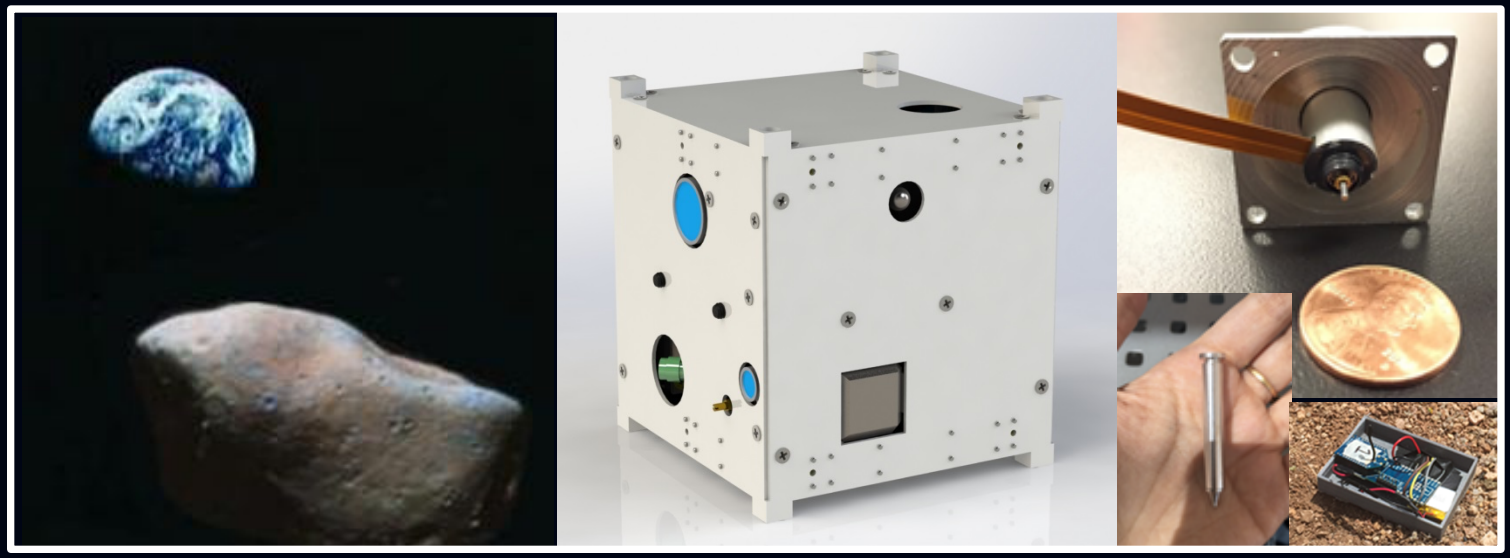
SET: Picosatellite Mission to Study Apophis



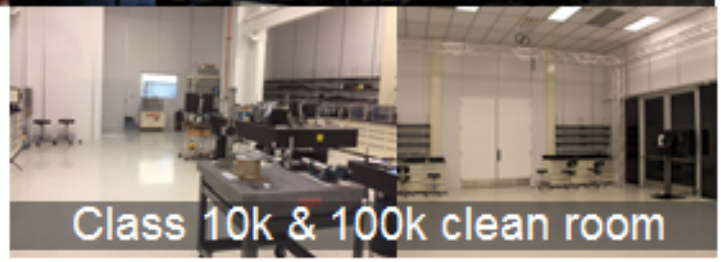
R. Astrain*, C. Cheney*, A. Deran*, V. Hernandez*, J. Houda*, E. Pettinato*, A. Taits*, K. Tucker*, A. Tummala*, A. Thoesen, J. Thangavelautham

SpaceTREX Laboratory
School of Earth and Space Exploration
Arizona State University

Interplanetary PicoSat Design Course

- Two semester capstone design course for grad students – concept to build to flight test
  - Geology, astrophysics, systems, mechanical, electrical, aerospace engineering

Facilities

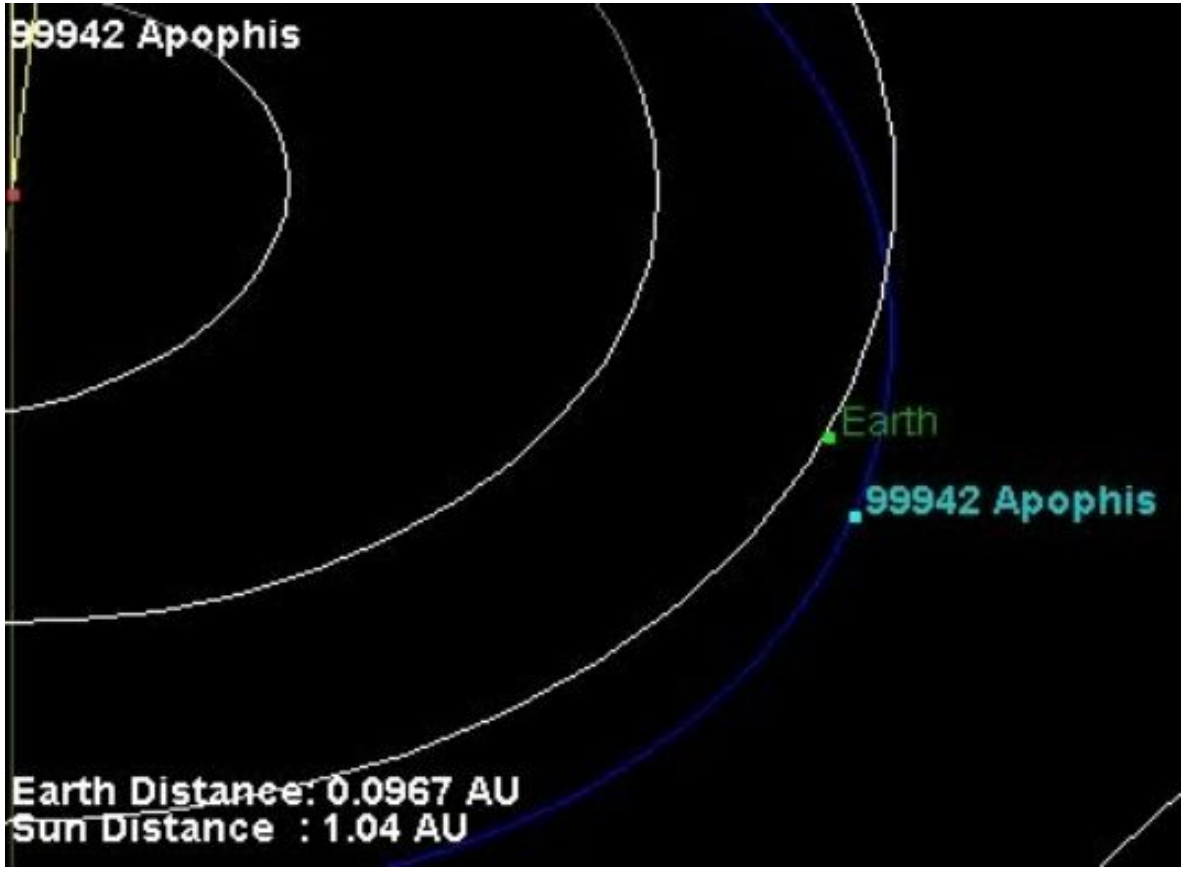


Facilities for conceptualization, designing, building, operating space missions.

