Interplanetary Small Satellite Conference

MIT KitCube

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Massachusetts Institute of Technology

MIT STAR Lab
Space Telecommunications, Astronomy, and Radiation

Outline

- Team
- Mission Overview
- Concept of Operations
- Spacecraft Overview
- Lasercom Payload
- Propulsion Subsystem
- Challenges
- Vision
- Questions

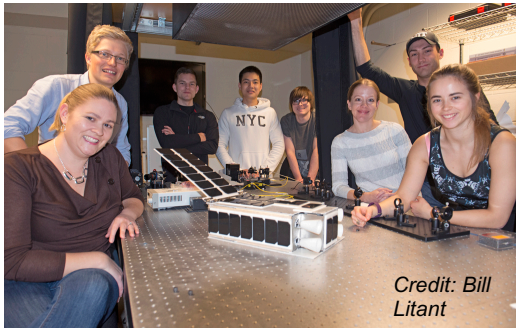
Student Team

Spring 2015: KitCube began as a undergrad and grad space systems engineering design course

Fall 2015: KitCube continued as a grad satellite engineering course

Fall 2015: KitCube joined by Project Selene students in Pasadena, CA

Spring 2016: KitCube has over 45 active team members, many continuing from previous semesters



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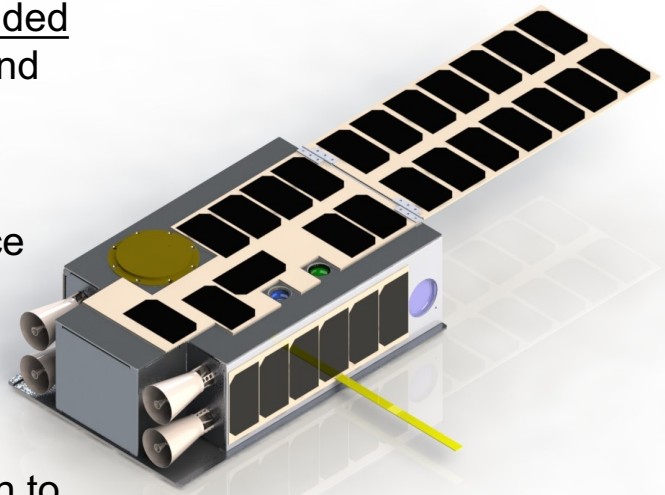
Mission Overview

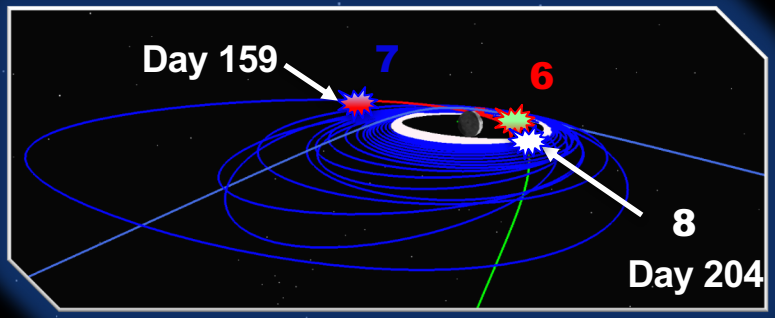
- Video: https://vimeo.com/153068013
- KitCube is a student-built, industry-funded 6U CubeSat that will fly to the moon and demonstrate:
  - Green monopropellant propulsion
  - Compact, power efficient free space optical communications with fine pointing capabilities
- Part of NASA's CubeQuest Challenge
  - Top 3 in GT-4 will get a SLS launch to the moon
  - KitCube has placed 2nd in GT-1 and GT-2. GT-3 will be Aug 2016, and GT-4 will take place Feb 2017

