

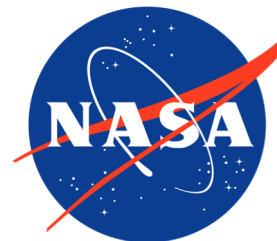
High Specific Impulse Electrospray Explorer for Deep Space (HiSPEED)

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Acknowledgements

Thanks to NASA for their support:

- