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

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<tr>
<th>Mission Statement</th>
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<td>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.</td>
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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. |
Neosat Goals (cont.)

**Primary Objective**

*Perform observations of a target object to evaluate technologies for a future Earth Impactor (EI) rendezvous mission.*

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

Material from: NEOSat: An Architecture for Small Interplanetary Spacecraft Development and Earth Impactor Threat Mitigation
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 cm² to 2,400 cm²
- 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 (Lrg) - Solar Panel (20 cm x 130 cm)

NEOSat (Sml) - Solar Panel (20 cm x 70 cm)
NEOSat: 6U CubeSat
NEOSat: 6U CubeSat (cont.)
Adding Components Back In …
Adding Components Back In …
(cont.)
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