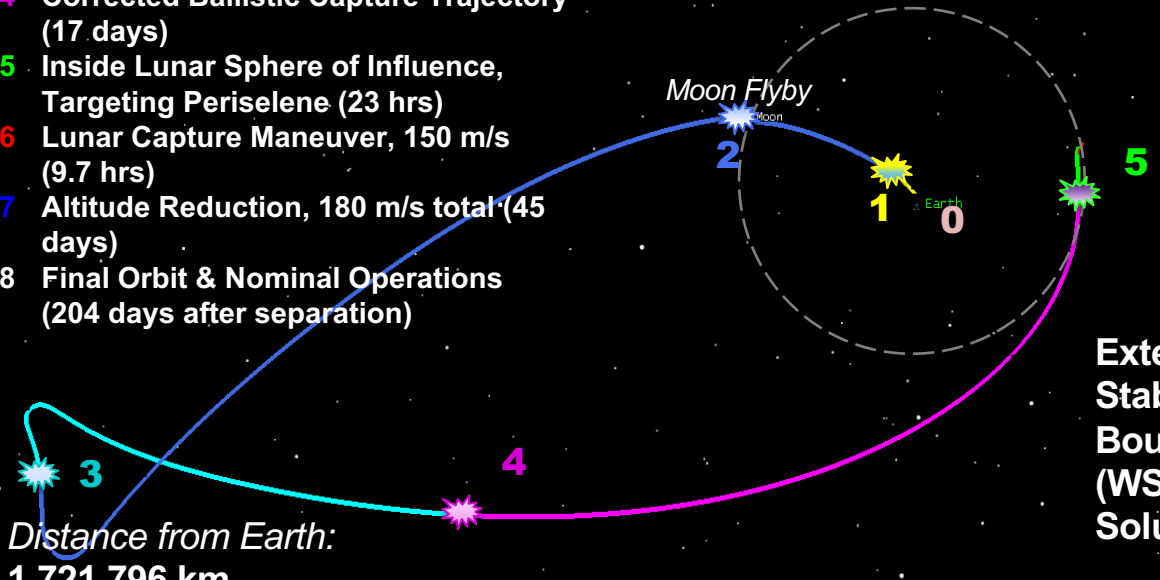


Credit: Max Khatsenko 02/16

CONCEPT OF OPERATIONS

0 Separation & Boot (4-8 hrs after T0)
1 Detumbling, Deployer Actuation, System Checkout (<8 hrs after separation)
2 Outbound to Exterior Weak Stability Boundary (74 days)
3 Falling Back to the Moon for Ballistic Capture (65.5 days)
4 Corrected Ballistic Capture Trajectory (17 days)
5 Inside Lunar Sphere of Influence, Targeting Periselene (23 hrs)
6 Lunar Capture Maneuver, 150 m/s (9.7 hrs)
7 Altitude Reduction, 180 m/s total (45 days)
8 Final Orbit & Nominal Operations (204 days after separation)





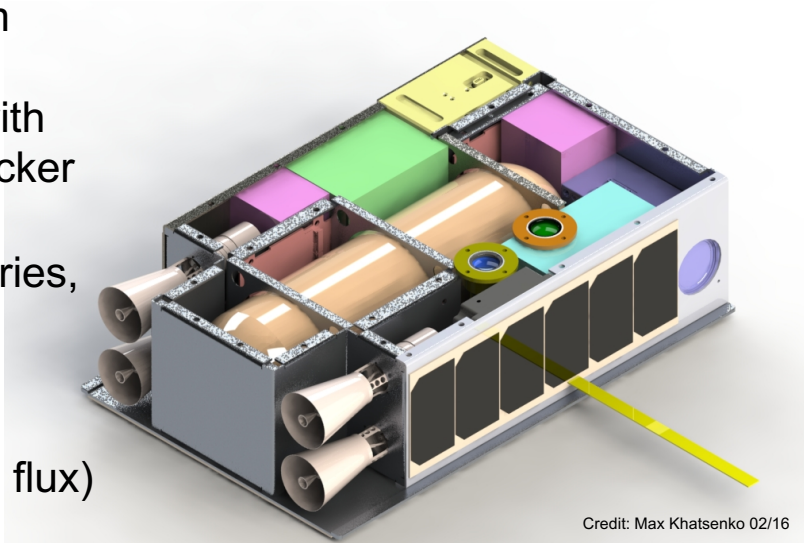
Distance from Earth:
1,721,796 km

Exterior Weak Stability Boundary (WSB) Solution[1]

