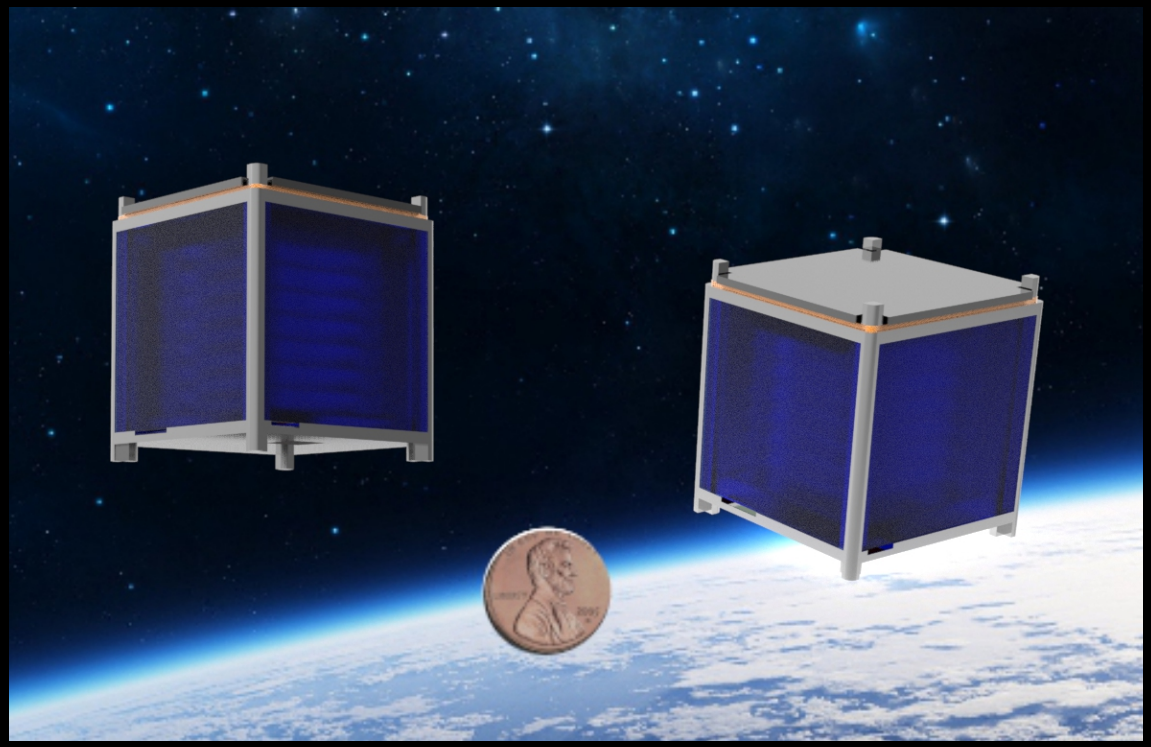


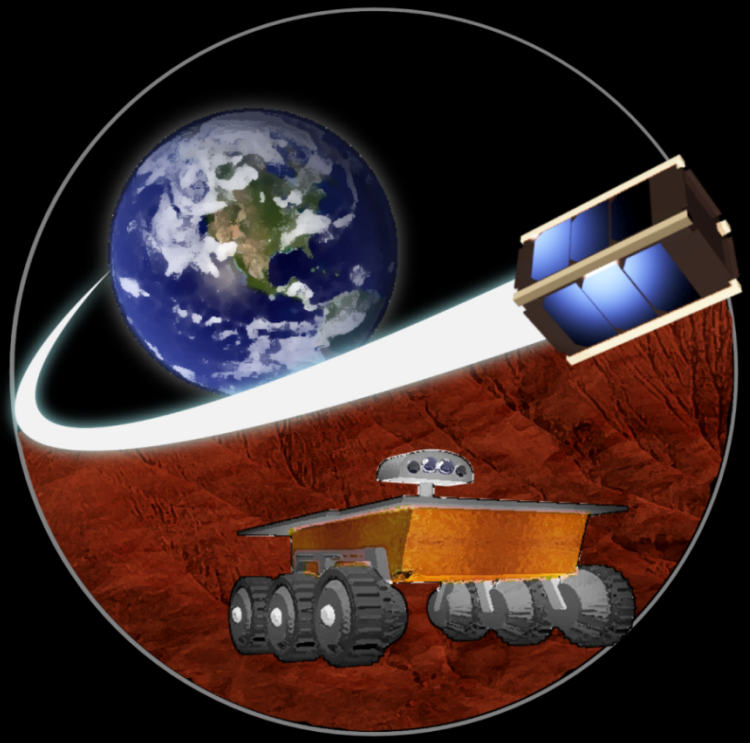
SpaceTREx

SunCube FemtoSats:

A New Tool in the Interplanetary Exploration Toolbox

Jekan Thanga , Mercedes Herreras-Martinez, Andrew Warren,
Aman Chandra, Ravi Teja Nallapu, Erik Asphaug
Space and Terrestrial Robotic Exploration (SpaceTREx) Laboratory
Arizona State University

ASU School of Earth & Space Exploration



SpaceTREx

Space and Terrestrial Robotic Exploration Laboratory

space.asu.edu

ASU School of Earth & Space Exploration

Motivation

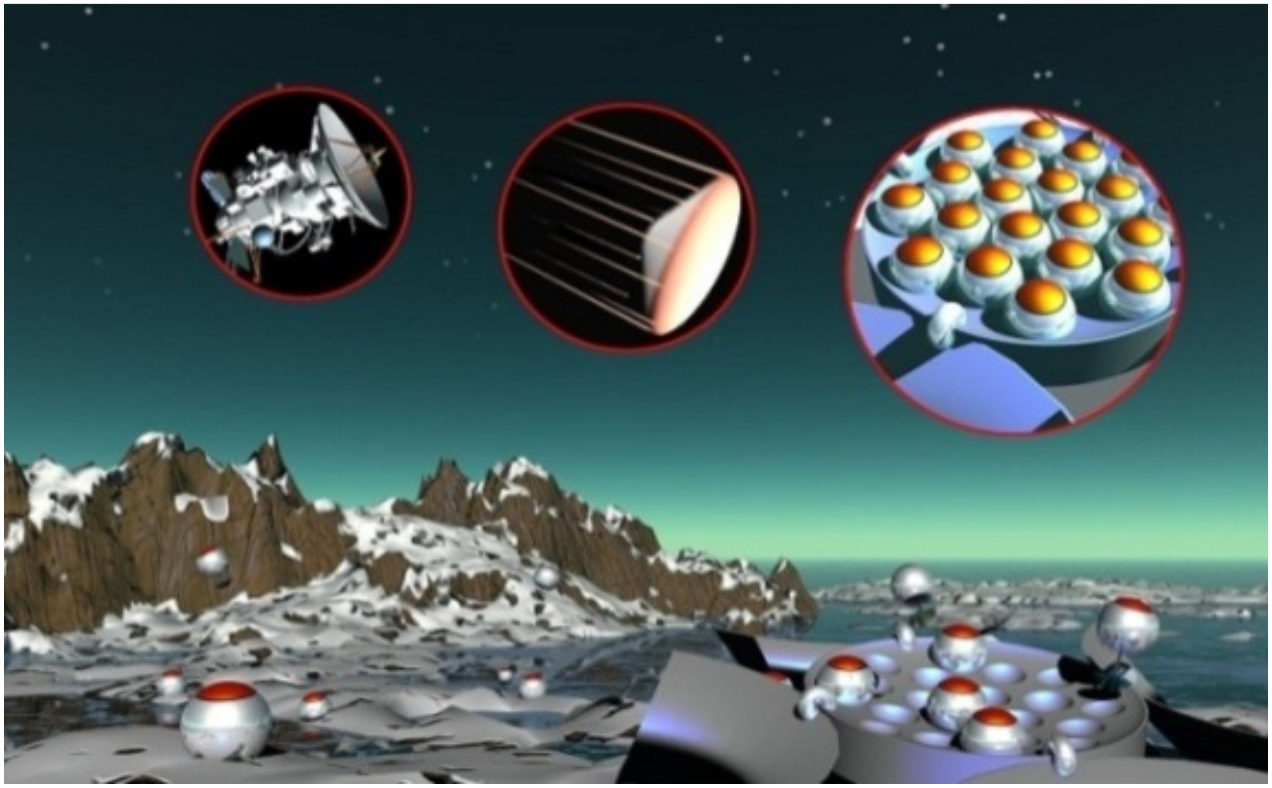
1. Enables access to space for educators, university, high school and middle school students