Mission in a Nutshell

From an orbiting mothership, deploy a 1-U satellite that will conduct a geophysical investigation of the surface and interior of Apophis

Apophis

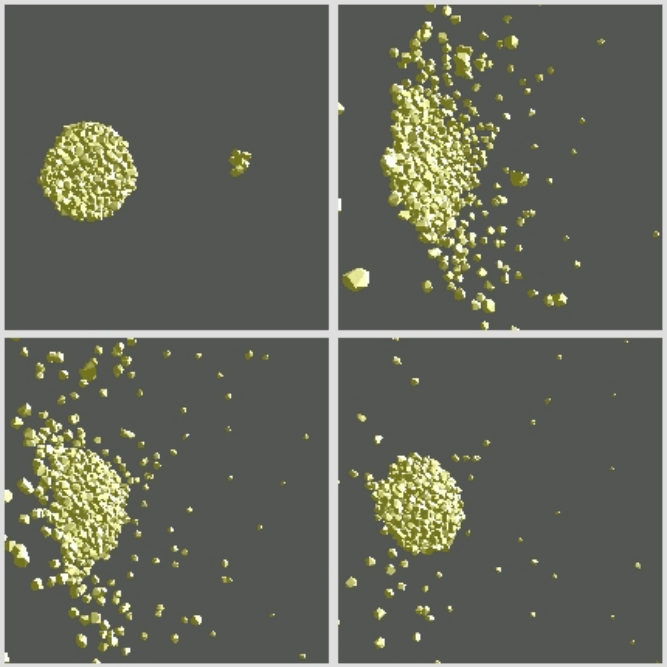

99942 Apophis
Earth
99942 Apophis
Earth Distance: 0.0967 AU
Sun Distance : 1.04 AU

Primary Science Mission Objectives

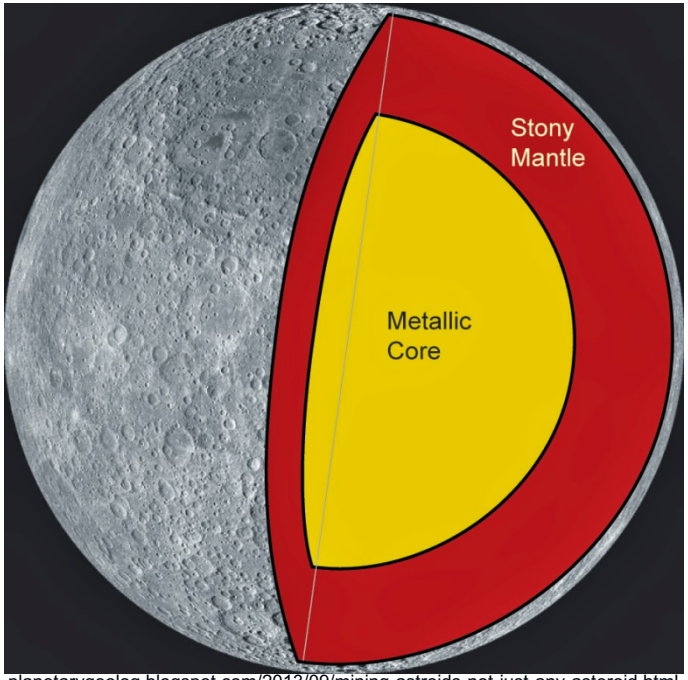
- Determine the physical characteristics of the regolith at Apophis
  - Grain sizes
  - Morphologies
  - Grain size distribution
  - Sorting
  - Alteration materials

