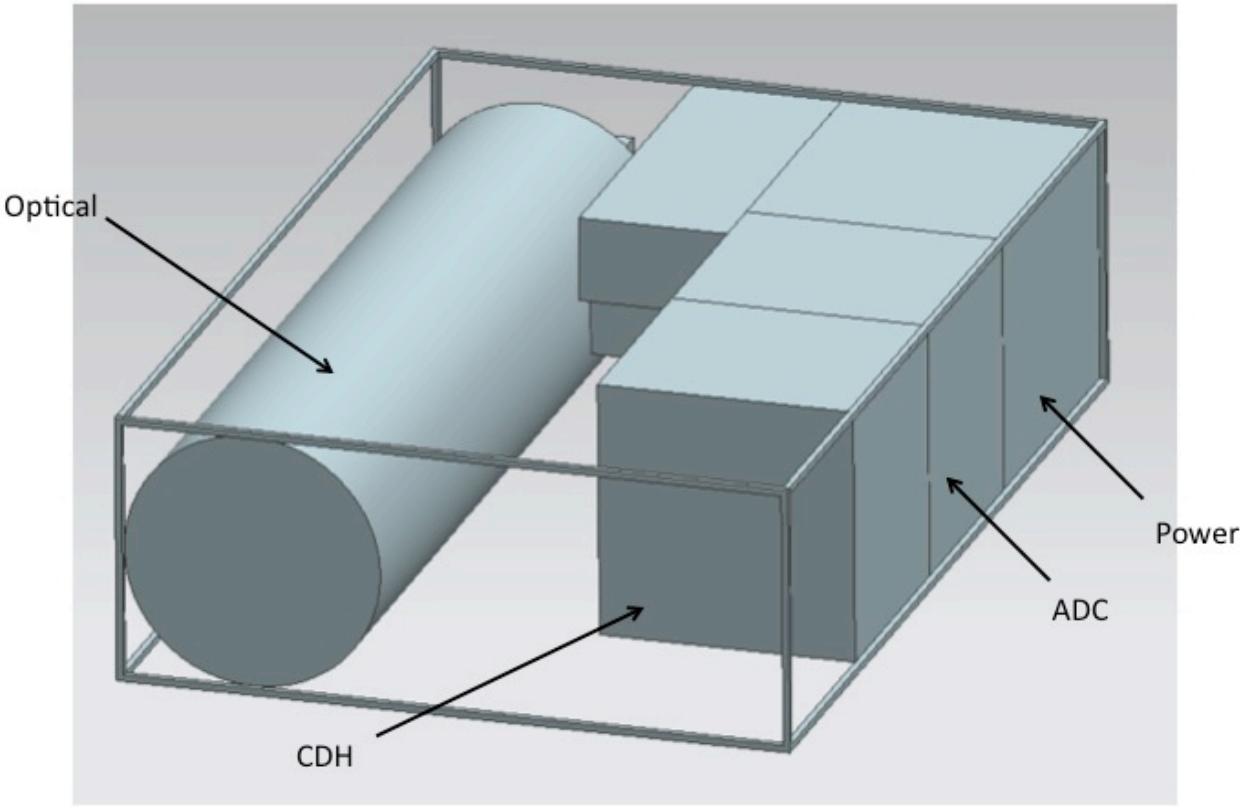
- S vs. X Band
- Trade between ground station antenna gain and achievable data rate
- Spacecraft antenna design: phased array vs. helical deployable antenna
- Evaluated Duty Cycle Options