Motivation

2. Enable low-cost access to space for researchers to send proof of concept experiments

- MEMs, Inflatables/Deployables, Propulsion, Networking, Science, Deploy-Cams

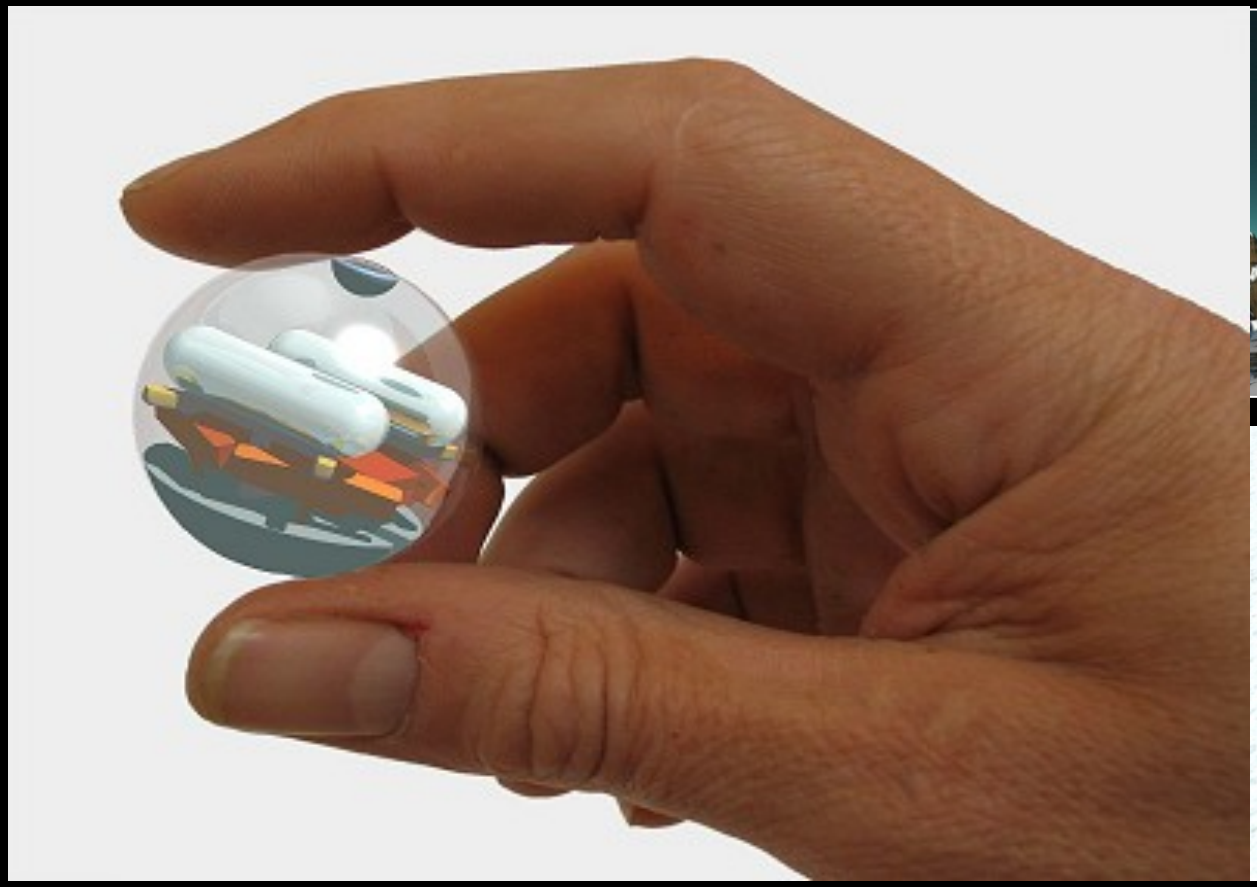
Motivation

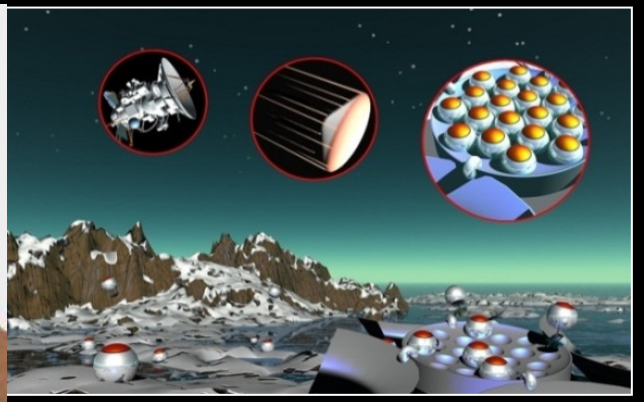


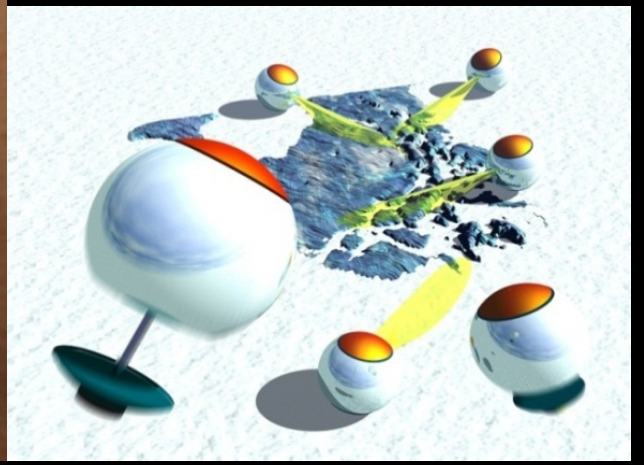
3. Develop low-cost, truly disposable spacecraft and robots, where thousands can be sent.

Network Exploration

SpaceTREx







[Dubowsky et al., 2006; Thangavelautham et al., 2008]

NIAC
NASA Innovative Advanced Concepts

SunCube FemtoSat

SunCube

SunCube FemtoSat

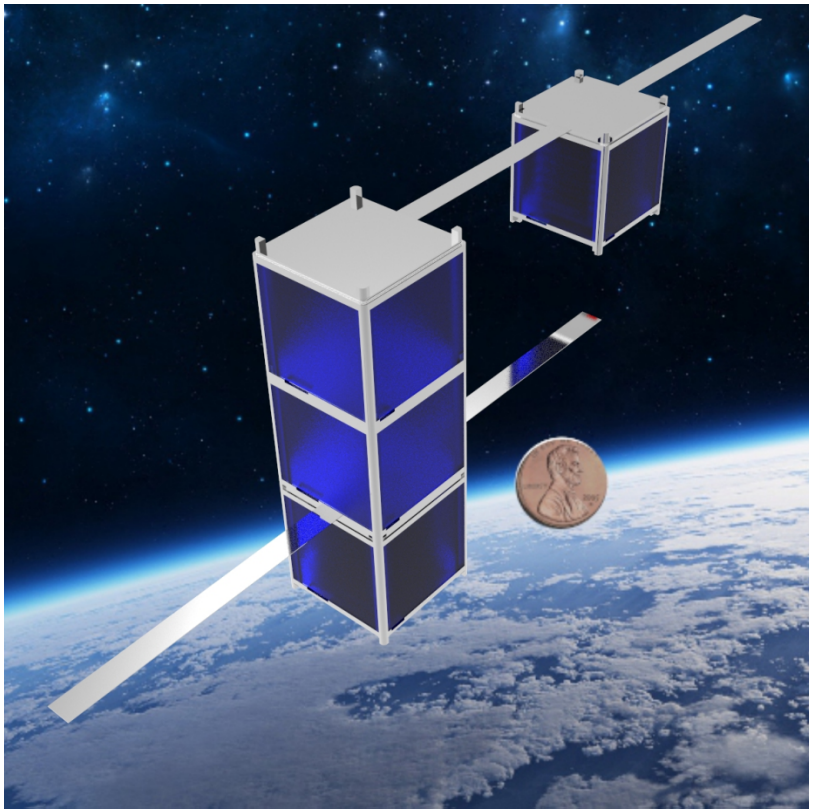
- We are devising a new standard
  - 1F

    Volume = 3 cm x 3 cm x 3 cm

    Mass = 35 g
  - 3F

    Volume: 9 cm x 3 cm x 3 cm

    Mass = 100 g



SunCube FemtoSat

- Main Goal
  - Specify volume and mass envelope
  - Put out a reference design for 1F and 3F
  - Propose a CubeSat chassis to enable deployment of 1F and 3F.

Open Standard:

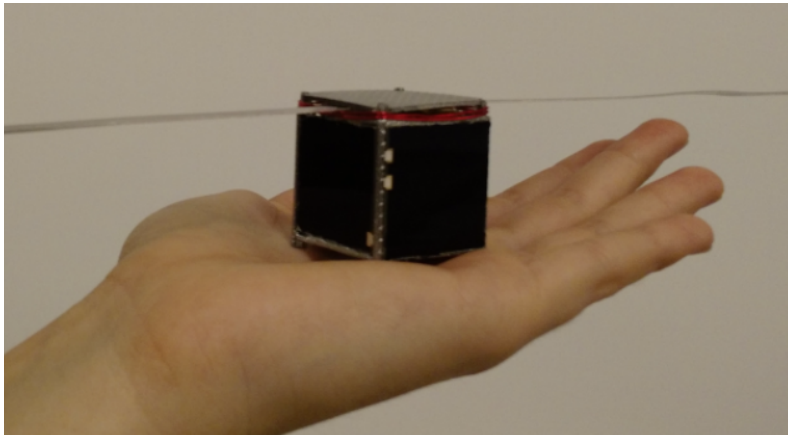
http://suncube.asu.edu/ or http://femtosat.asu.edu/