Credit: Max Yates 02/16

Spacecraft Overview

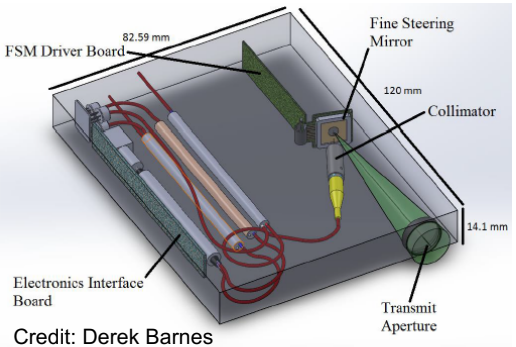
- Communications: X band (in flux) & UHF radios, with lasercom
- Pointing: 3-axis controlled with reaction wheels and star tracker
- Power: Solar panels & batteries, with deployable 6U panel
- Propulsion: Miniature green monopropellant thrusters (in flux)
- Custom designed avionics & aluminum structure



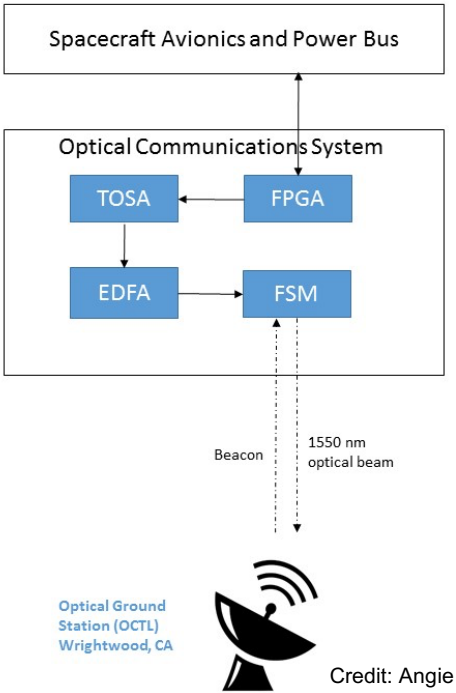
Credit: Max Khatsenko 02/16

Laser Communications

- Master Oscillator Power Amplifier (MOPA) configuration with custom 1550 nm Fiber Laser Module and optical fiber collimator
- Volume: ~0.5U, Mass ~0.91 kg, Tx optical output power ~1.2W



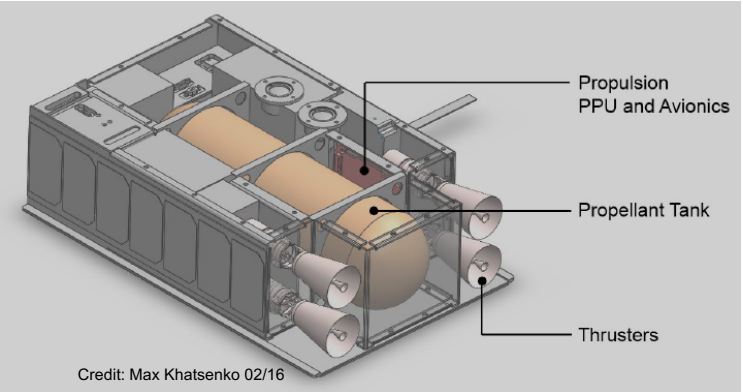
Credit: Derek Barnes



Credit: Angie Crews

Green Monopropellant

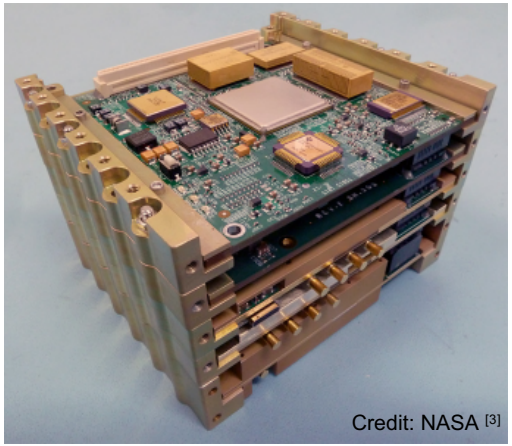
- AF-M315E: Stable, low-toxic propellant developed by the AFRL
- 4x Busek BGT-X5 as current baseline
- Momentum desaturation using canted thrusters (2º)