NEOSat – Solar Panel Configuration

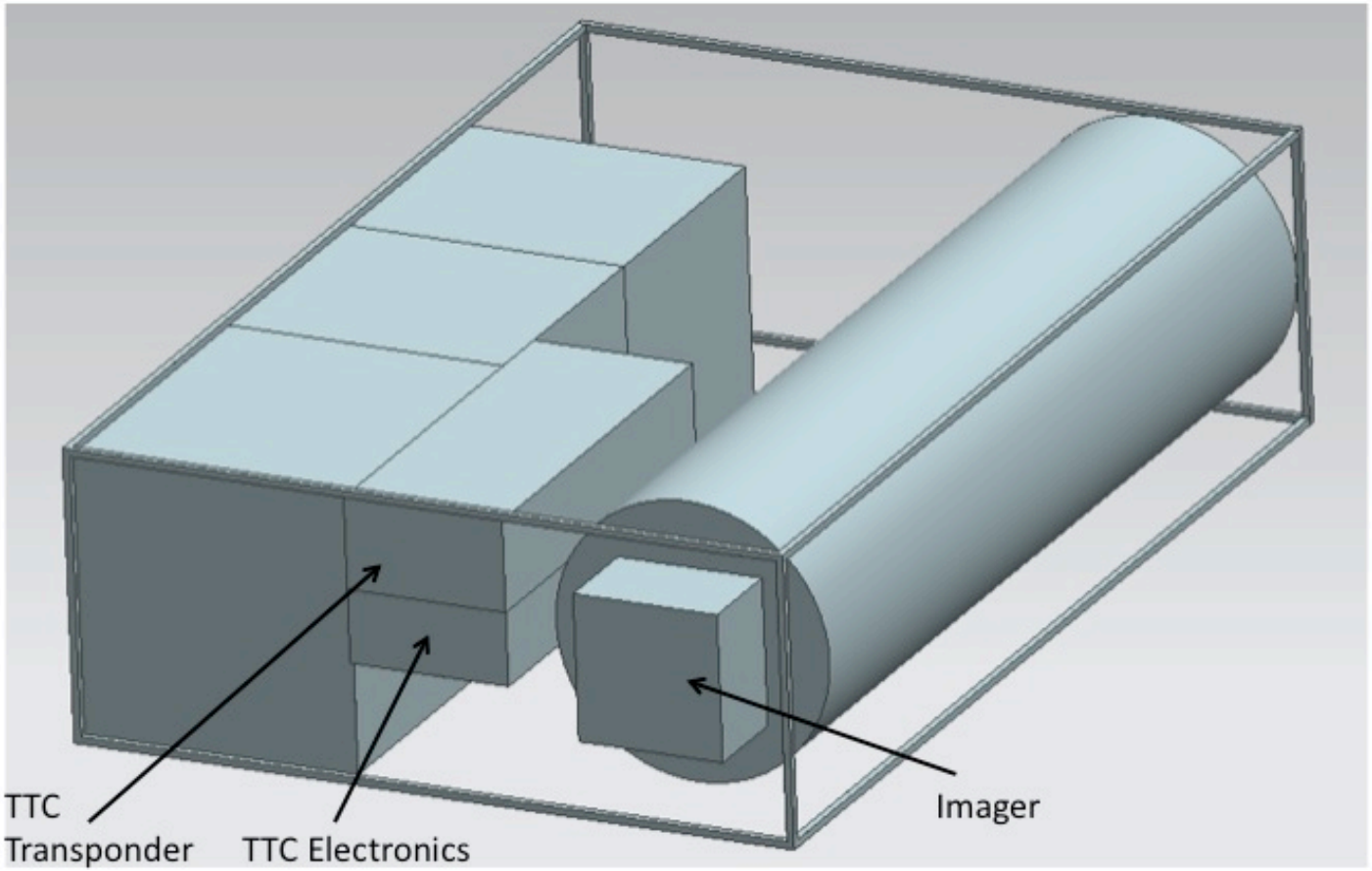




