Enabling Low Cost Planetary Missions Through Rideshare Opportunities

J. J. Lang, J. D. Baker, T. P. McElrath, T. Moreno, J. S. Snyder
Jet Propulsion Laboratory / California Institute of Technology
June 20, 2013

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Jet Propulsion Laboratory
California Institute of Technology

A Low Cost Approach for Exploration

CubeSats have revolutionized Earth science mission by providing regular, low-cost access to space through standardization.

Regular access to space provides various ways to lower-cost:

1. Higher Risk Approaches
2. Increased community for operating missions
3. Innovative uses of technology (through standards)
4. More Focused Science Investigations

Photo Credit: USC AENES Project

Can the CubeSat be used for Planetary Science missions to reduce cost?

Two Ways to Approach the Problem

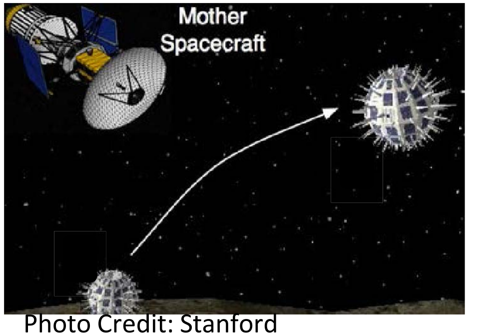

Photo Credit: Stanford

Stand Alone CubeSat Architectures

Pros:

- Can utilize current hardware (higher risk approach)
- Ideal for "Swarm" concepts

Cons:

- Limited propulsive capability reduces potential targets
- Long transit durations
- Communication distances
- Reduced number of launch opportunities (only escape launches)

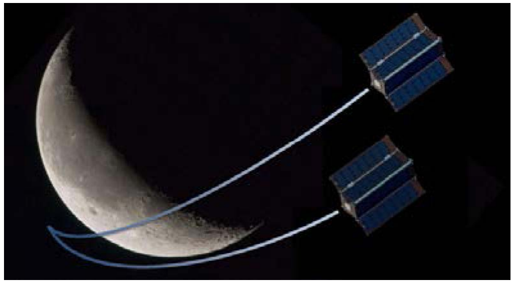

Photo Credit: NASA/JPL

Mother/Daughter CubeSat Architectures

Pros:

- Provides opportunities for high priority science at various locations
- Eliminates Deep Space capability issues

Cons:

- Relies on a much more expensive mission
- May require higher quality assurance requirements (ensure doesn't affect the larger mission)
- Reduced number of launch opportunities

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Deep Space Travel is Not Easy!

Stand-alone Planetary CubeSat missions must overcome significant technological hurdles to succeed

Photo Credit: NASA/KSC

Long distance communication requires increased power or antenna area

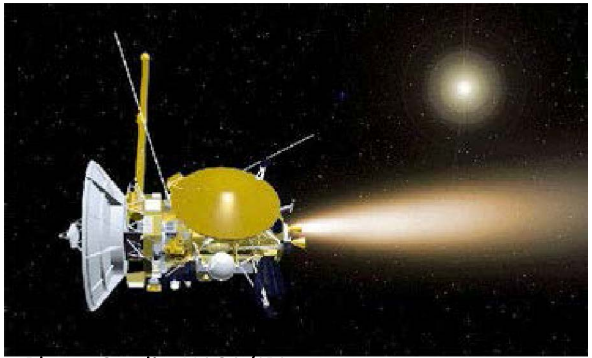


Photo Credit: NASA/JPL

Propulsion systems require increased potential energy or power

The result is a **significant increase in complexity** in order to force the Deep Space functionality to fit within the **current CubeSat standard**

CubeSats As Daughter Craft

Mother/Daughter architectures maintains the CubeSat standard but sacrifices opportunity

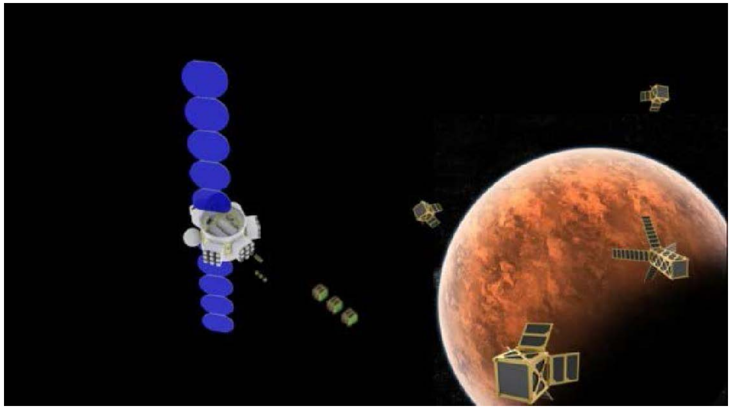
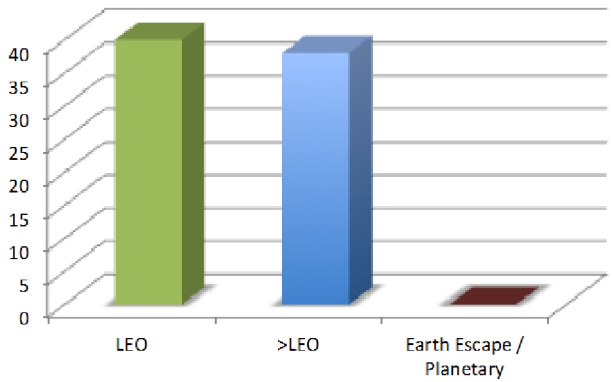


