National Aeronautics and Space Administration

Miniature Tether Electrodynamics Experiment (MiTEE) II

Principal Investigator: Vritika Singh (382), JPL
Co-I's: Marco Quadrelli (347E), JPL; Brian Gilchrist & Darren McKague U. of Michigan
Student Contributors: Maya Pandya, Geoffrey Jenkins, Mitchell Miller, Cade Wright, Jesus Christian, Liam Spence, Mayukh Nath, Ryan Barnhart, Alexander Shaw, Preston Fossee, Allison Hancock
Program: SURP

Project Objective:

The Miniature Tether Electrodynamics Experiment (MiTEE) is a student driven educational technology demonstration mission using the CubeSat architecture to investigate the use of miniaturized (~10-30 m), low-power, electrodynamic tethers (EDT) to provide propellant-less propulsion for drag make-up and maneuvering, as well as enhanced communication capabilities for "smartphone"–sized picosatellites (1 kg–100 g) and femtosatellites (<100 g).

In the past three years, MiTEE-2 has gone from its initial design phase to the fabrication of a fully functional 3U-Cubesat. In just the past year, we completed assembly and final integration of our flight structure, refined flight code, and completed necessary pre-flight tests such as DITL (day in the life), vibration and thermal vacuum. Launch Schedule: Late 2019 or Early 2020 (ELaNA XX). Additionally, MiTEE-2 development started in 2019 based on lessons-learned and the use of a 10-30 m tether instead of a 1 m boom.

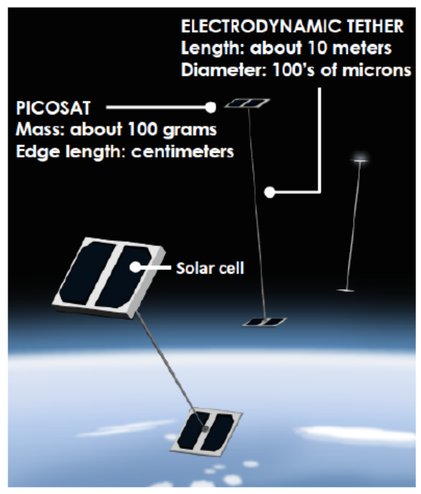


Figure 1: Concept of elecrodynamic tethers with pairs of femtosats as a maneuverable constellation.

Benefits to NASA and JPL:

If validated through the MiTEE missions, electrodynamic tethers (EDT) could help enable a new paradigm for sophisticated, ultra-small, positionable constellations of pico/femtosats [1, 2, 6]. This in turn enables greater capacity for multipoint, simultaneous measurements or more frequent single point measurements. A short EDT is fundamentally not constrained in terms of delta-V, provides its own gravity gradient attitude control, can serve as a possible high gain antenna (communications and science), and/or as a plasma probe. This ultimately enables the development of constellation missions for ionospheric-thermospheric-magnetospheric (ITM) science that can be jointly proposed to NASA. This could fit well with the upcoming Global Dynamics Constellation (GDC) being defined in the near future [3,4].

FY18/19 Results:

MiTEE-1: Example Lessons Learned

- Better dimensional tolerance tracking
- Incorporate I&T procedures early in design phase
- Prototype spacecraft build-up plan early
- Formalize system of dedicated student liaisons between all subsystem teams
- Implement formalized timeline milestone goals early in the design phase

MiTEE-2 Key Redesign Tasks (By Subsystem/Function)

- Command and Data Handling – evaluate changing multiple MSP430 architecture to single processor. Research commercial operating systems.
- Communications – Evaluate simpler antenna, tether as antenna. Develop picosat comm system. Consider Globalstar or equivalent.
- Plasma – Consider dual LP (twin probe) concept. Make electron emitter less fragile.
- Electrical Power System – Evaluate combining CCPS and HVPS boards into one.
- Orbits & Attitude Determination and Control System – Develop more capable ADCS for tether operation.
- Structures – Replace 1m boom with a (10-30m) tether deployment system for picosat.
- Mission Ops – Evaluate deploying from ISS to reduce primary concerns for collisions.

DARTS Training @ JPL [5]

- 2 UM students attended JPL DARTS Summer Course, Aug 2019: Liam Spence, Mitchell Miller
- Advisor: Dr. Marco Quadrelli (Mobility and Robotic Systems, 347E)

Education Through Multi-Semester/Multi-Year Experiential Opportunities = MiTEE

- Goal 1: Deepen technical knowledge while developing systems-thinking skills
- Goal 2: Design skills, team skills, life-long learning skills

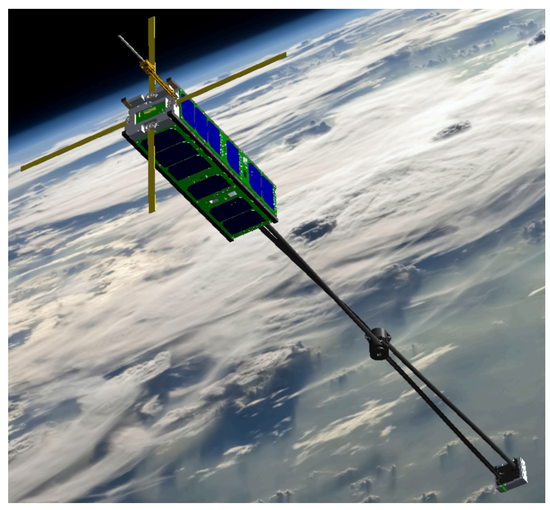


Figure 2: MiTEE-1 concept with fully deployed boom and picosat form-factor end-body.