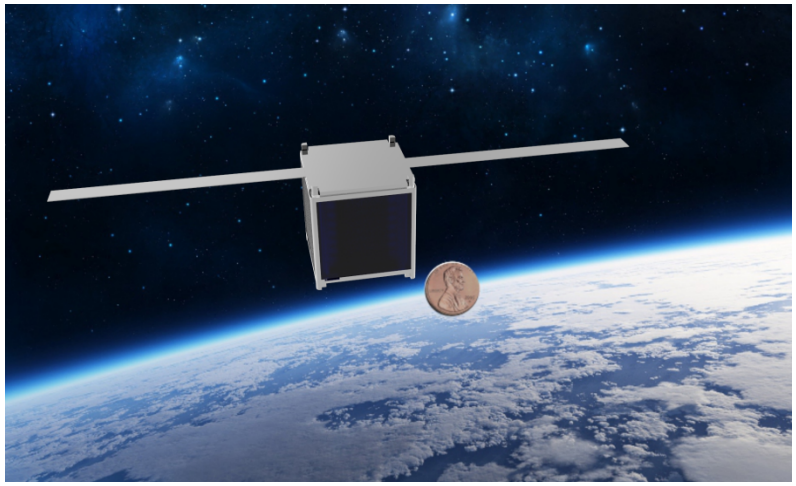
FemtoSat Standard

- By devising an open standard, we enable anyone to choose to build on the standard
- Encourages innovation, an ecosystem of developers, users, interest groups
- Standards could help push technology miniaturization and outlook in the next 15 years

FemtoSat – 1F Reference Design

- Mass: 35 g
- Volume: 3 cm x 3 cm x 3 cm
- Launch Cost: $ 1 to 3k
- Parts Cost: < $300
- Target Orbit: LEO
- Target Life: 1-2 Years
- Power: 3TJ Solar Cell + Battery
- Comms: UHF Radio 3-5 KBps
- Camera: 3 MP CCD





FemtoSat 1F

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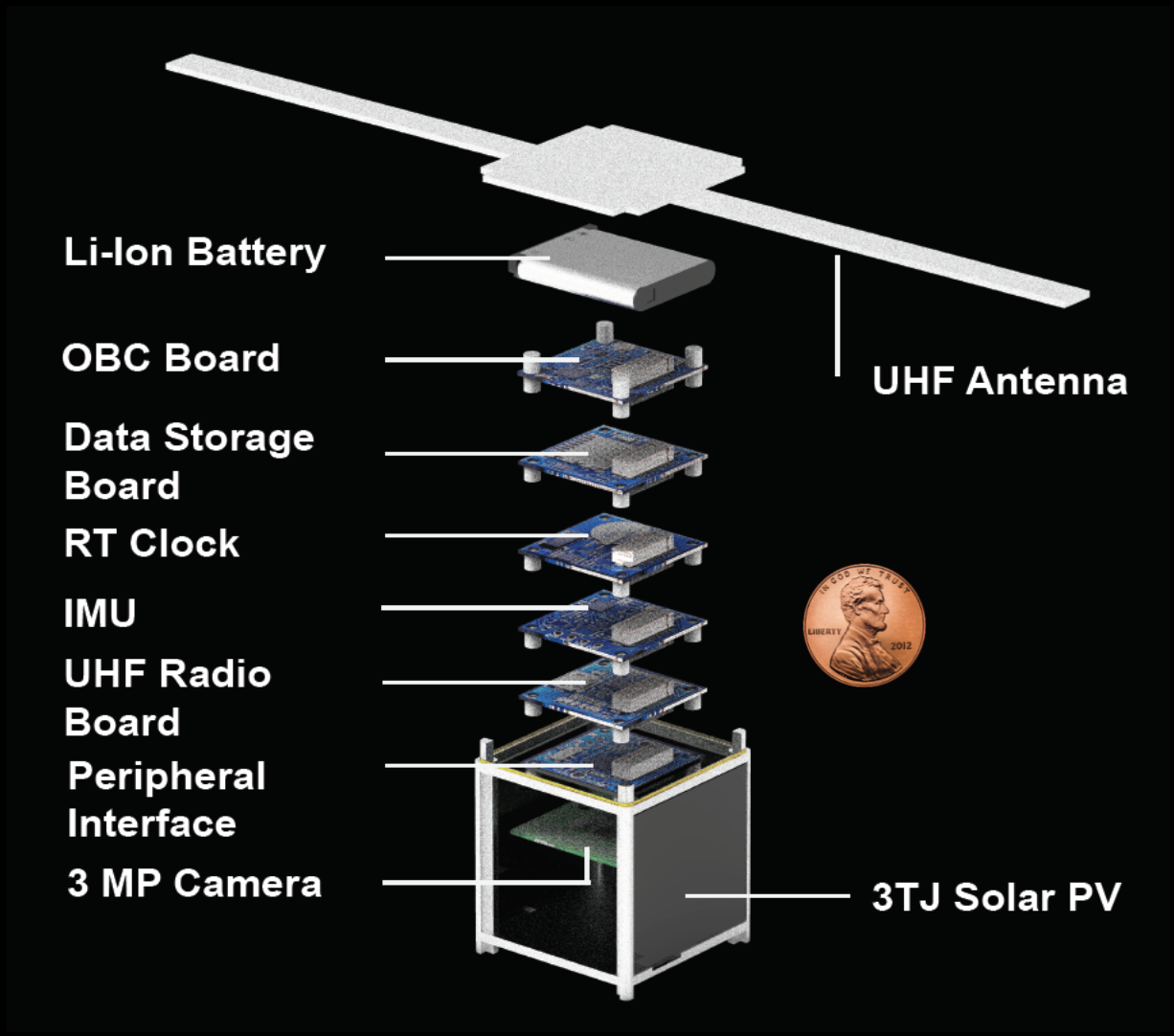
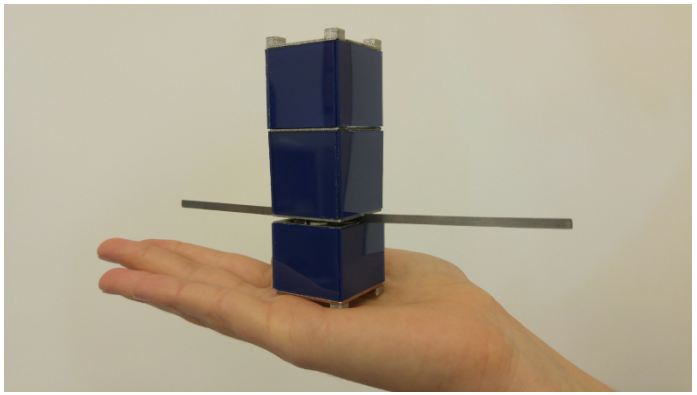
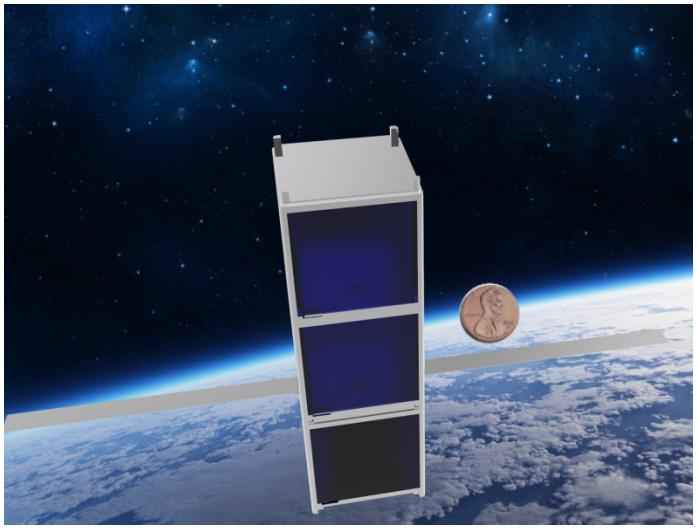


FemtoSat – 3F Reference Design

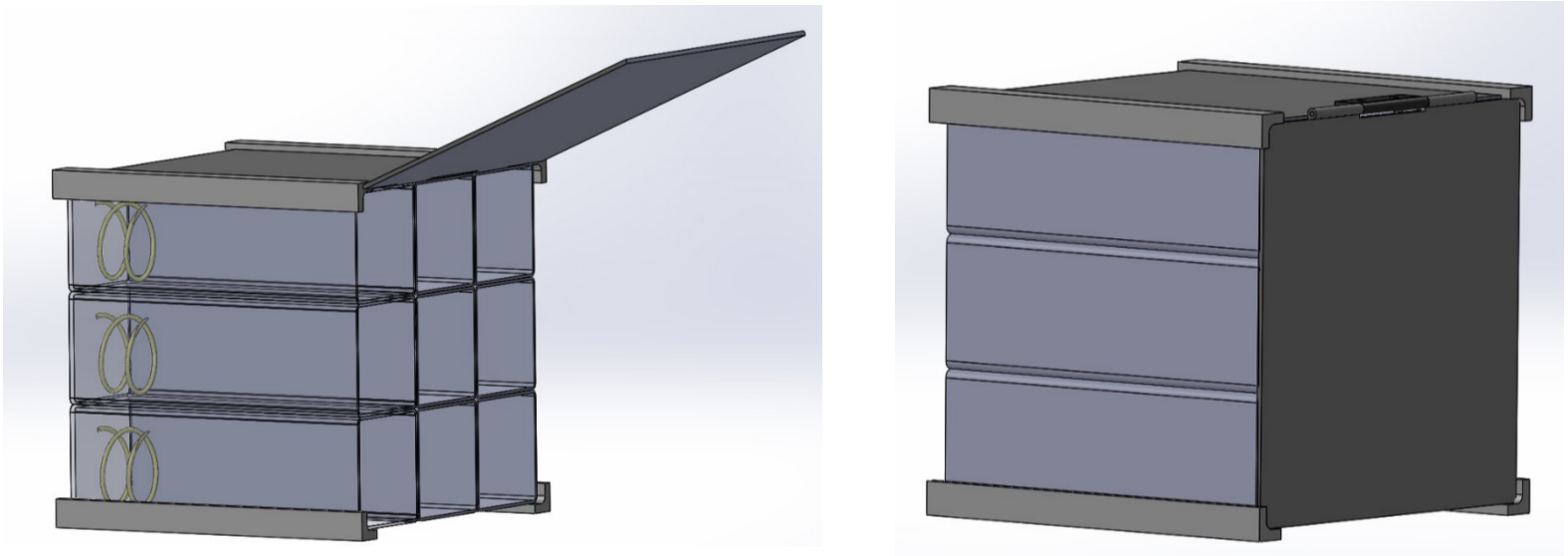
- Mass: 100 g
- Volume: 9 cm x 3 cm x 3 cm
- Launch Cost: $ 3 to 8k
- Parts Cost: < $600
- Target Orbit: LEO
- Target Life: 1-2 Years
- Power: 3TJ Solar Cell + Battery
- Comms: UHF Radio 3-56 KBps
- Camera: 3 MP CCD mono or stereo





