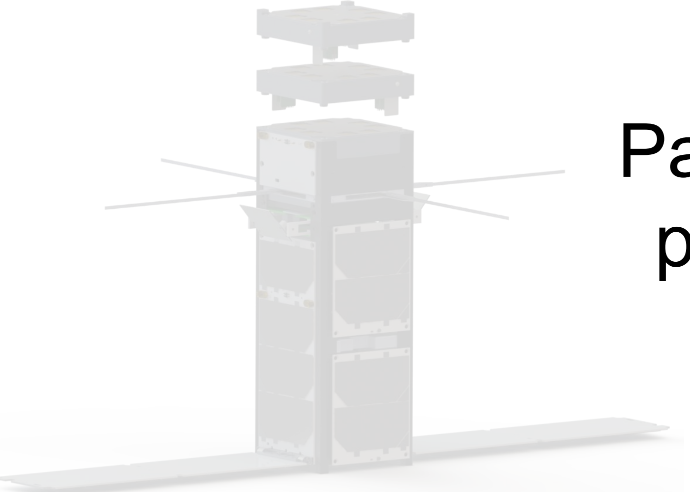
High Specific Impulse Electrospray Explorer for Deep Space (HiSPEED)



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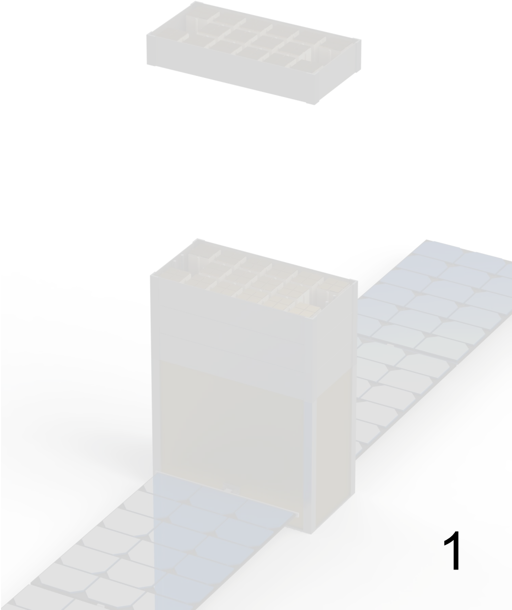
Cooperative Agreement (CA) number:
80NSSC18M0045



Acknowledgements

Thanks to NASA for their support:

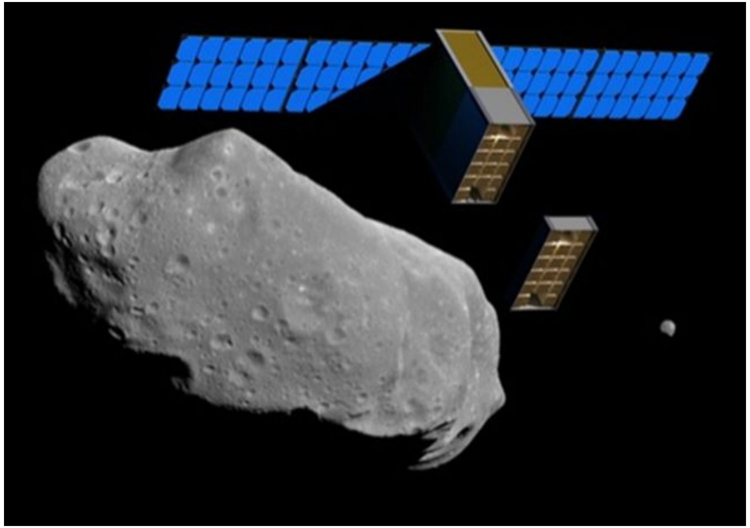
- Swati Mohan (Collaborator - JPL)
- Jim Crockell (STP)
- Sasha Weston (STP)
- Rodolphe De Rosee (Ames)

MIT Team:

- Oliver Jia-Richards
- Gustav Pettersson
- Graduate and undergraduate students

HiSPEED: Enabling a Deep Space Revolution

- Today, deep space missions are rare and expensive
- SmallSats' lower costs would
    - Increase science return
    - Empower more players
    - Develop future technologies
    - Diversify exploration
- CubeSat technology almost there
    - Deep space systems survival
    - Capable Instrumentation
- **HiSPEED to unlock propulsion**



HiSPEED Components and Team

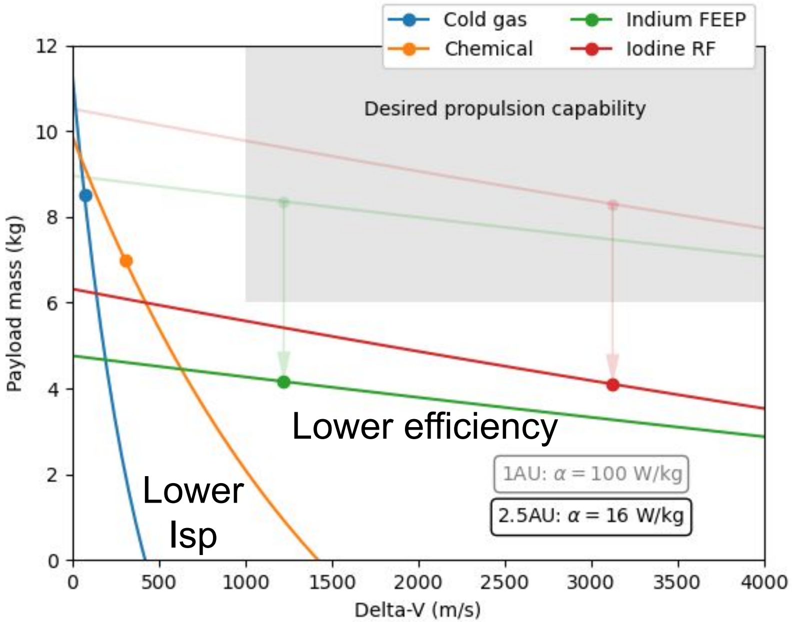
Propulsion (MIT)
Staged Ionic-Liquid Electrospray

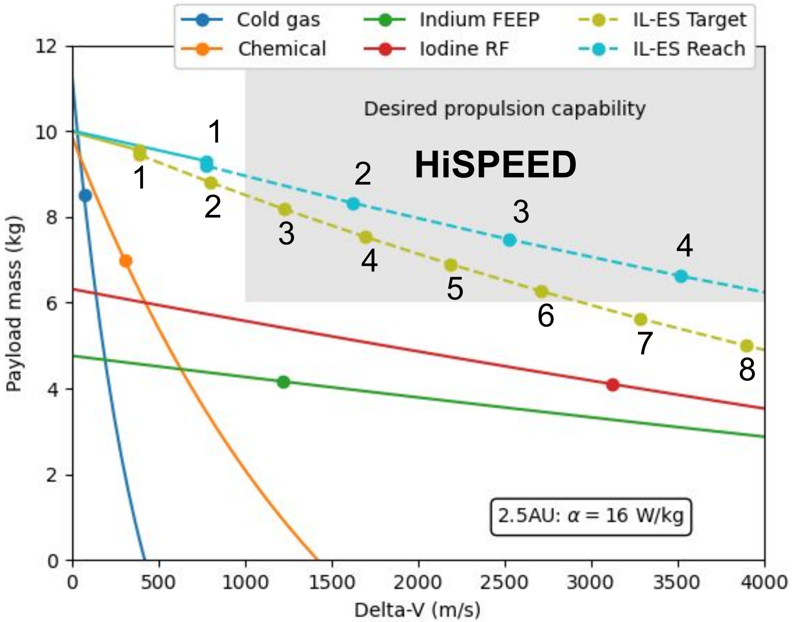
Controls (JLP)
Small Satellite Dynamics Testbed