Secondary Science Mission Objectives

- Determine the internal structure of asteroid Apophis

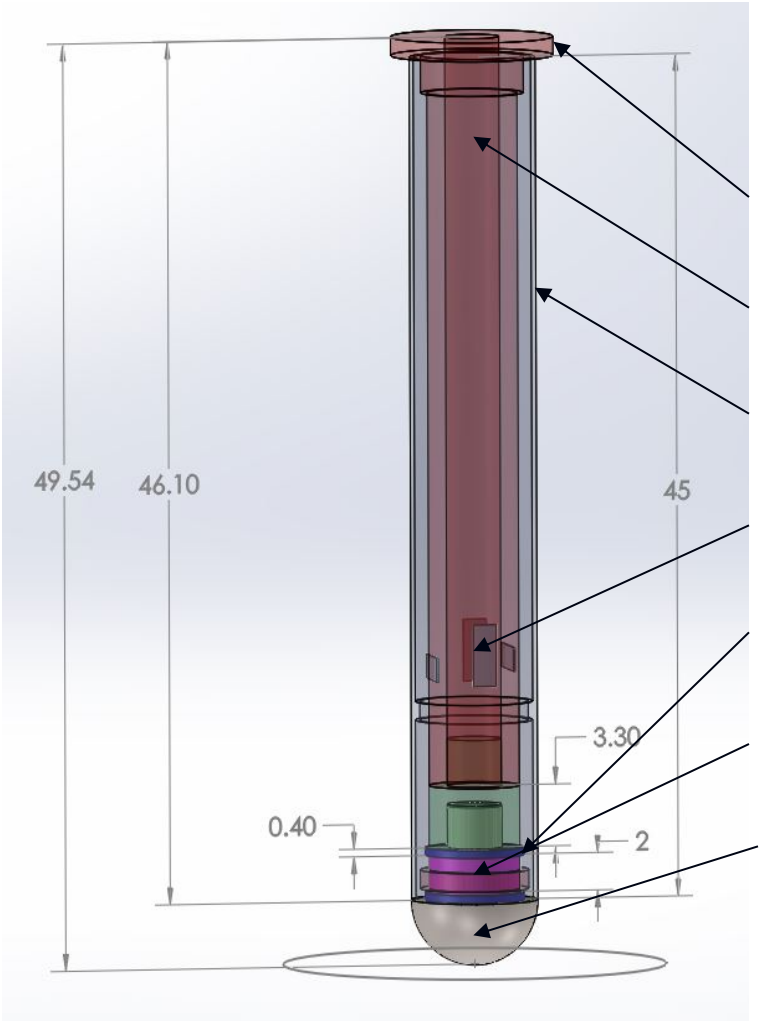


es.ucsc.edu/~fnimmo/CODEP/



planetarygeolog.blogspot.com/2013/09/mining-astroids-not-just-any-asteroid.html

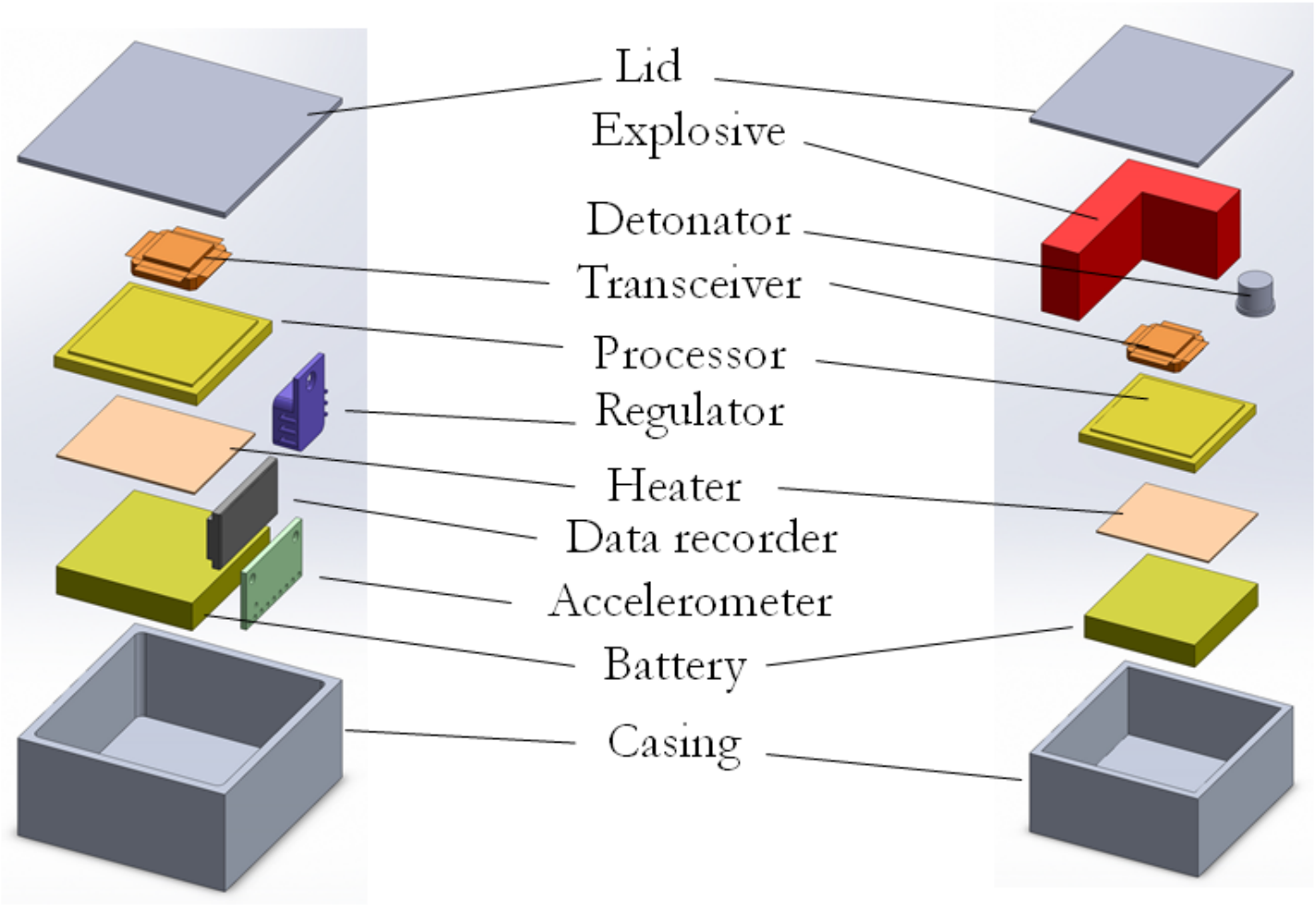
Instruments



Component (diameter)

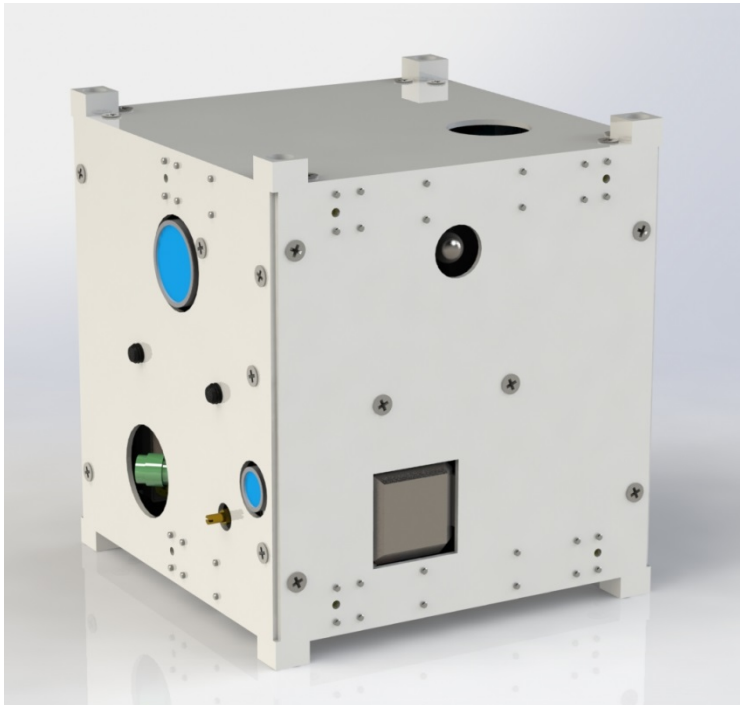
1. Base (9 mm)
2. Fiberglass Shaft (6 mm)
3. Al Friction Sleeve (7 mm)
4. Strain Gauges
5. Macor Washer (6 mm)
6. Piezo Force Sensor (6 mm)
7. Tip (7 mm)

Instruments - Seismology

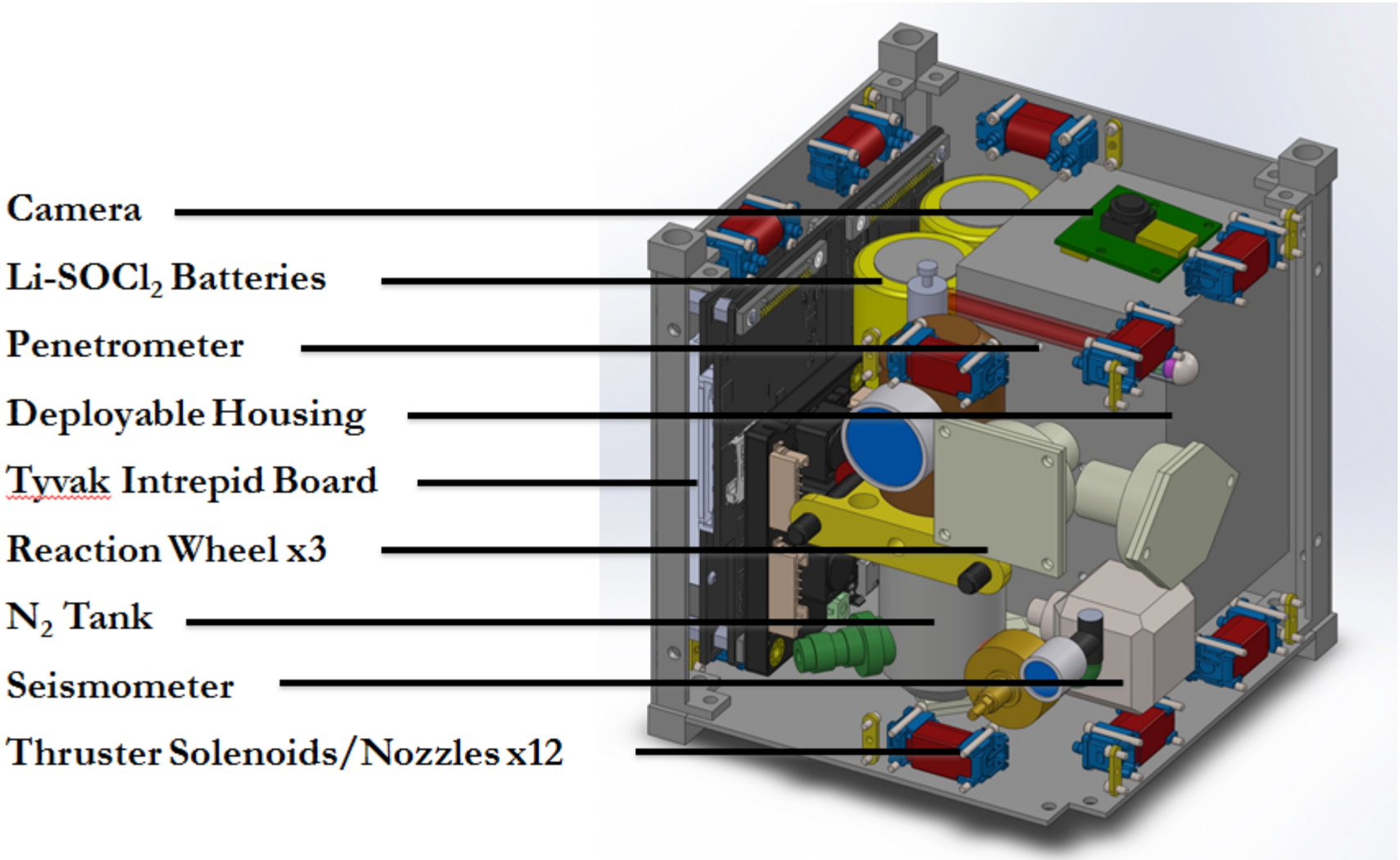


System

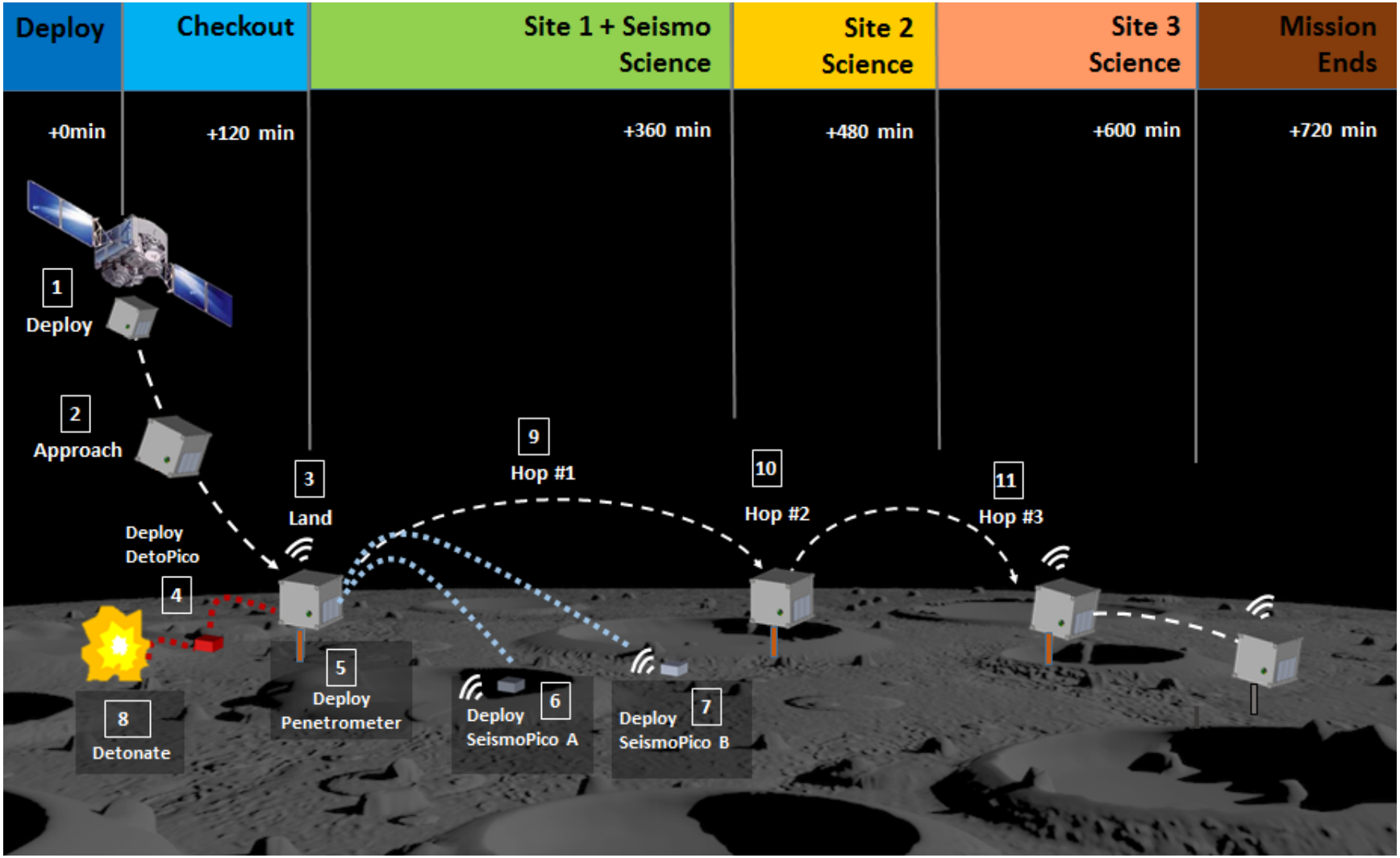
- Mass: 1 kg
- Volume: 10 x 10 x 10 cm
- Battery: 72 Wh ($LiSOCl_2$)
- Instruments:
  - Camera
  - Penetrometer
  - Seismometery (3 deployables)
- Mission Life: ~12 hrs max
- Propulsion: Cold Gas (N_2)
- ACS: 3-axis Reaction Wheels
- Computer: Tyvak Intrepid



System


Camera
Li-SOCl$_2$ Batteries
Penetrometer
Deployable Housing
Tyvak Intrepid Board
Reaction Wheel x3
N_2 Tank
Seismometer
Thruster Solenoids/Nozzles x12

Concept of Operations

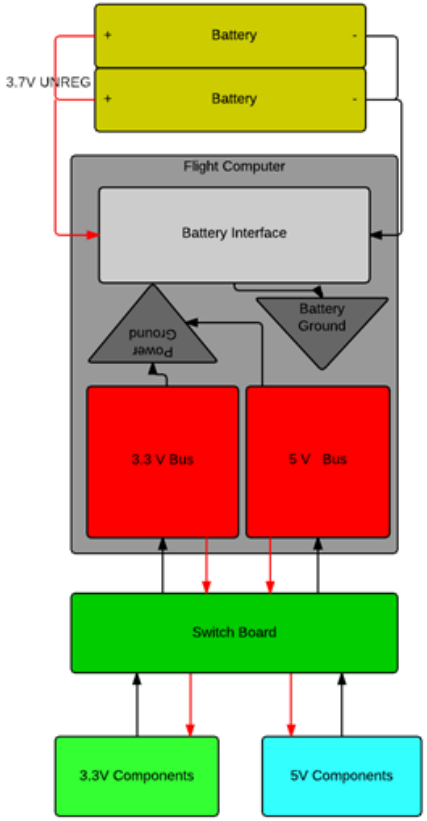


System Budgets

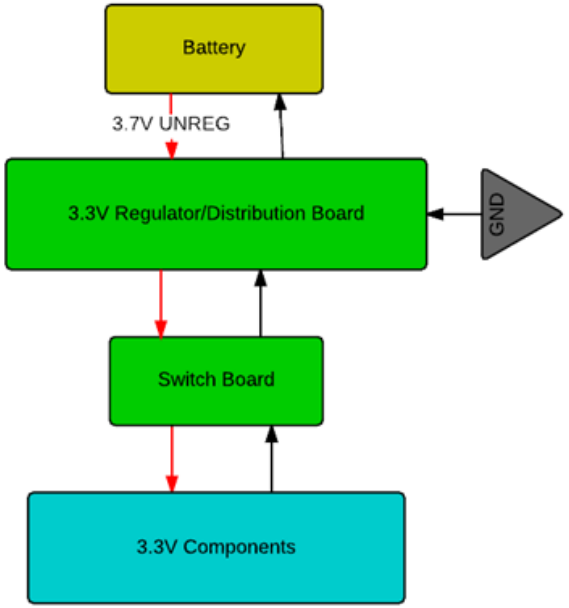
Subsystem	Component	Volume (cm^3)	Mass (g)
Structure	Frame	30	127
	Thermal Insulation (Aerogel)	30	5
Payload	Explosive Charge	51.5	59
	Remote Geophone (x2)	103	124
	MEMS Seismometer	9.6	35
	Penetrometer	2	5
	Camera	20	5
Propulsion & ADCS	Reaction Wheels (x3)	20	150
	Cold Gas Propulsion	125	121.2
CD & H	Tyvak Intrepid - ARM 9 CPU	156	55
Comms.	Tyvak Daughter UHF Comm	15	21.2
Energy Storage	$LiSOCl_2$ Battery	98.6	102
	Total	**600 cm^3**	**810 g**
	Margin (%)	**40 %**	**19 %**