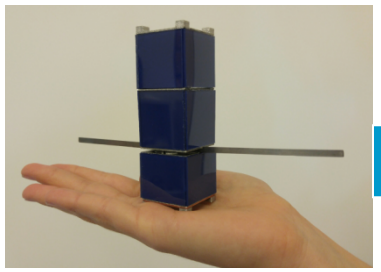
Deployment

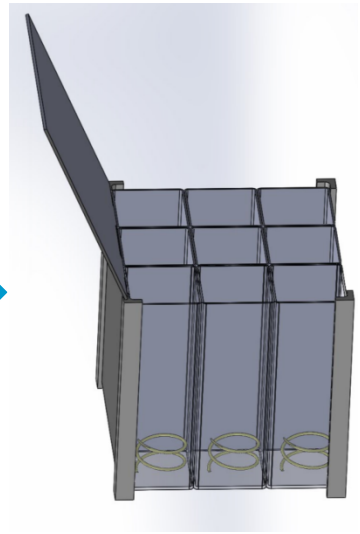
- The 1F and 3F deployed from a CubeSat PPOD.
- A 1U could hold 9 3Fs or 27 1Fs
- A 3U could hold 27 3Fs or 81 1Fs



F-POD Deployer

Packaging for Space





3F SunCube

1U F-POD

3U P-POD

Packaging for Space

- Bootstrap existing CubeSat standards and the tried and tested P-POD to launch FemtoSats.
- We use a design approach that stood the test of time, multiple launch providers and approaching a 99.9 % success rate.

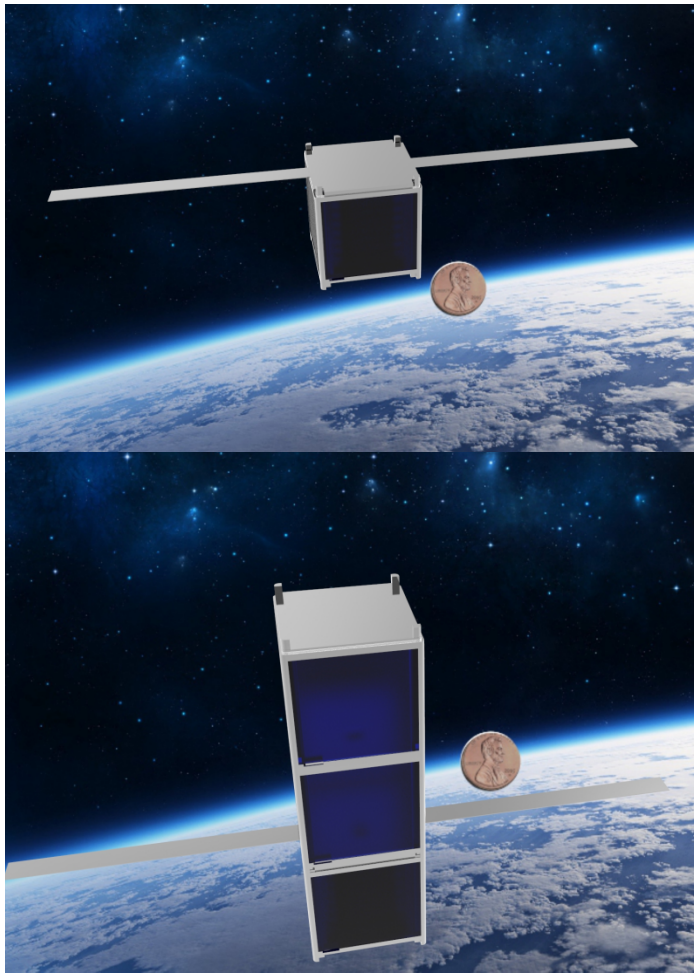
Requirement Specifications

- Strict rules to avoid deploying free floating artifacts, personal items etc.
- Ban on human remains.
- Strict rules needed to avoid littering issues.
  - Case and point Mt. Everest.

Launch Costs

Launch Costs

- SunCube 1F
  - $1,000 to the ISS via NanoRacks (1 month stay)
  - $3,000 into LEO
- SunCube 3F
  - $3,000 to the ISS via NanoRacks (1 month stay)
  - $8,000 into LEO



Interplanetary Travel

- Interplanetary are far fewer, but several commercial opportunities on the horizon.