Photo Credit: Busek

Relies on a much more expensive mission (higher quality assurance)



Reduced number of launch opportunities (requires higher reliability)

The reduction of opportunity forces **more consideration for mission reliability and quality assurance, increasing the cost and complexity** of the systems

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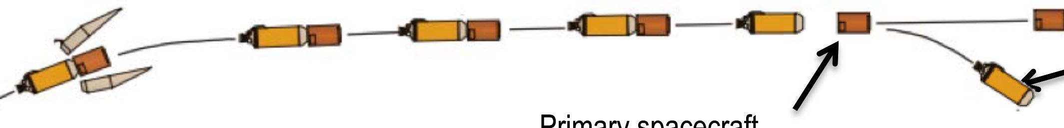
A New Standard for Planetary Missions

The ESPA ring and lunar gravity assists provide the required standards and opportunity to enable low-cost Planetary Missions



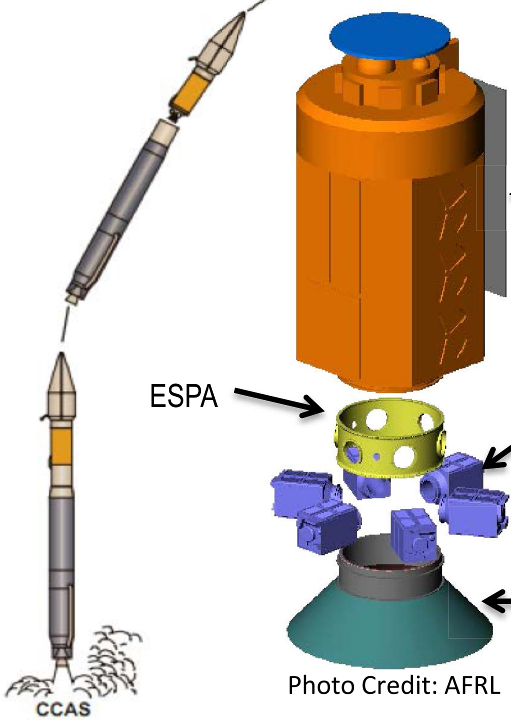


Photo Credit: AFRL

Photo Credit: Lockheed Martin

ESPA Ring

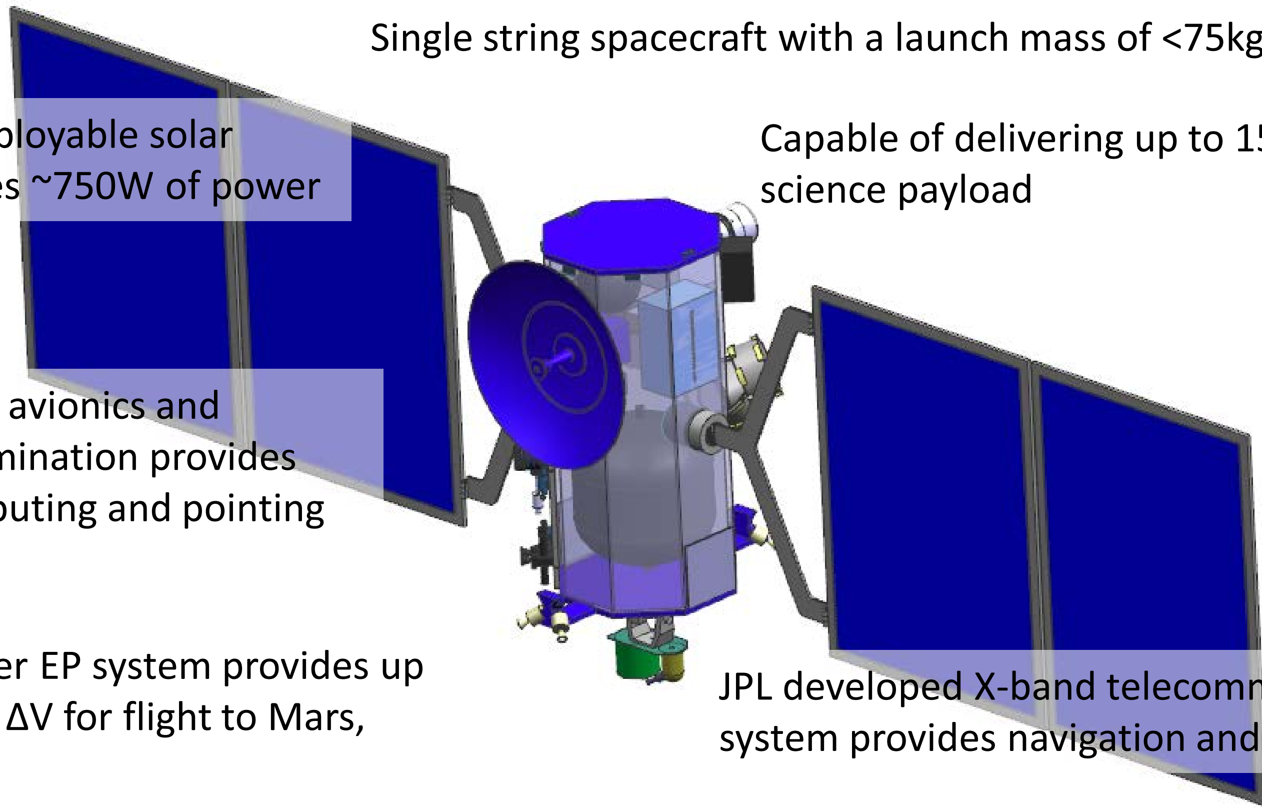
- The EELV Secondary Payload Adapter (ESPA) provides a standard launch interface for spacecraft <180kg