Power Architecture

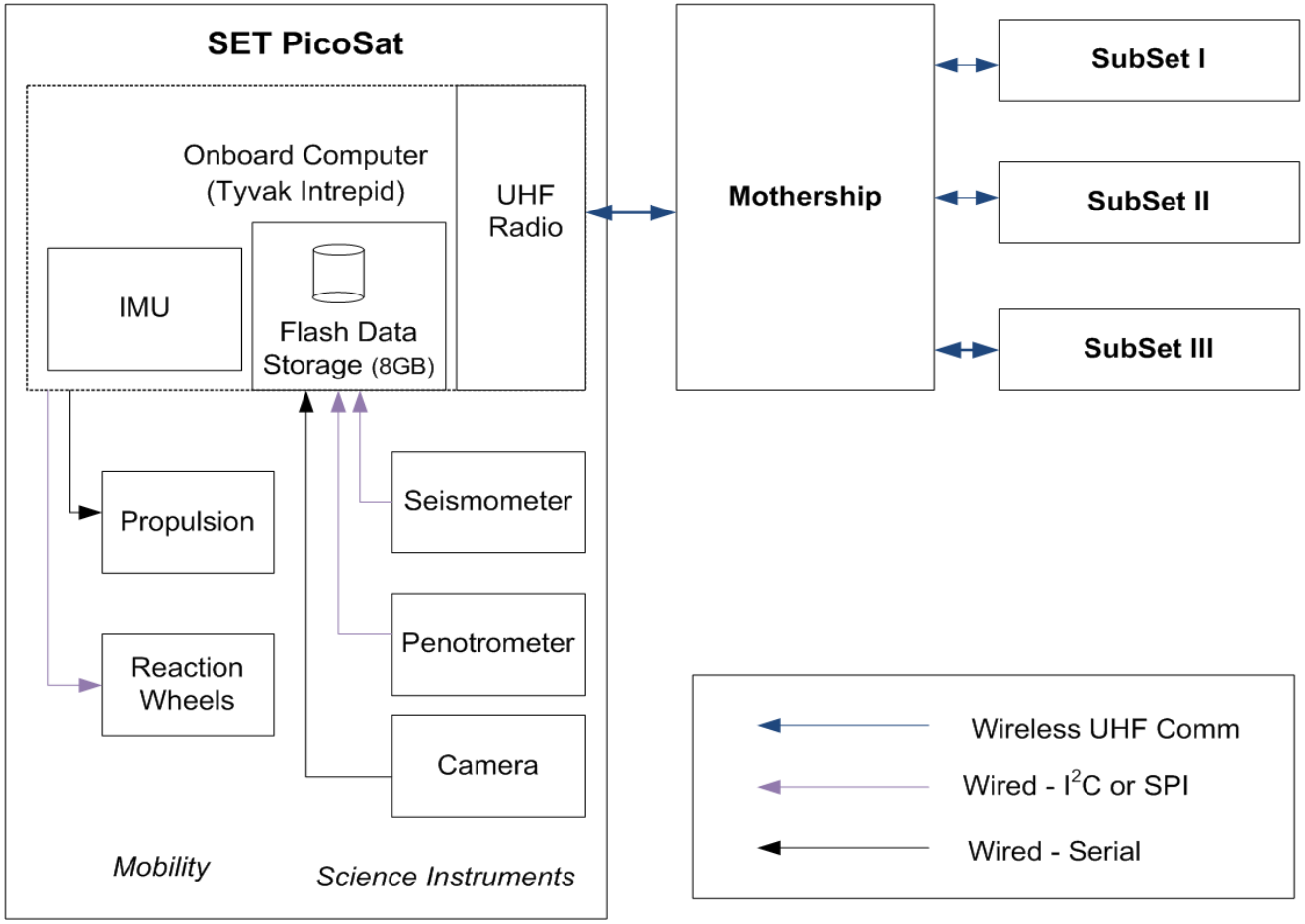
Set Architecture



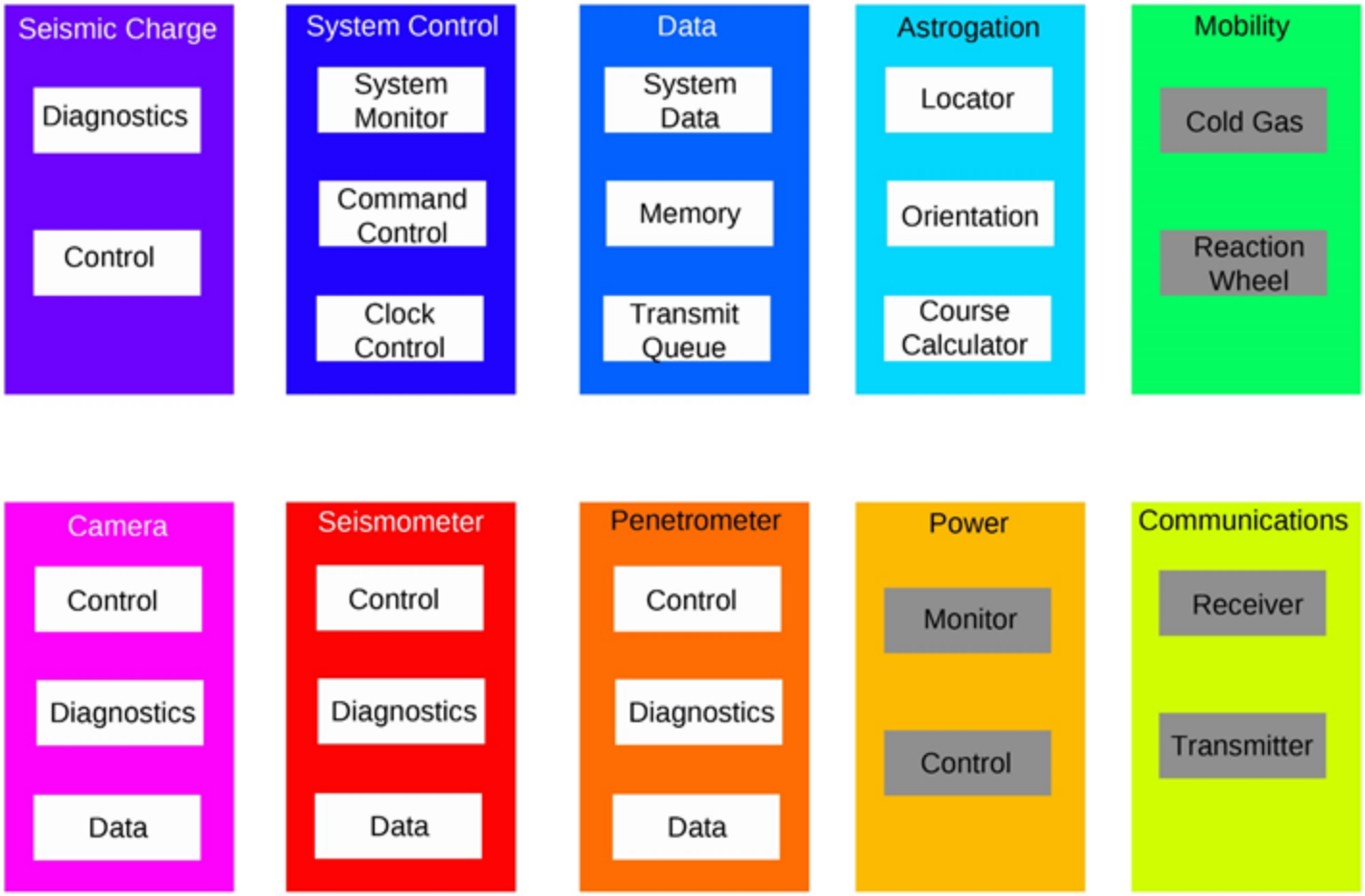
subSet Architecture



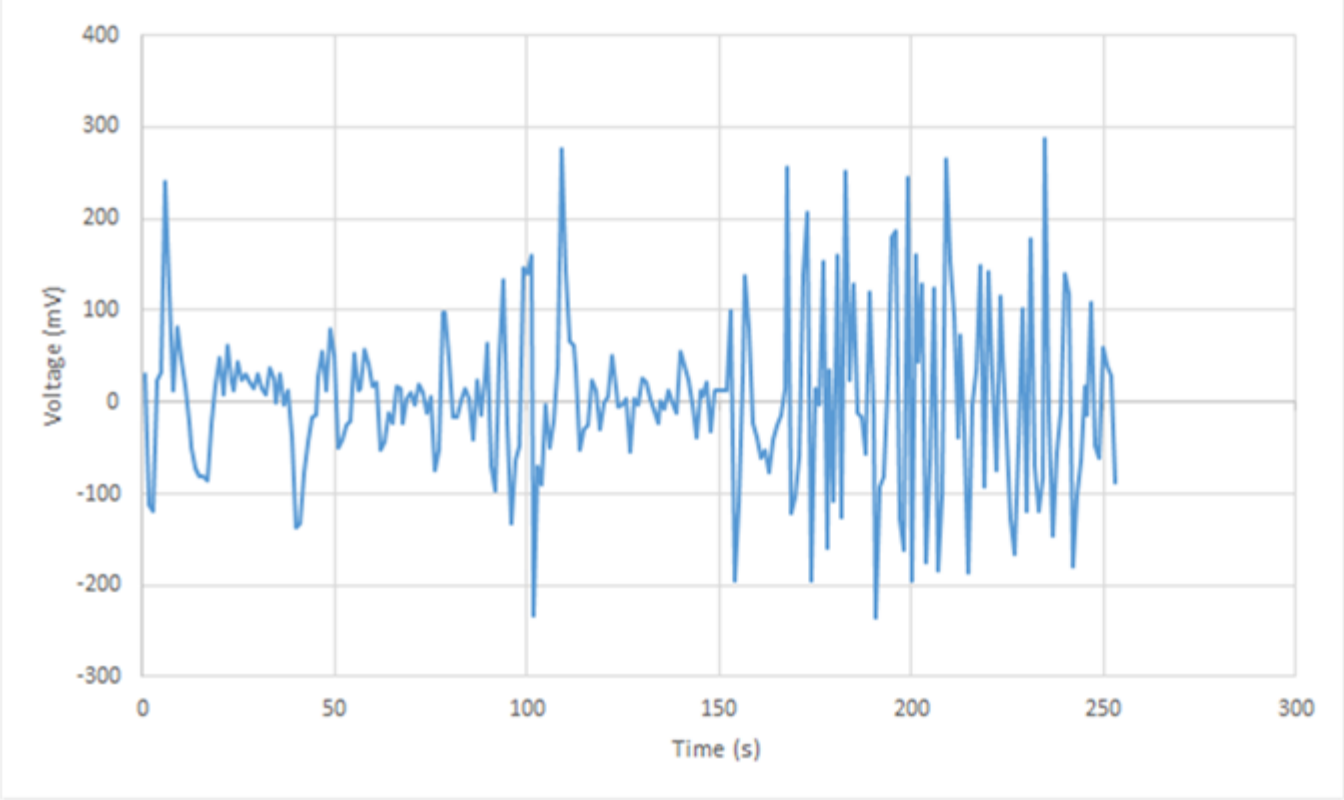
Computer Hardware/Comm Architecture

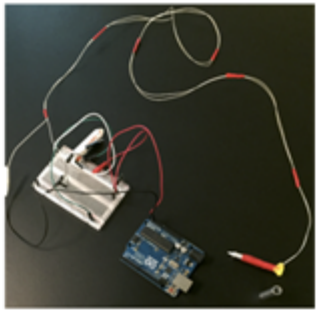


Software Architecture

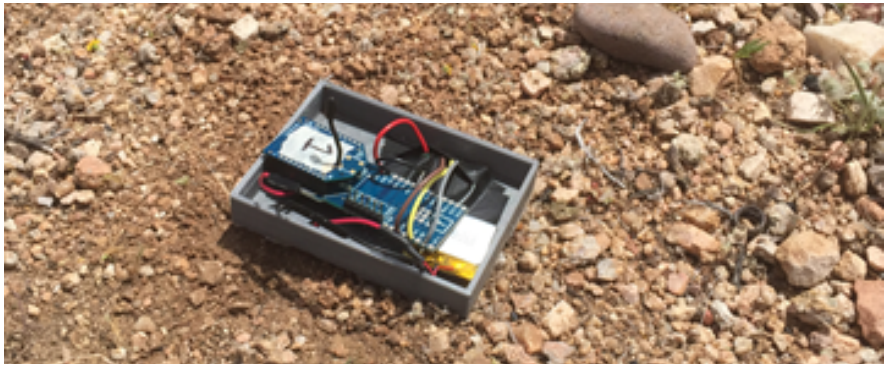


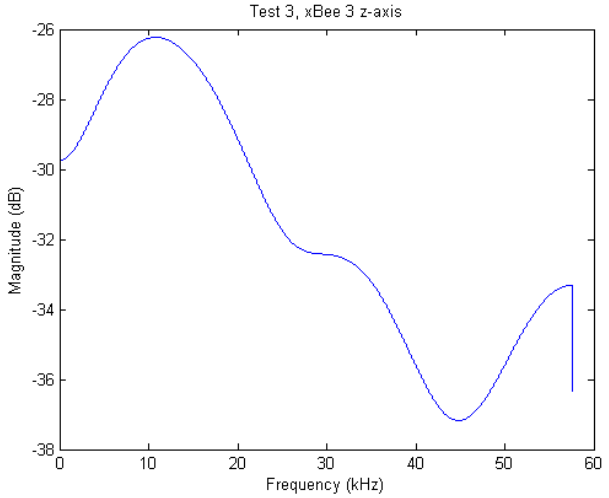
Prototype Development

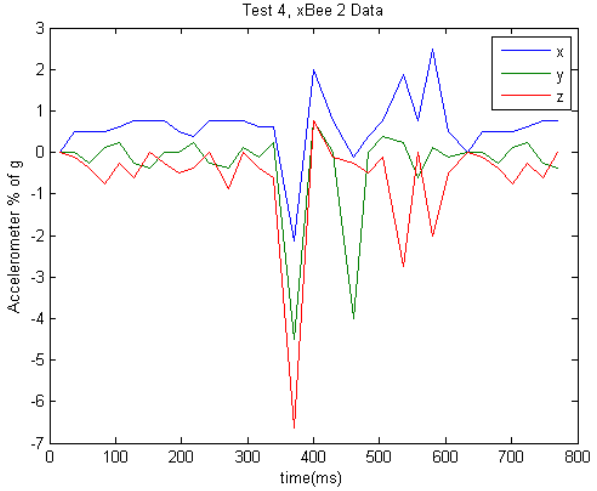




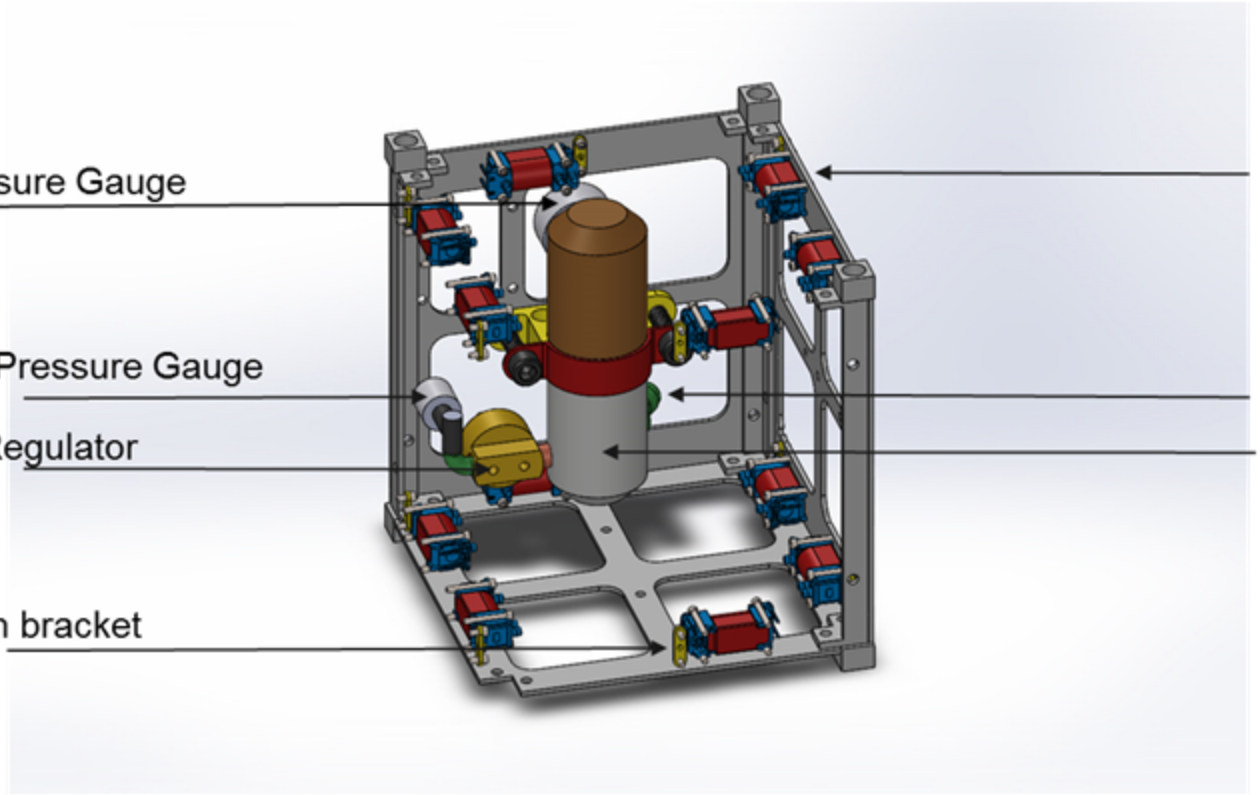
Seismometer Experiments



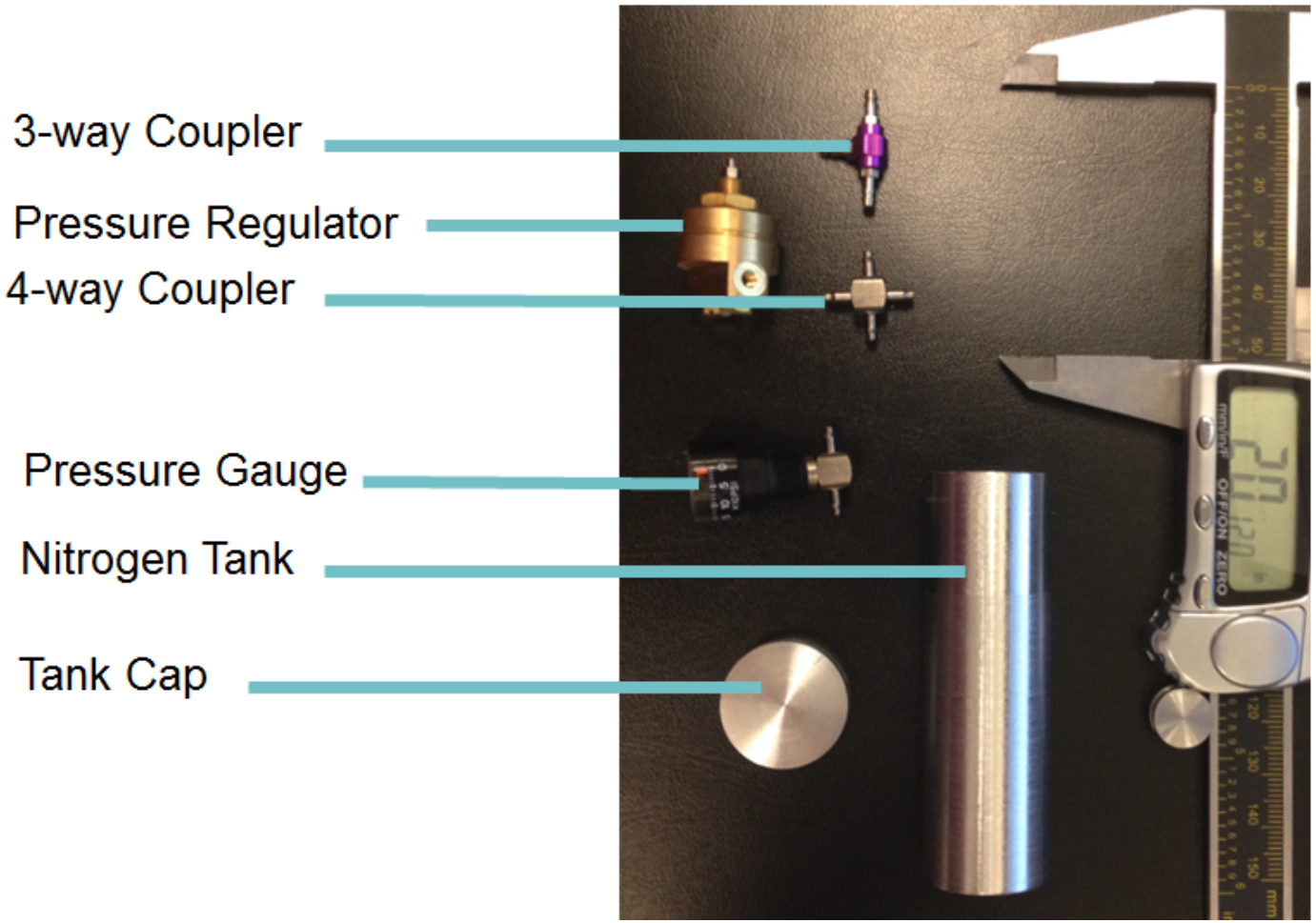




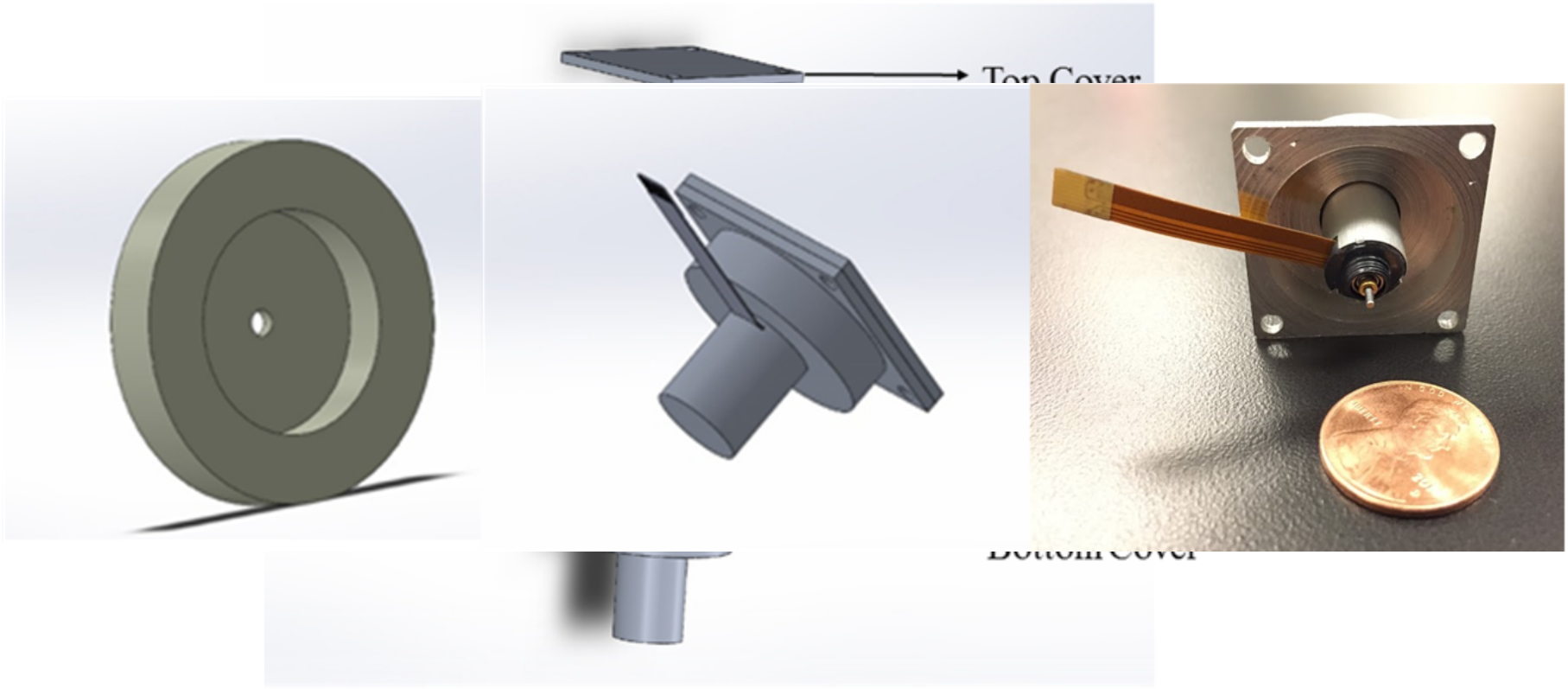
Propulsion