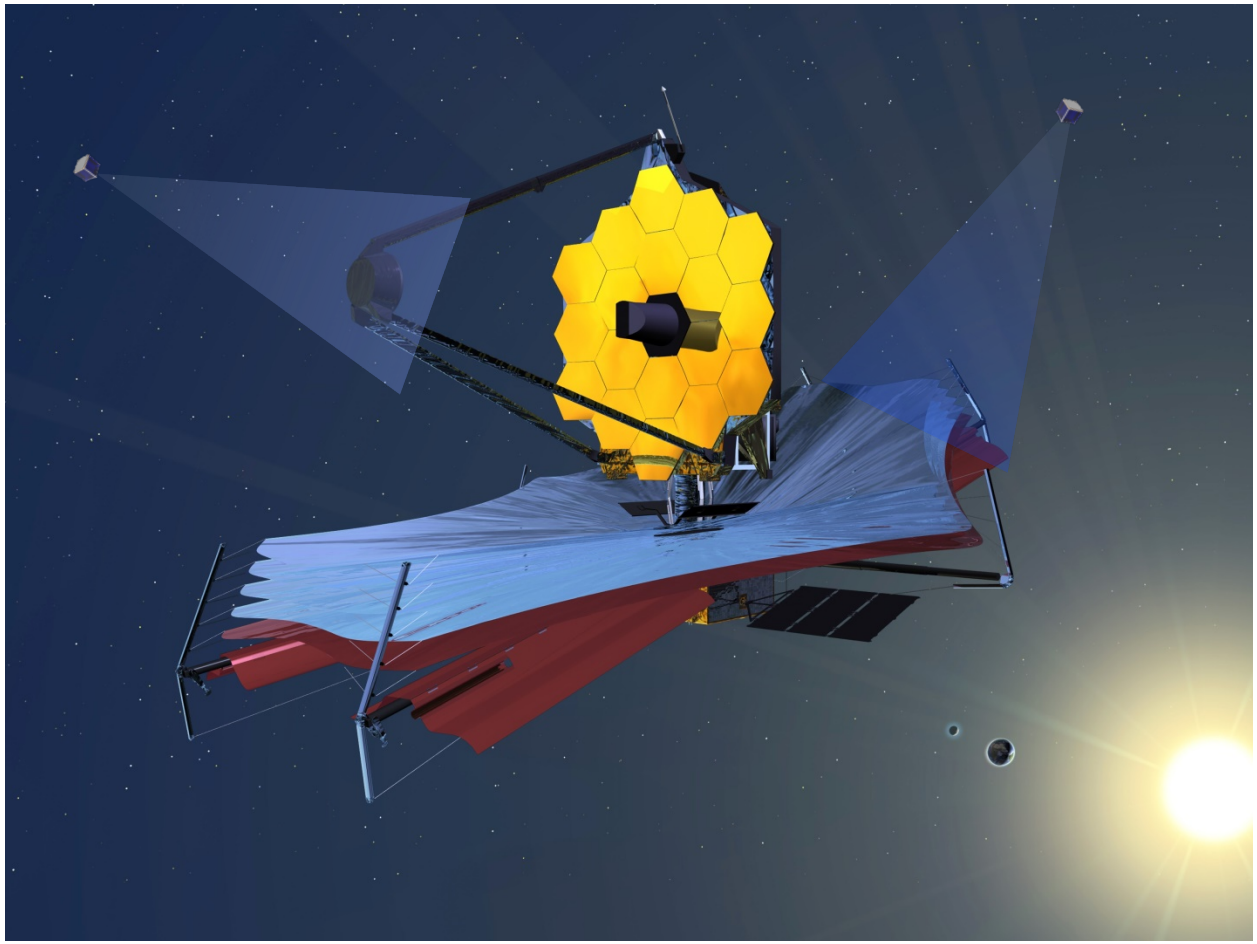
Going Interplanetary: Sherpa Option

Earth Escape

- $27k for 1F
- $81k for 3F

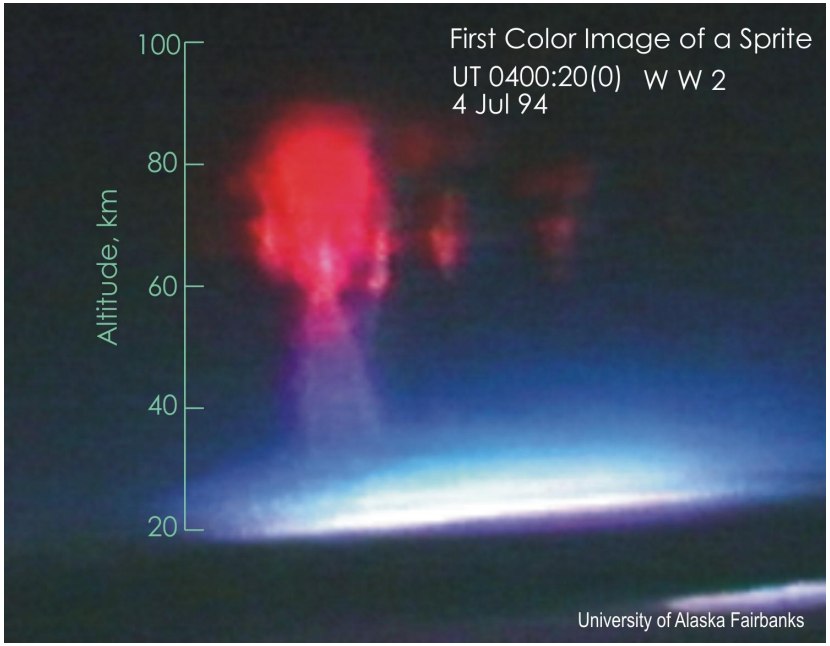
World of possibilities!!

Spacecraft Selfies

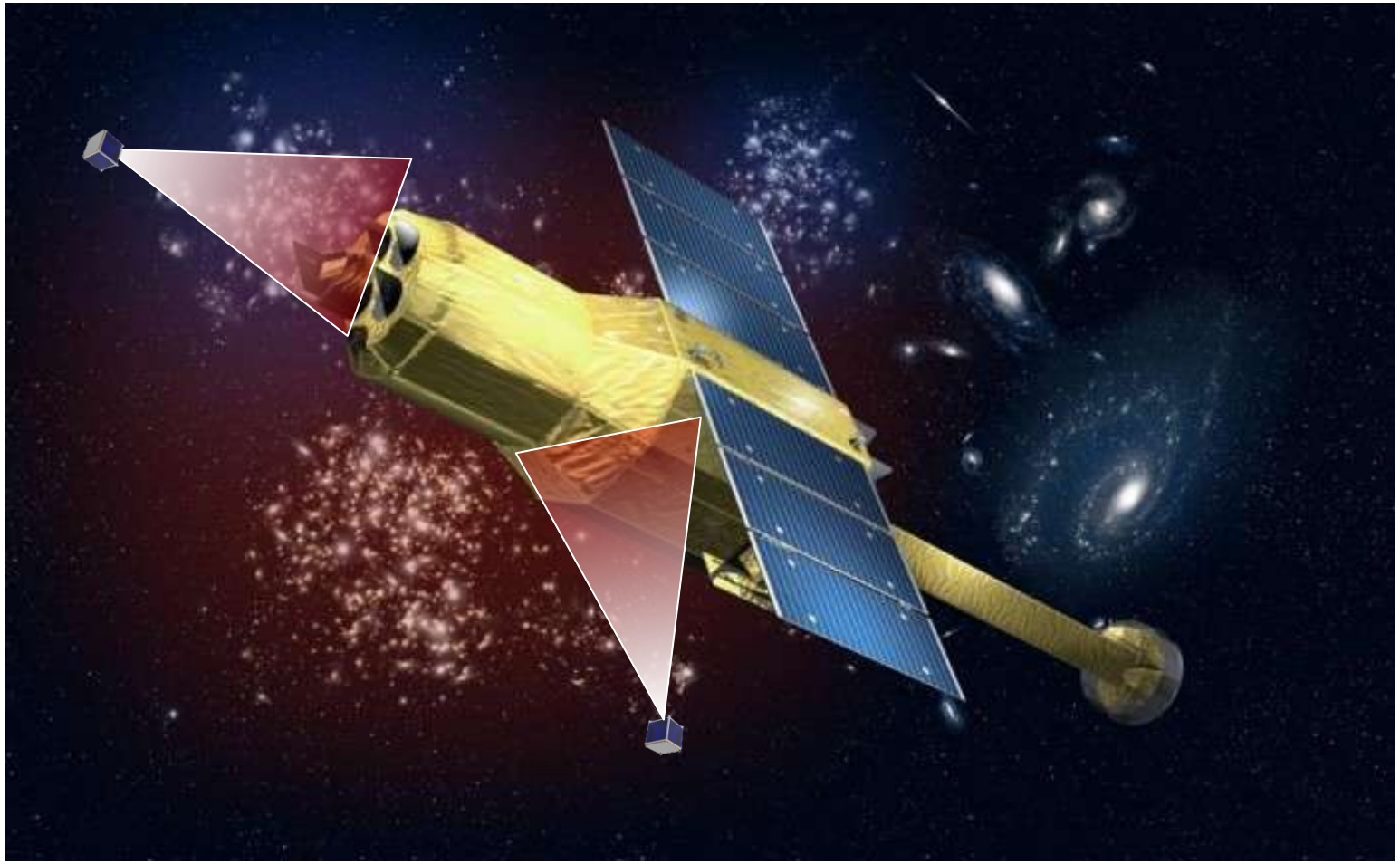


Looking for Rare Phenomena

- Observe rare lightning phenomena
- Climate change
- Disaster relief/observation
- What other rare events are out there ??

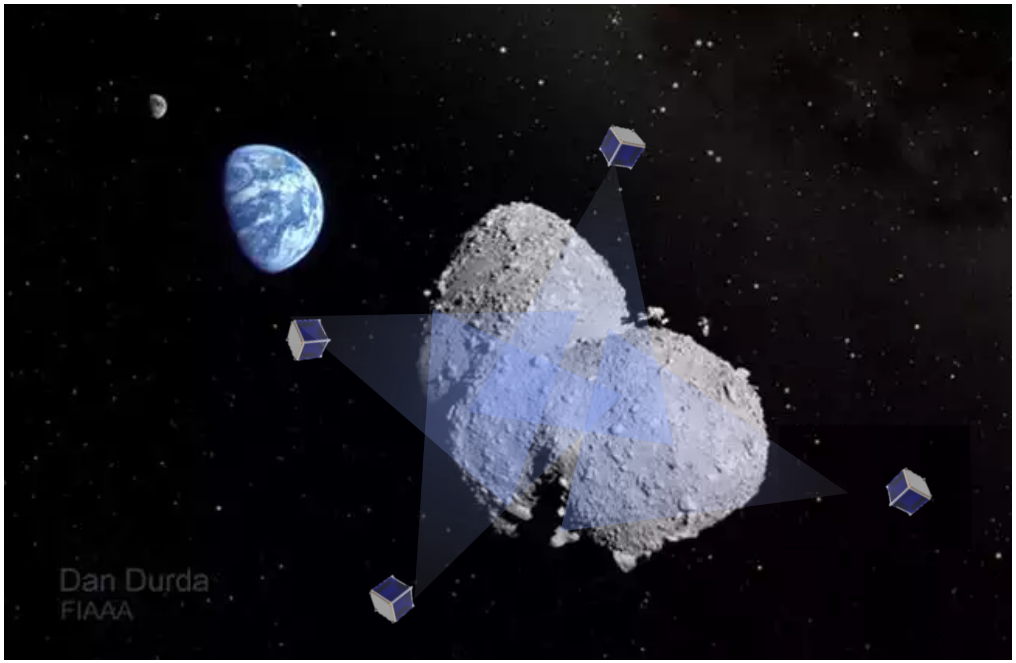


Troubleshooting



Asteroid and Comet Missions

- Low mass, very small surface area – enable hovering, surface mobility on low gravity surfaces.
- Requires development of Femto reaction wheels.