Missions (MIT/JPL)
Deep-Space Trajectories and Proximity Operations

Systems (JPL)
Team Xc Study

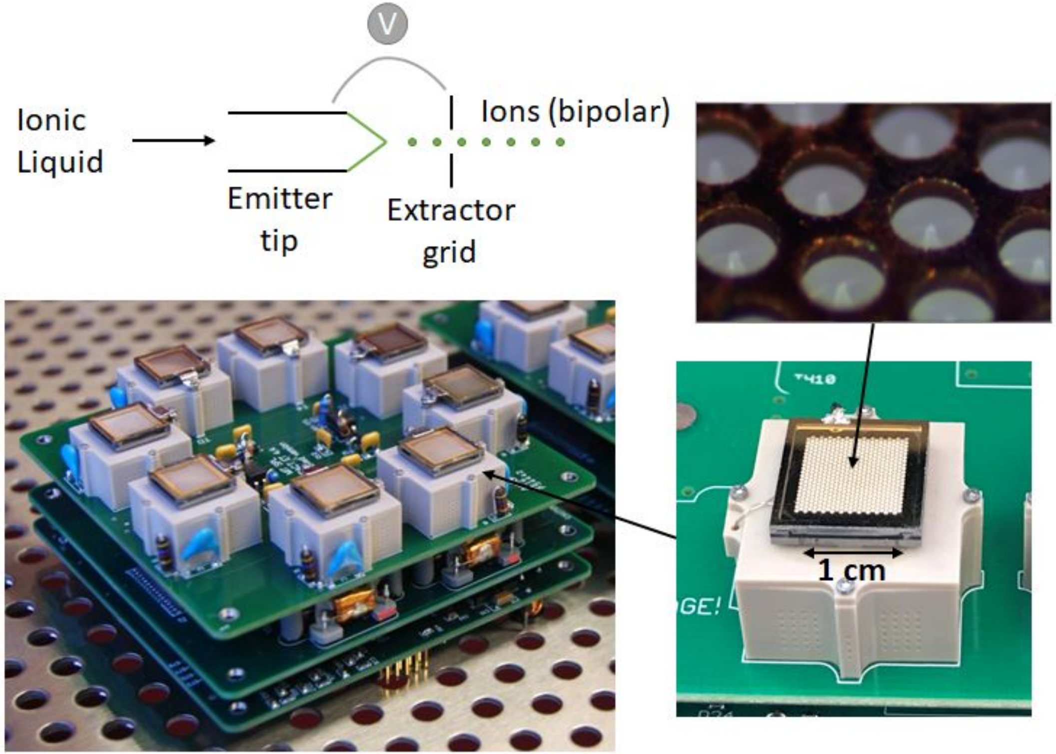
Staged Electrosprays Fill the Propulsion Gap

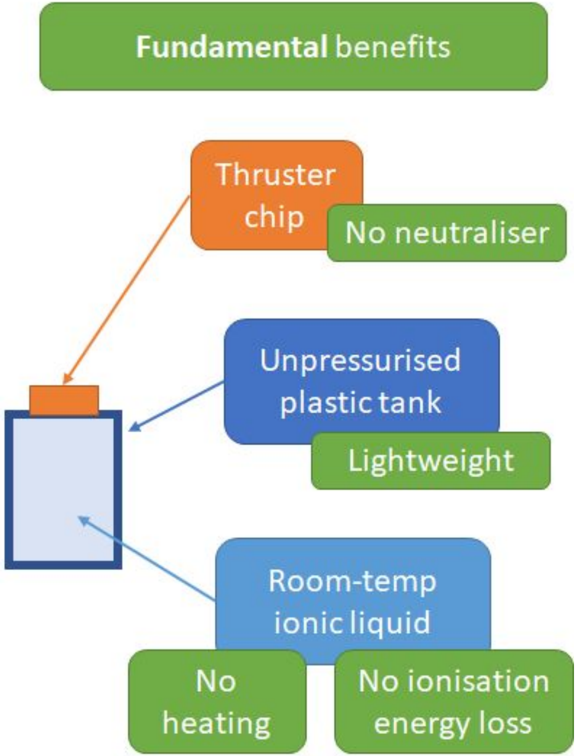




Deep-space (asteroid belt) payload vs delta-V for a 6U CubeSat.