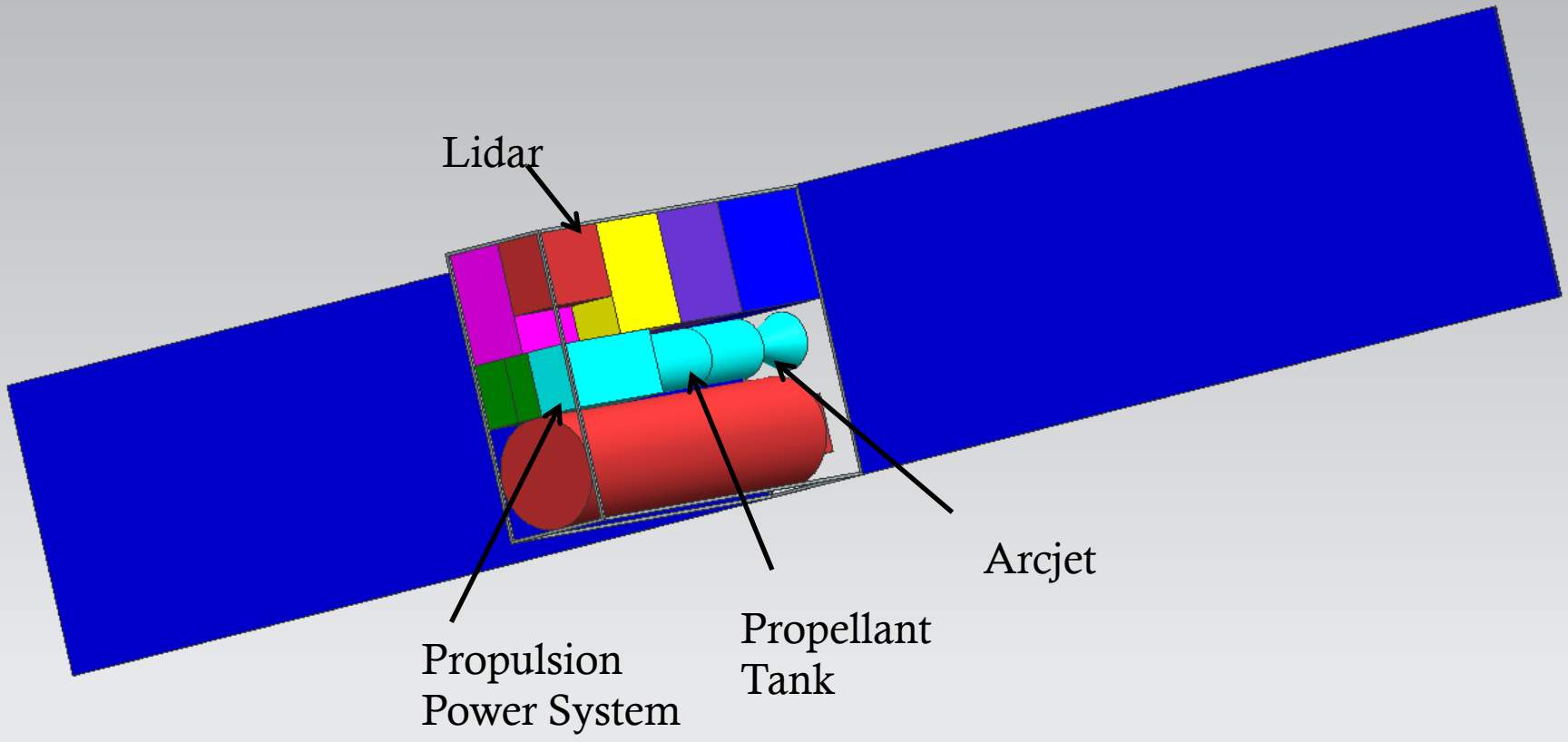
NEOSat: 6U CubeSat



NEOSat: 6U CubeSat (cont.)



Adding Components Back In …



Adding Components Back In …
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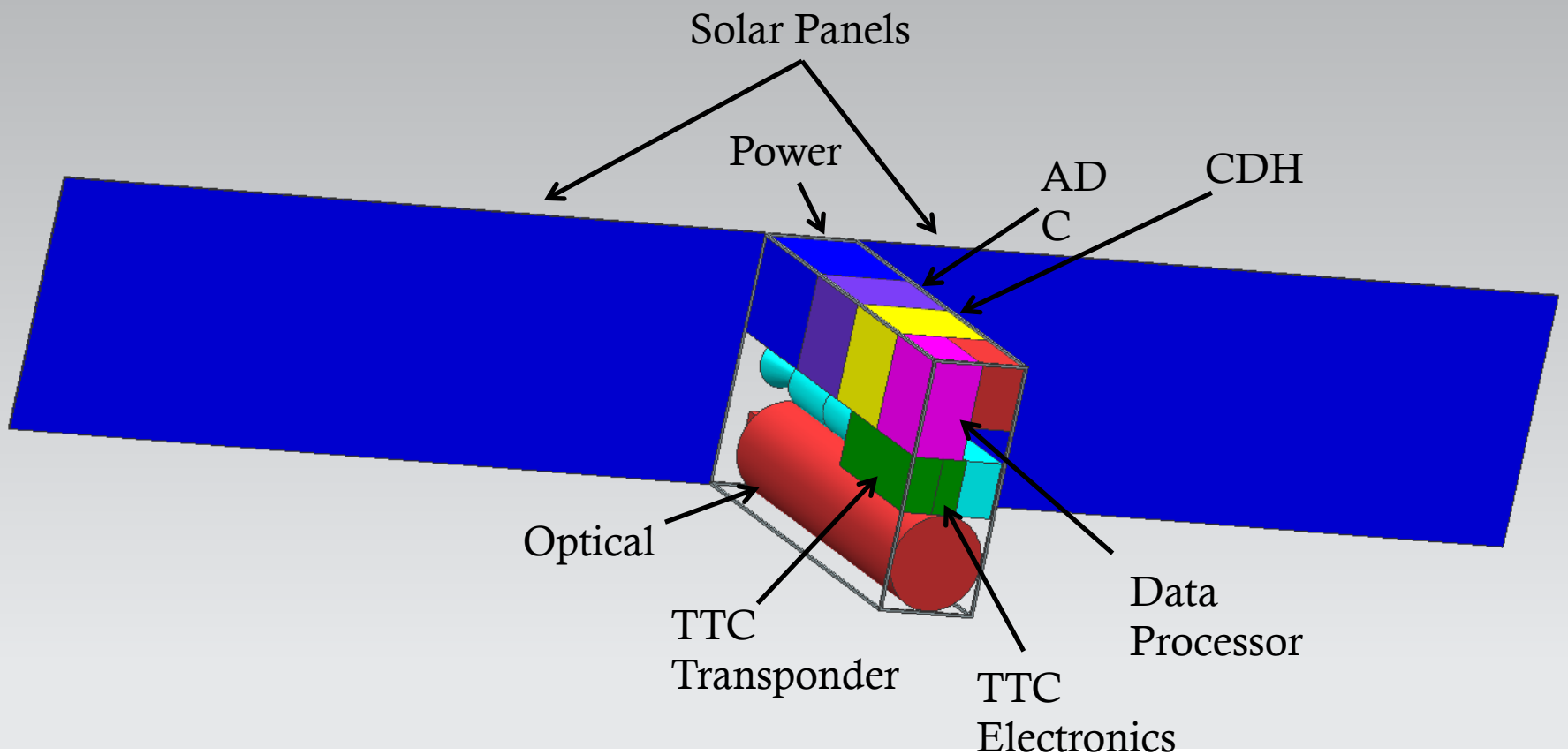

Conclusions

- We were able to maintain most of the functionality that we desired to have at the smaller size
- We removed several elements that we prioritized as having lower comparative importance
- Our largest system degradations were in power generation and optical resolution due to the smaller aperture (~ 8cm) and focal length (~30 cm + folded optics capability) and smaller solar panel surface area (20 cm x 130 cm vs. 50 cm x 250 cm)

Conclusions (cont.)

- We were able to compensate for the communications degradation through:
  - Increasing ground station gain
  - Using a network of ground stations (more transmit time)
  - Managing and prioritizing data transmissions
- We also considered reduction to a 3U form factor, however, this placed too much of a constraint on the optical system and completely precluded propulsion and LIDAR and thus was judged infeasible