Network exploration on Asteroids & Comets

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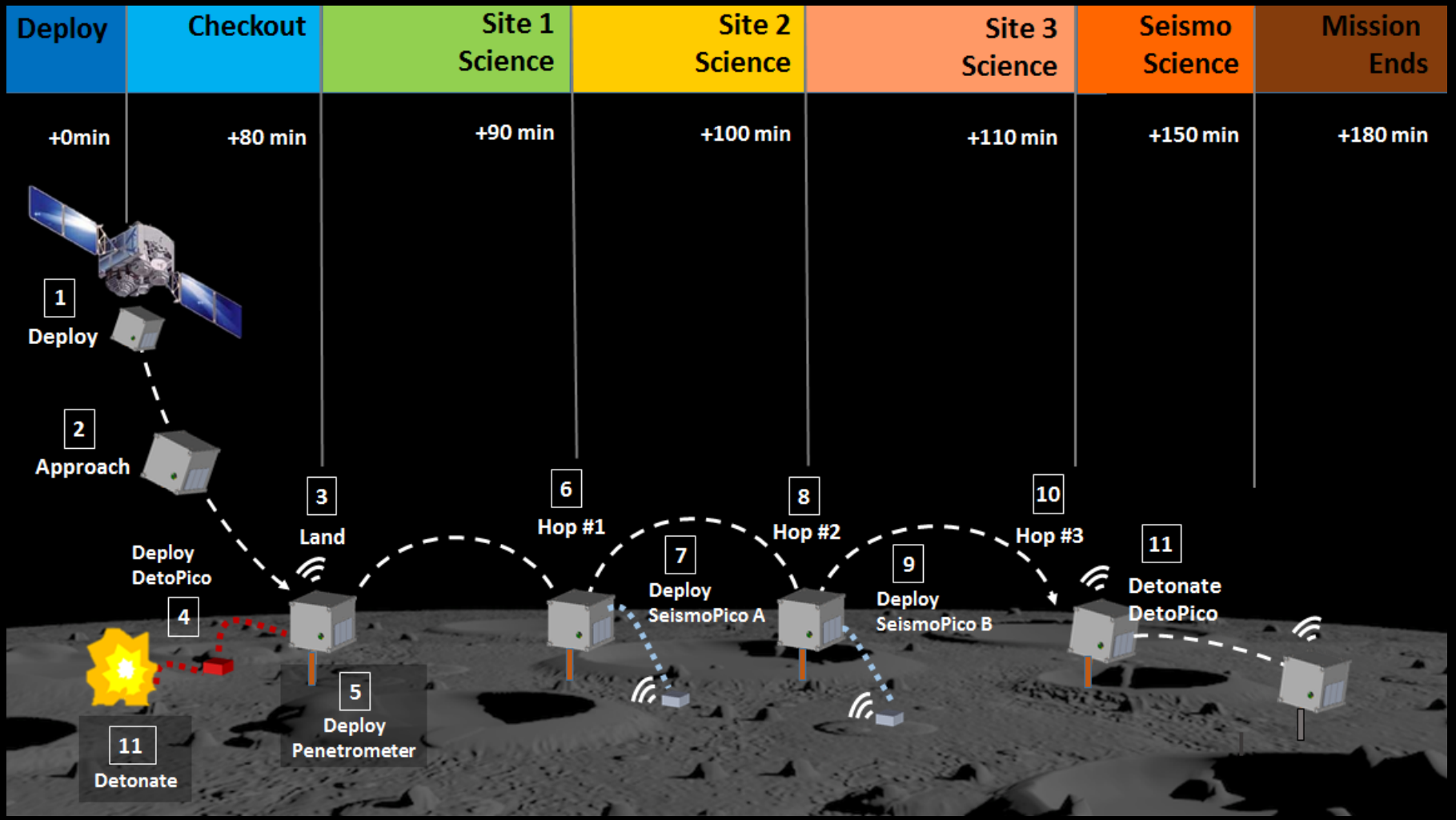
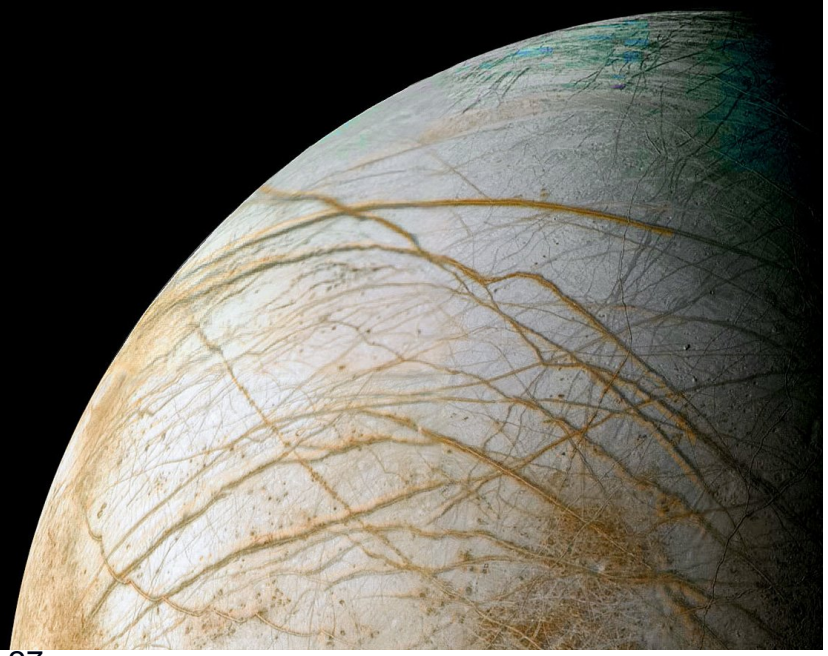


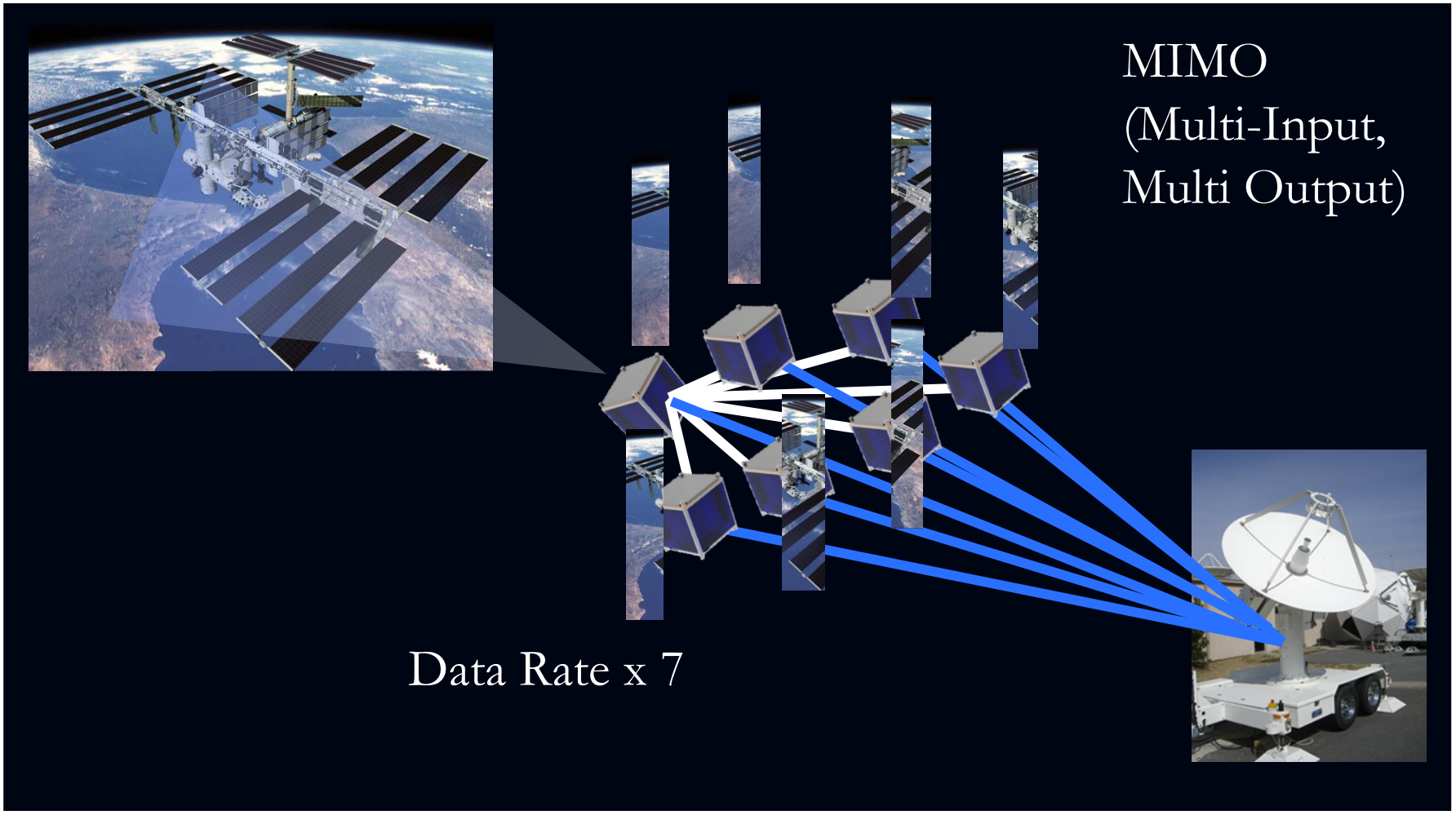
(Hernandez et al., 2015)

Having Many Eyes All at Once

- Augment the reach of a large mission such as the Europa Flyby spacecraft.
- Perform high risk, high reward science.