Lunar Gravity Assists

- Lunar gravity assists can be used to customize the departure energy and direction to any potential target of interest including NEOs, Venus and Mars

Potential Platform for Planetary Exploration

The Micro Surveyor spacecraft provides the low cost launch flexibility of a CubeSat with the capability of a traditional Deep Space spacecraft



Single string spacecraft with a launch mass of <75kg

Two 1.5m^2 deployable solar arrays provides ~750W of power

Capable of delivering up to 15kg of science payload

CubeSat based avionics and attitude determination provides sufficient computing and pointing

COTS low-power EP system provides up to XXX km/s of ΔV for flight to Mars, Venus or NEOs

JPL developed X-band telecommunication system provides navigation and communication

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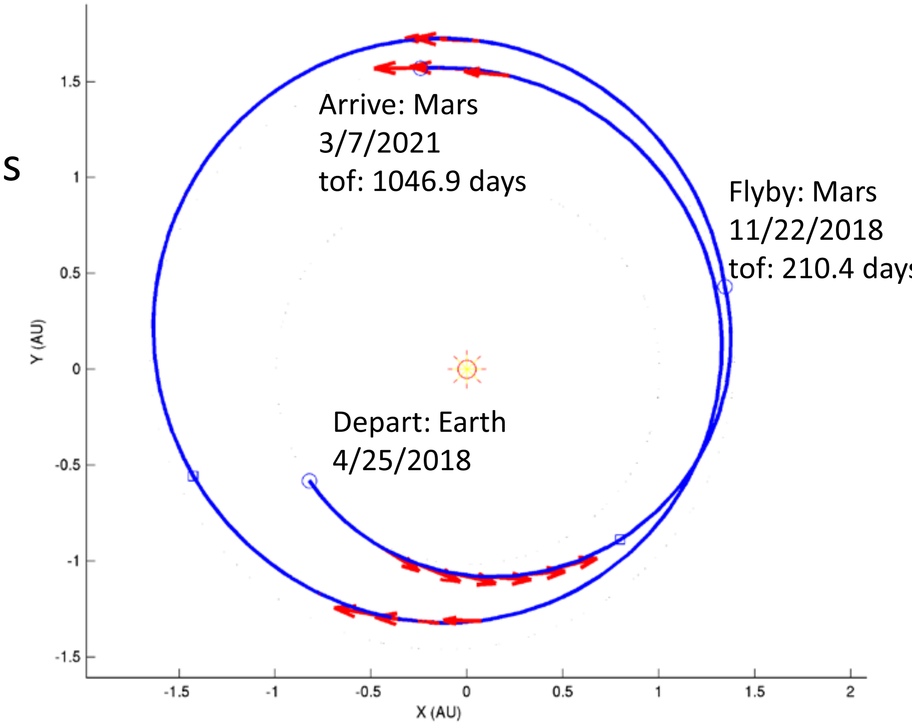
Potential Targets of Interest

From GTO, Planetary Science mission could potentially be conducted at Venus, Mars and NEOs

- Example Mars Trajectory
  - Launch date: December 2017
  - Time to Earth Departure: 6 months
  - Transfer flight time: ~3 years
  - Mars Arrival Time: March 2021
  - Total Delta V to Mars: 2.8 km/s
- Venus and NEO Trajectories
  - NEOs
    - Launch in late 2019
    - Flight time of ~21 months
  - Venus
    - Launch in late 2018
    - Flight time of ~16 months to Venus



Summary

- To reduce cost of Planetary Missions, we must increase the regularity of these missions
- CubeSat form factor has physical limitations, requiring a more capable spacecraft to perform missions
- A program similar to CLI using the ESPA ring would control the standards required for increased launch opportunities
- Micro Surveyor provides a potential compromise between CubeSat and Deep Space technologies