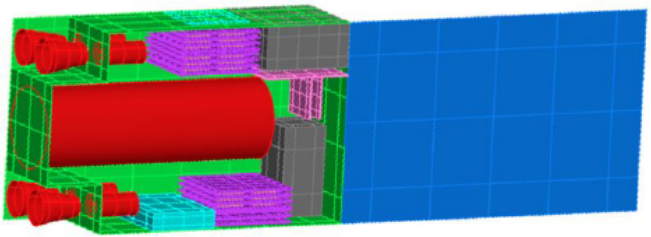


Nominal Thrust (mN) [2]	500, throttle-able
Specific Impulse (s) [2]	220-225 nominal at 400 psi feed
Propulsion Mass (kg)	5.00 wet, 2.95 dry
Expected Delta-V (m/s)	362.5
Duty Cycle	2.7% (5 seconds on, 3 minutes off)
Number of Maneuvers	23 (81,414s total burn duration)

Challenges

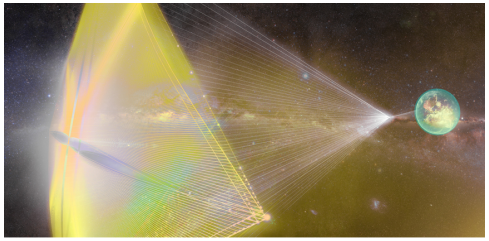
- Iris radio
  - Size, cost, and availability timeline
- Propulsion
  - Low propellant margin & high cost
- Navigation
  - Exact SLS drop-off unknown
- Thermal management
  - Thrusters catalyst heating
- Cost
  - Fundraising only goes so far
- Team Transitions


Credit: NASA [3]


KitCube Thermal Desktop Model, Credit: Pierre Bertrand 02/16

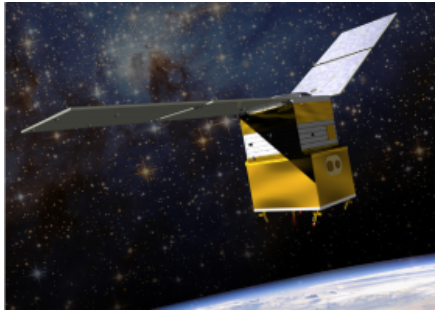
Vision

- Mission enabler for small satellite missions that require improved pointing and lasercom capabilities
  - BridgeSat- optical communications
  - SkyBox- high data rate transfer
  - CHOMPTT- optical time transfer
  - StarShot- precise pointing and lasercom



Source: Breakthrough Initiatives 2016 [4]

- CubeSat green monopropellant demonstration
  - Low-cost interplanetary missions
  - Constellations enabler
  - GPIM* mission in late 2017 [4]



Source: NASA 2013 [5]

- Training next generation of space engineers!

* Green Propellant Infusion Mission

Questions

- Kitcube.mit.edu
- Facebook: MIT KitCube
- Twitter: @KitCubeQuest

References

[1] Yates, Max. Boundary(WSB) Solution assumptions**:** BGT-X5 Thrusters (2.7% Duty Cycle, ISP 220 sec), and S/C Mass: 11 kg dry + 2.2 kg fuel. 02 2016.

[2] Busek Space Propulsion and Systems, "BGT-X5 Green Monopropellant Thruster: 0.5N green monopropellant thruster delivers 565N-s in 1U CubeSat volume for high performance space applications," Datasheet Rev D, 2016.

[3] NASA, "Iris V2 CubeSat Deep Space Transponder," 07 2015.

[4] Breakthrough Initiatives, "StarShot," 04 2016.
http://www.breakthroughinitiatives.org/

[5] NASA, "Green Propellant Infusion Mission Project," 03 2016.