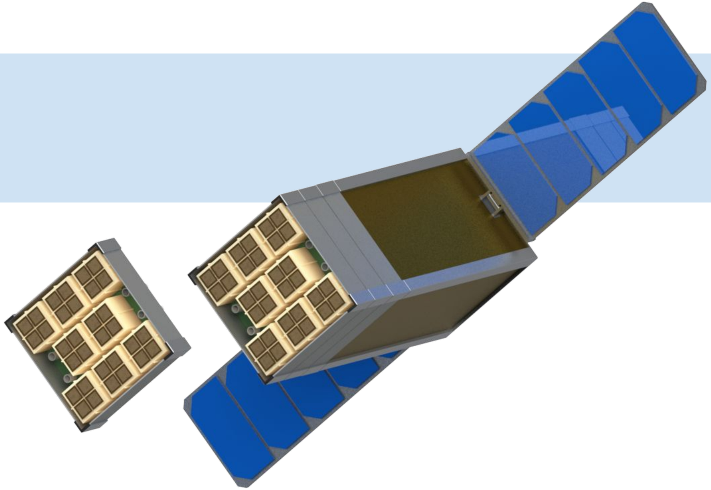
Ionic-Liquid Electrosprays are Fundamentally Efficient

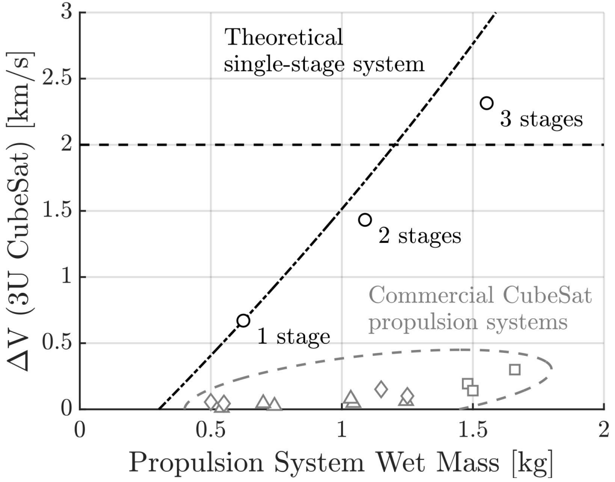




Staging Principle

- Several sets of thrusters overcomes lifetime limit
- Fundamental benefits of technology preserved
  - **High specific impulse**
  - **High efficiency**
  - **Several km/s ΔV**
- Enabled with **present** technology
  - Thrusters
  - PPU
  - Staging (STEP-1)



