Introduction to the SmallSat Paradigm

Adam Nelessen

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Short Course Introduction and Goals

Objective:
Explore the current state-of-the-art for Small Satellites and their capabilities for deep space planetary missions

Emphasis:
Small Satellites for *in situ* planetary exploration

Topics:
- Overview of international efforts
- Review state-of-the-art of SmallSat subsystems
- Understand past and present SmallSat missions
- Look forward toward concepts in formulation
- Explore enabling technologies
Short Course Logistics

- Every presentation is 20 minutes
- Presenters will be given a 5 minute and a 1 minute warning
- Coffee and snacks will be provided at each coffee break
Adam Nelessen – About Me

Jet Propulsion Laboratory (3 years)
- Mars 2020 EDL Systems Engineer
- Aerocapture R&TD Principal Investigator
- Former Mars Program Systems Engineer
- Former Team-X/Xc Lead Systems Engineer

Education
- MS, Aerospace Engineering, Georgia Institute of Technology
- BS, Mechanical Engineering, Northern Arizona University
What is a Small Satellite?

There are a variety of definitions

**CubeSats**

Defined in U’s, where
1U = 10cm x 10cm x 10cm

Rough mass rule-of-thumb: 1U ≈ 2kg

**ESPA-Class**

Support 24” x 28” x 35.5” SmallSats

180kg maximum

**Arbitrary mass and volume limits**

“Less than 50kg and 24U”
What is a Small Satellite?

Approximate Cost Cap ($M)

- SIMPLEx: $55
- Discovery: $500
- New Frontiers: $1000
“Small Satellite” Philosophy

- **Risk Tolerant:** A whole new mission class, with accompanying design principles, is emerging

- **Low-Cost:** Simplicity of these systems can lower costs

- **Focused Science Objectives:** Small missions commonly accommodate only 1-2 science payloads

- Best-suited for **short-duration objectives, sacrificial elements, and networks & constellations**
SmallSats are Trending

Nanosatellites by launch years

Database includes and term nanosatellite implies them all:
- All CubeSats (0.25U to 27U).
- Nanosatellites from 1 kg to 10 kg. Non-CubeSats are in kg.
- Picosatellites from 100 g to 1 kg.
- PocketQubes, TubeSats and SunCubes.
SmallSats Expand Access to Space

Nanosatellites by locations

- South and Central America, 40, 1.9%
- Rest of the World, 110, 5.1%
- Canada, 37, 1.7%
- China, 60, 2.8%
- Africa, 18, 0.8%
- Europe, 512, 23.9%
- US, 1257, 58.8%
- India, 21, 1.0%
- Japan, 55, 2.6%
- Russia, 28, 1.3%

www.nanosats.eu

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New Frontiers in Small Probe Exploration

Recent efforts highlight the potential for Small Spacecraft probes and landers

Minerva
Credit: JAXA

MarCO
Credit: NASA
https://photojournal.jpl.nasa.gov/catalog/PIA19388

Philae
Credit: ESA/ATG Medialab
https://www.flickr.com/photos/europeanspaceagency/10796307373/
## Key Challenges for Deep Space SmallSats

### Propulsion
- There is currently no proven orbit insertion method at SmallSat scales
- Safety concerns have so far limited propellant options
- Cold gas offers low thrust and $I_{sp}$

### Radiation
- Most commercial-off-the-shelf hardware is developed for the LEO environment
- More R&D is needed to mature small spacecraft hardware for the environments of deep space

### Power, Telecom, Science Instruments
- Inverse square laws demand area and aperture
- SmallSats are more sensitive to solar distance

### Cost
- Some high-cost items do not scale with size:
  - Interplanetary navigation
  - Ground systems