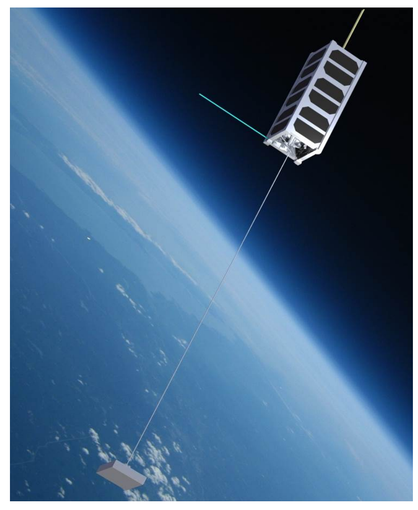
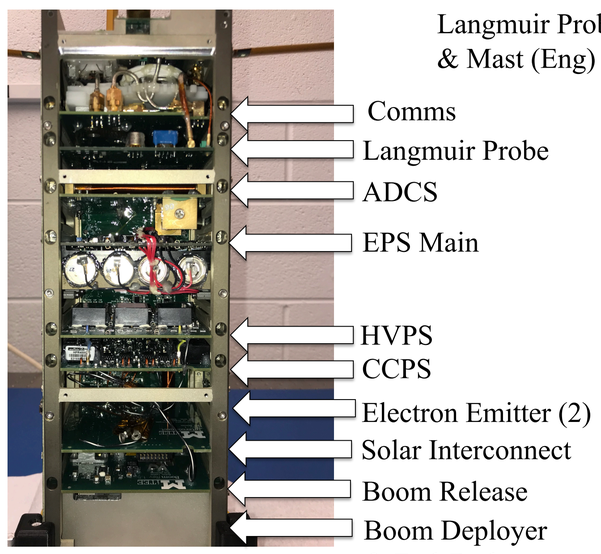
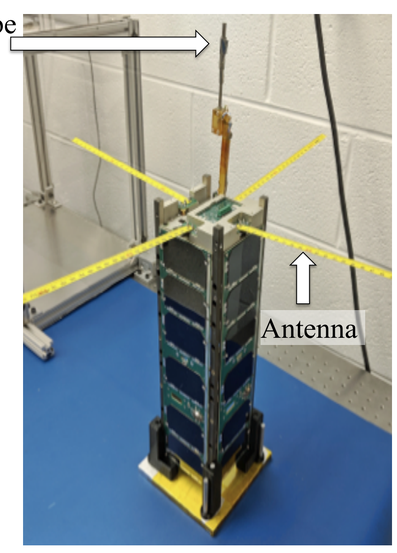


Figure 3: Early MiTEE-2 concept with tethered picosat partially deployed



MiTEE-1 with solar board removed from front face



MiTEE-I Langmuir probe and antenna deployment

References /Publications:

1. Bell, et al: Investigating Miniaturized Electrodynamic Tethers for Picosatellites and Femtosatellites, *J. Spacecr and Rockets*, 54 (N.1) 2017.
2. Bell, et al: Experimental investigation of electron collection by rectangular cuboid in a high-speed plasma, *IEEE Plasma Sci*, 45 (N.7) 2017.
3. NRC report: Achieving Science with Cubesats: Thinking Inside the Box, http://www.nap.edu/23503
4. Committee on the Planetary Science Decadal Survey, National Research Council of the National Academies, Vision and Voyages for Planetary Science in the Decade 2013–2022, National Academies Press, Washington, DC, 2011.
5. http://www.dshell.jpl.nasa.gov/DSENDS/index.php
6. B. E. Gilchrist, O. Leon, G. Miars, I. C. Bell III, S. G. Bilen, D. Winship, W. Faistenhammer, D. Yoon, D. Cheyne, R. Barnhart, J. Lafayette, Y. Liu, C. Wright, H. Tang, G. Jenkins, C. Cooper, "Picosat/Femtosatellite Electrodynamic Tether Propulsion", *6th Intl Conf on Tethers in Space*, Madrid, Spain, June 12-14, 2019.
7. O. Leon, W. Hoegy, J. McTernan, G. Miars, B. E. Gilchrist, "Correcting Langmuir Probe Measurements on Small Satellite Structures by Tracking the Spacecraft Potential using the Twin Probe Technique", *6th Intl Conf on Tethers in Space*, Madrid, Spain, June 12-14, 2019.

PI/Task Mgr. Contact Information:
Email: vritika.singh@jpl.nasa.gov
Phone: 626–788-6283

National Aeronautics and Space Administration
Jet Propulsion Laboratory
California Institute of Technology
Pasadena, California

www.nasa.gov