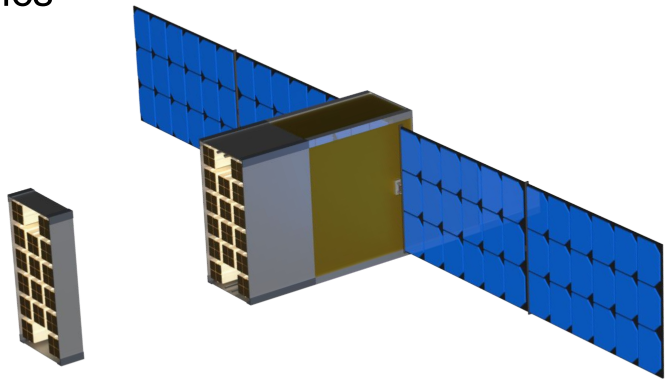


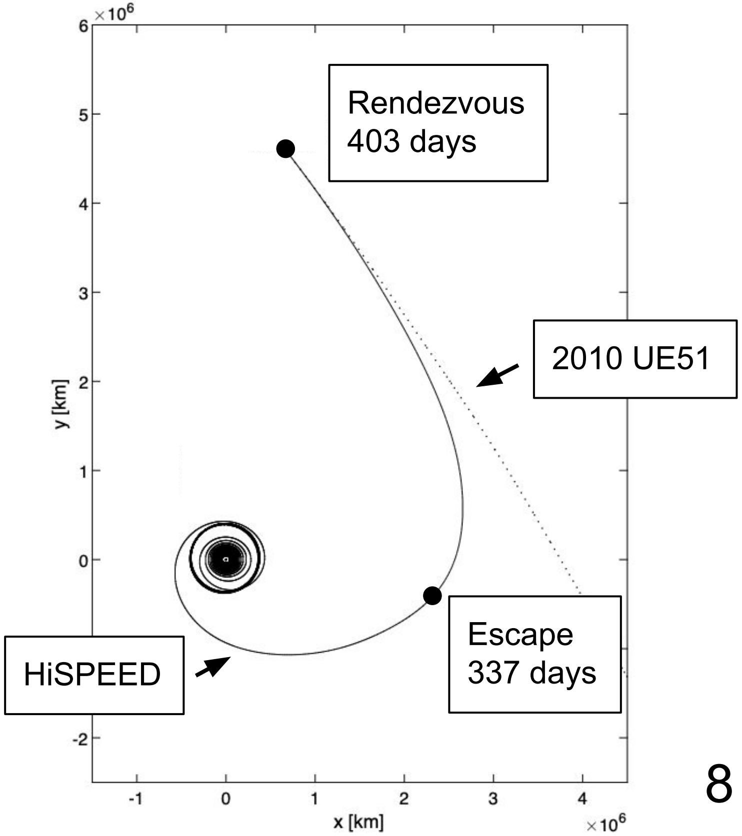
Feasibility Study

Conducted through a study by the JPL Team Xc Concurrent Design Center

Mission from geostationary orbit around Earth to the near-Earth asteroid 2010 UE51

Design closes for both current and future thruster performance metrics





STEP-1 – Staged Electrospray Pathfinder 1

Before embarking on a deep-space mission we will fly a technology demo

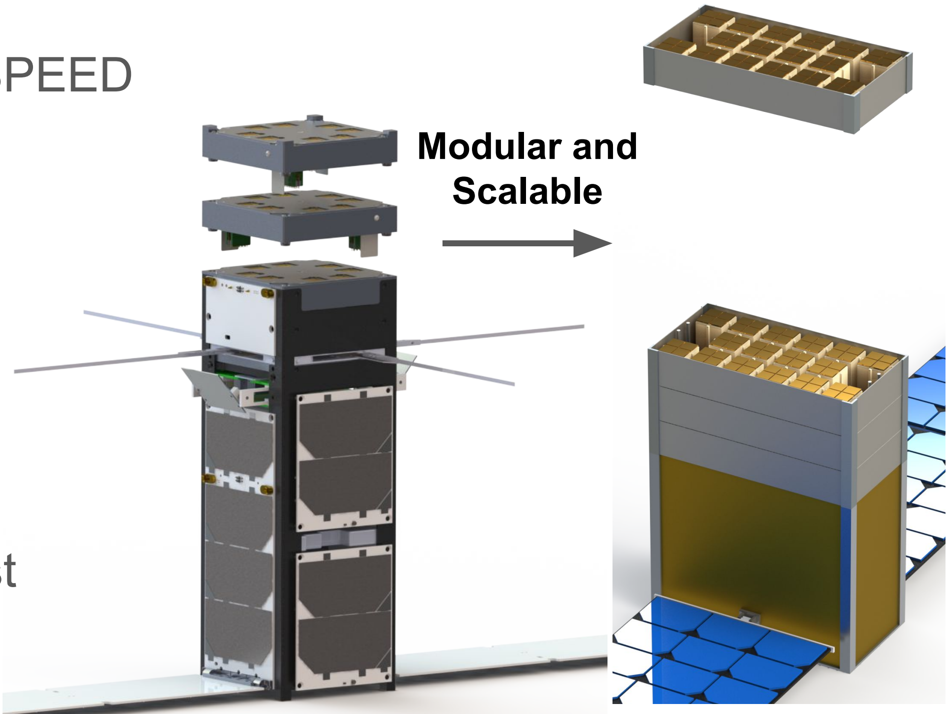
STEP-1 Demonstrates:

- ➔ Last major technology step for HiSPEED
- ➔ Propulsion scaling and modularity
- ➔ Thruster technology efficiency
- ➔ Propellant microvalve operation

STEP-1 Provides:

- ➔ Thruster flight qualification
- ➔ Staging flight qualification
- ➔ Student training in design/build/test

STEP-1 was selected for NASA CSLI

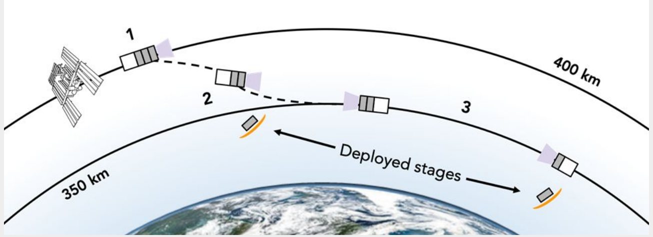


3U STEP-1 6U HiSPEED

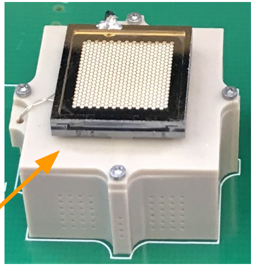
STEP-1 Design and Operations

ΔV ~ 10 m/s per stage in STEP-1 scales to HiSPEED with **ΔV ~ 1 km/s per stage and ~60% efficiency**

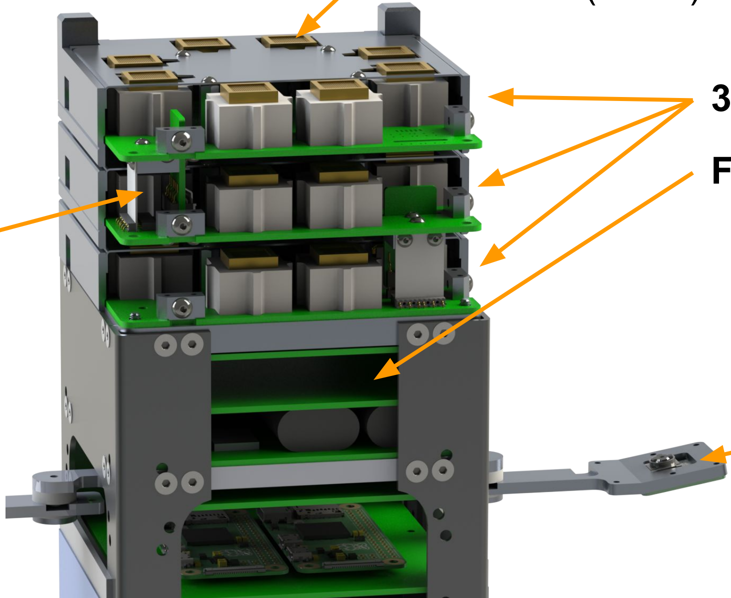
STEP-1 CONOPS from ISS launch



1. Deployment to low-Earth orbit
2. Reduce orbit and stage demo
3. Trajectory and attitude control

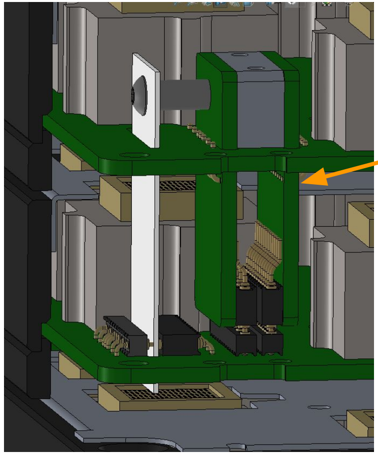


Thruster (~1cm)