Tank Pressure Gauge
Operating Pressure Gauge
Pressure Regulator
Nozzle with bracket
(12 total)
Parker X-Valve
(12 Valves total)
Fill Nipple
300psi Air Tank

Propulsion


3-way Coupler
Pressure Regulator
4-way Coupler
Pressure Gauge
Nitrogen Tank
Tank Cap

Reaction Wheel System



Discussion

- Ongoing work to simplify & parallelize mission concept
- Quantify science products
- Determine effectiveness of science instrument and a descope plan
- Challenges in navigation/localization
- Flight qualification of critical components

Conclusion

- A low-cost approach to asteroid exploration proposed using a 1U short duration mission
- Soft and/or powered landing followed hopping on asteroid surface to perform science
- Miniaturization of science instruments promising – challenges in determining effectiveness
- Awaiting flight qualification testing opportunity.

Acknowledgements

AZ Space Grant

NASA

agi

JPL
Jet Propulsion Laboratory
California Institute of Technology

TEAM X
Jet Propulsion Laboratory

Orbital
Innovation You Can Count On®

KeyShot
by Luxion

ASU School of Earth & Space Exploration

ASU Ira A. Fulton Schools of engineering

ASME
SETTING THE STANDARD

ASU NewSpace
ARIZONA STATE UNIVERSITY

Thank You!