Communications

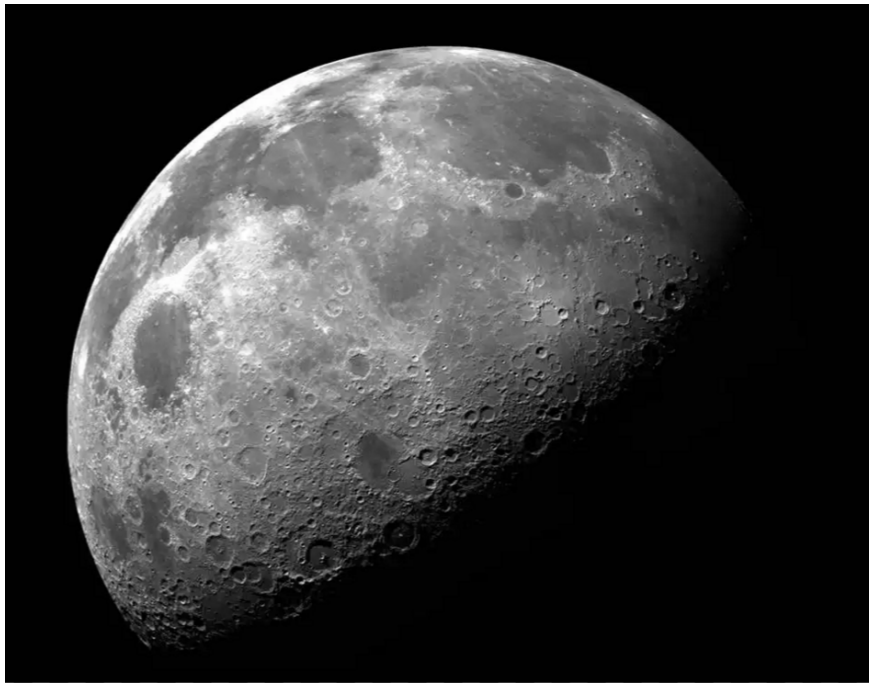


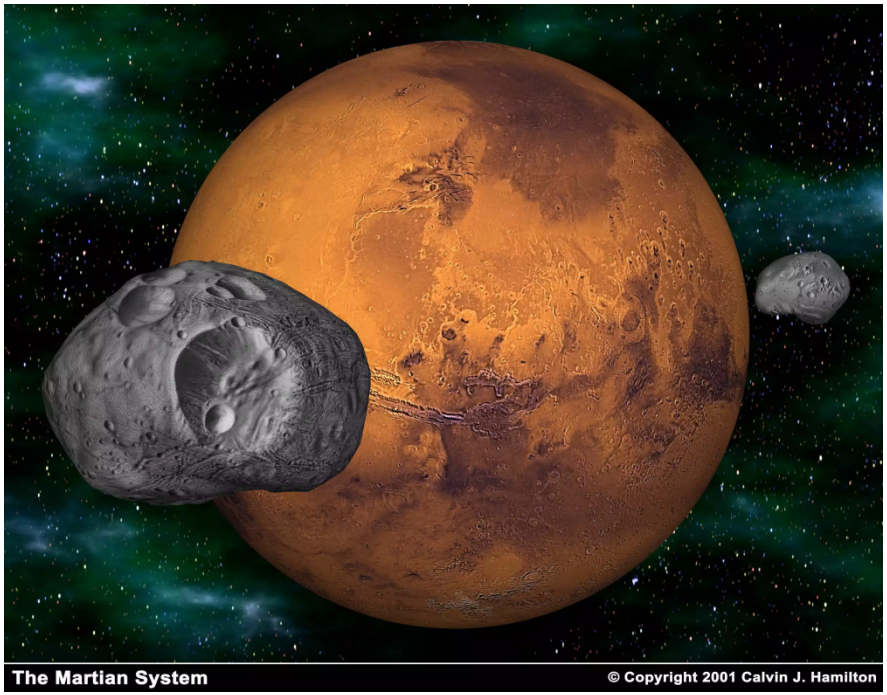
Mass Budget

	Component	Mass (g)
Structures	Chassis	8
Computer	CD&H	1.1
	Data Storage	1.4
	RTC	1.6
Communications	UHF Radio	1.2
	UHF Antenna	3
Attitude Control	IMU Board	1
	Magneto-torquers	0.5
Power	Power Board + Battery	5.2
	Solar Panels	3
Payload	Camera Module – 3MP	4
Total		**30**
Margin		**14 %**

Interplanetary Exploration

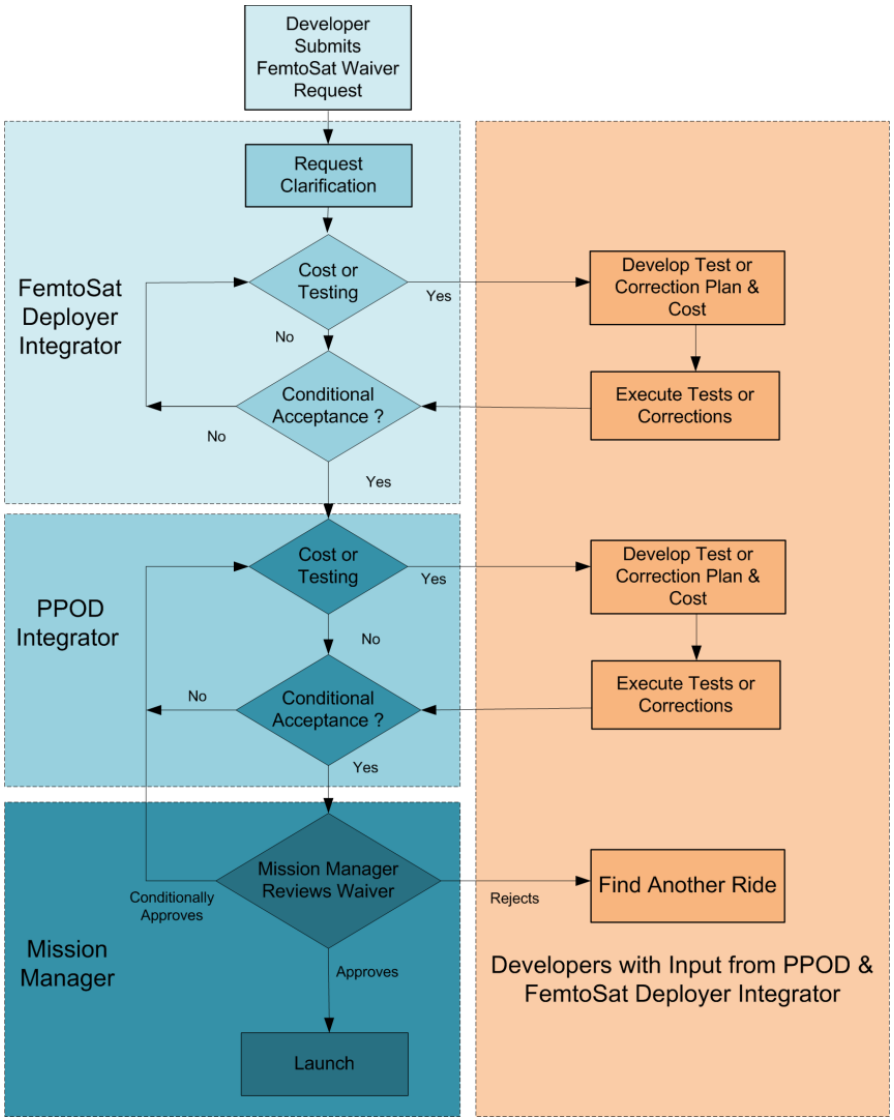
- Delta V = 4 km/s for 4 kg spacecraft, 0.5 kg dry mass, Isp = 200 s