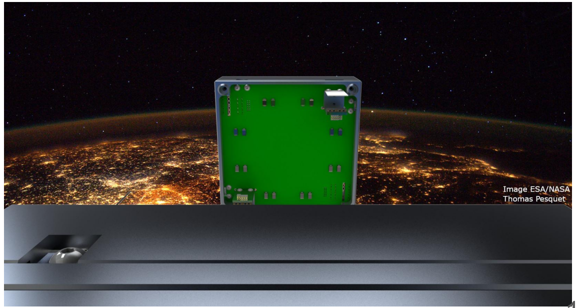


3-Stage electrospray propulsion

Flight-heritage PPU



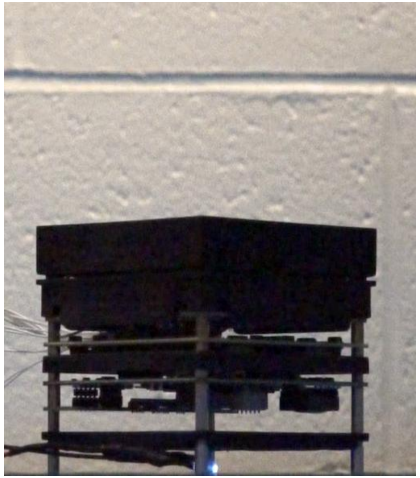
Interstage



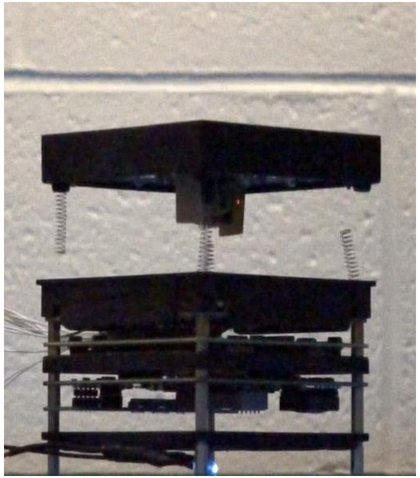
High frame rate recording

STEP-1 Staging Prototype Results

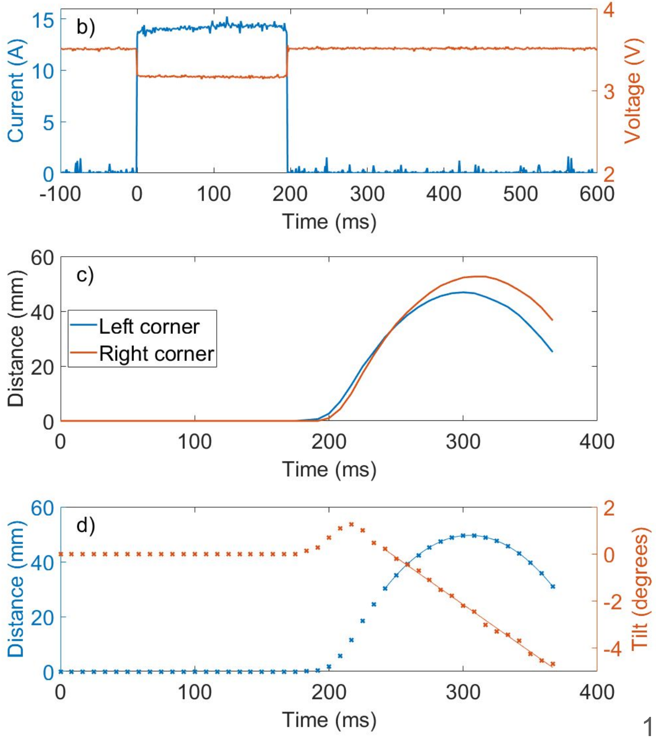
- Fully integrated payload prototype
  - 200 ms, 14 A to separate
  - 0.64 m/s separation speed