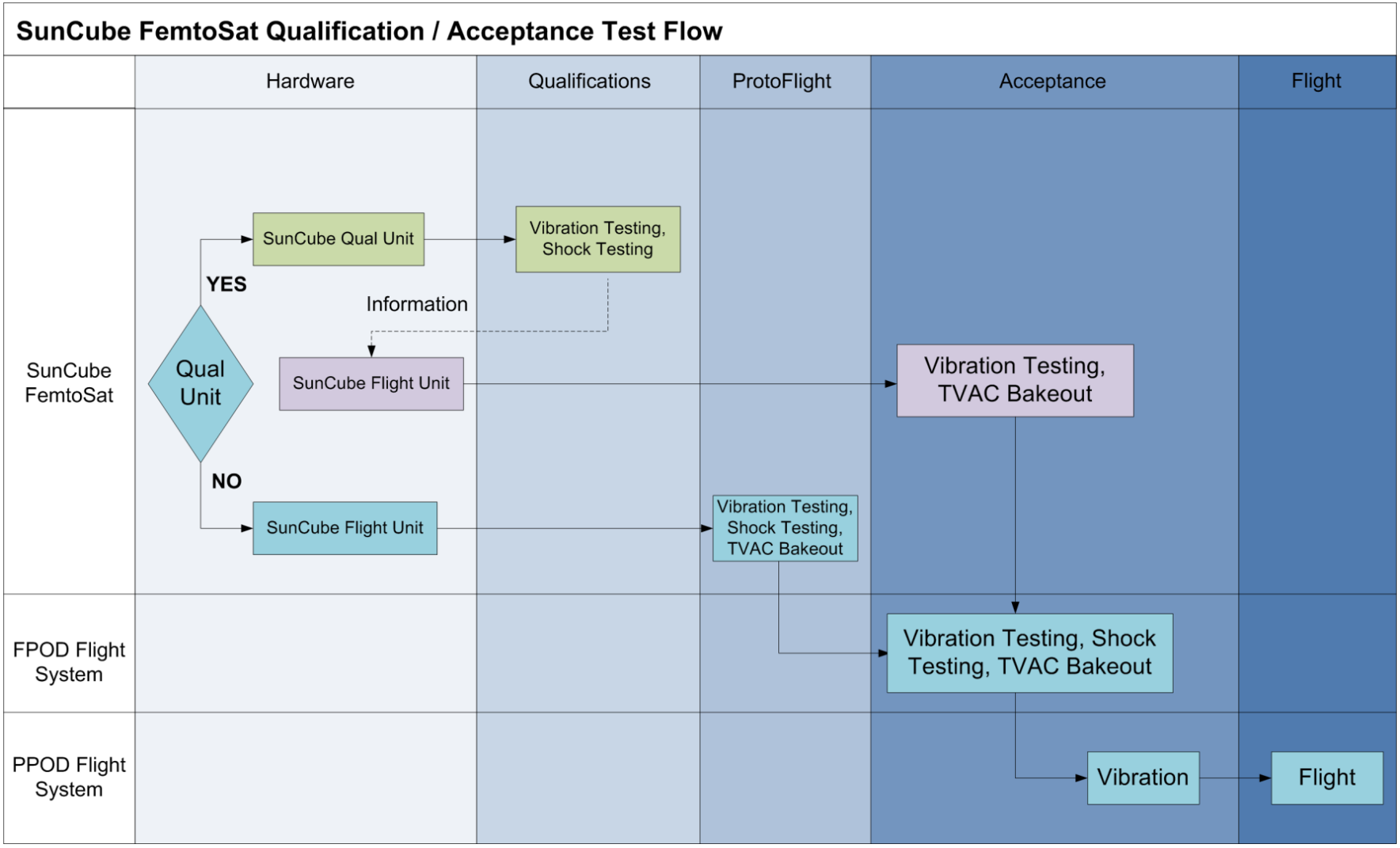


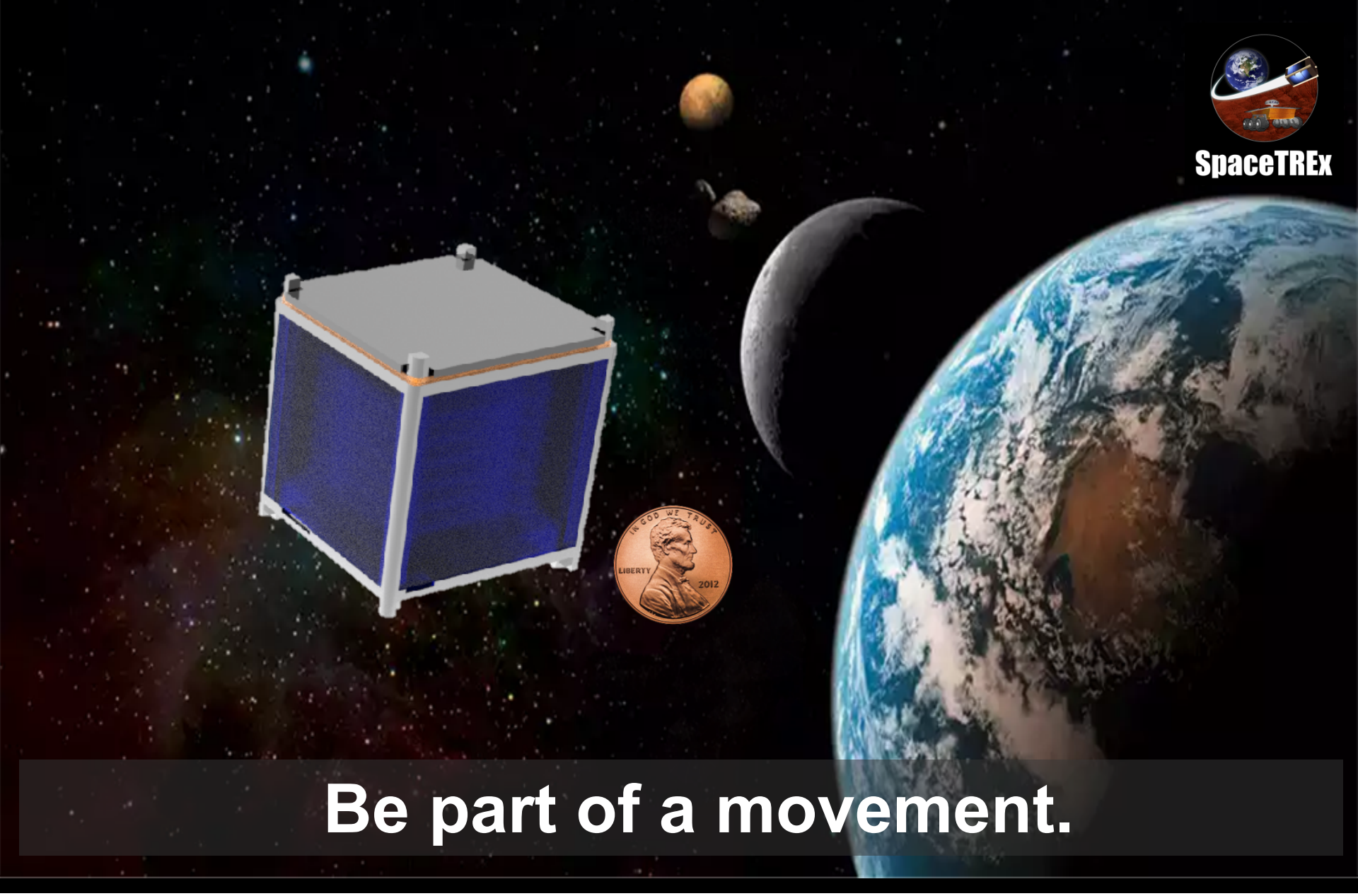
Waiver Request

- Process in place to handle special requests
- Requires acceptance by:
  - FemtoSat Deployer Integrator
  - PPOD Integrator
  - Mission Manager



Flight Qualification Process





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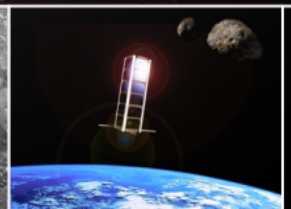
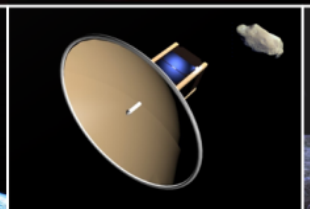
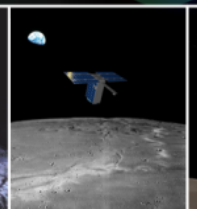
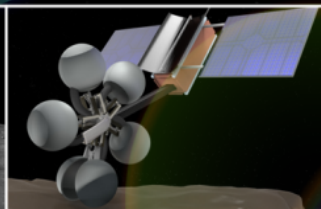
Adventure Awaits



Space Missions

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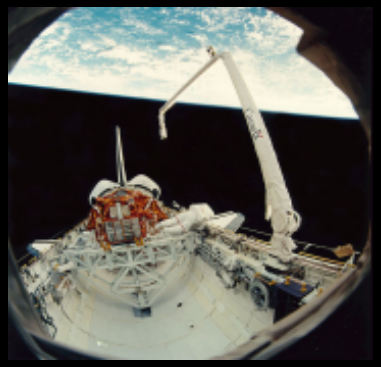
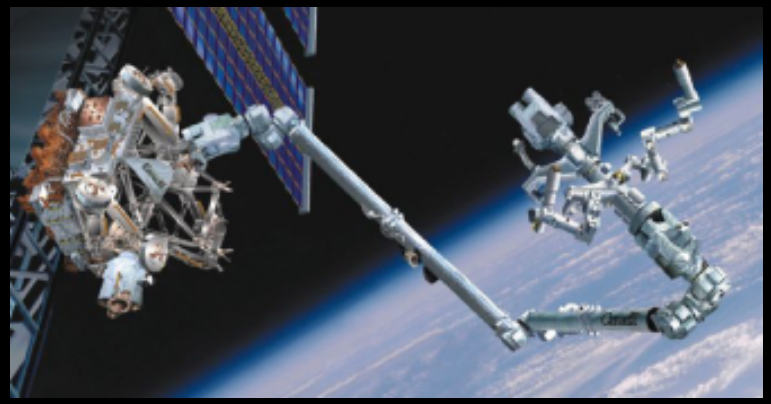
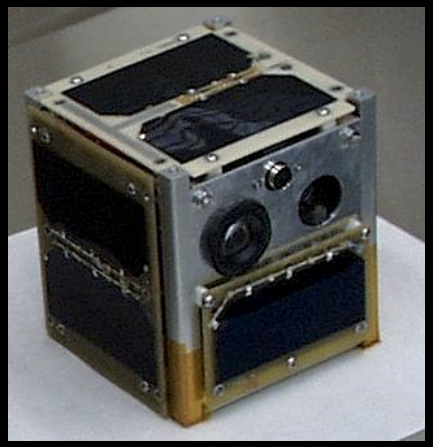


Canadarm



Canadarm II, Dexter

DARPA Orbital Express



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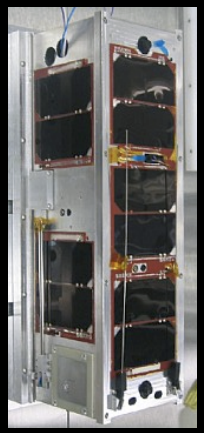
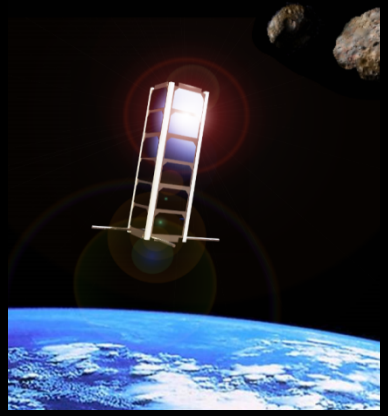
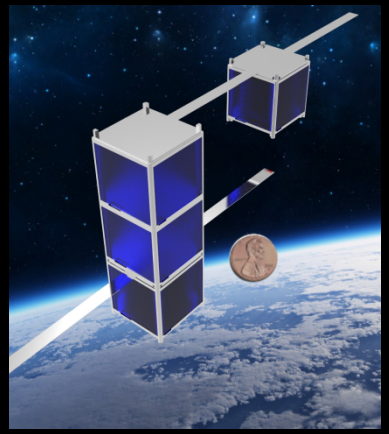


CanX2



AOSAT I

SWIMSat



SunCube
FemtoSats