t = 0 ms



t = 250 ms



STEP-1 Team and Status

Principal Inv.

Prof. Paulo Lozano
MIT AeroAstro - SPL

PhD Students

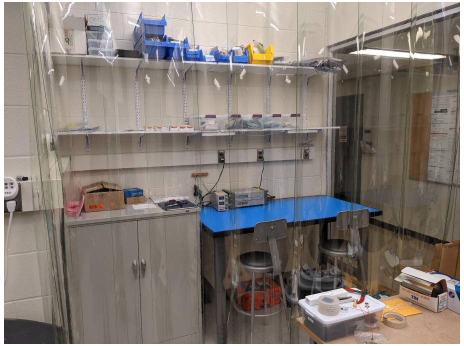
Gustav Pettersson
Oliver Jia-Richards

Undergrads

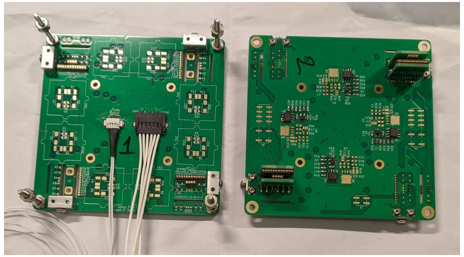
About 10 involved in
parts of the mission!

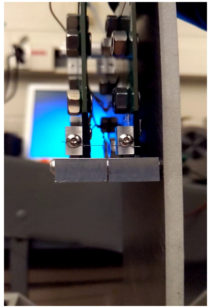
Review Team

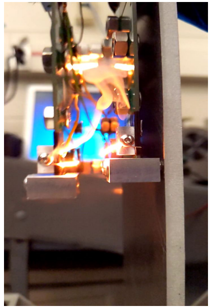
NASA JPL
MIT Lincoln Labs
MIT Haystack
Irvine CubeSat
KTH Stockholm

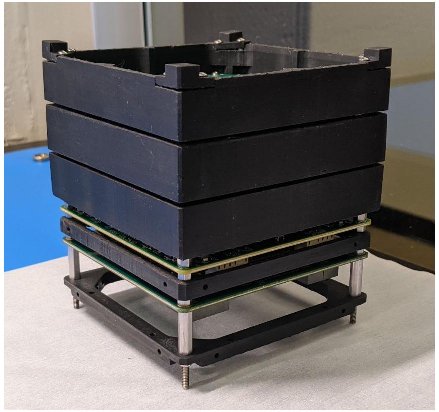


Dedicated Lab Space

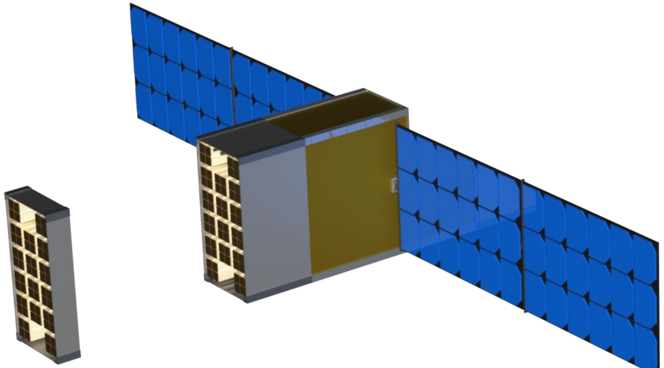








Payload Development



Thank You

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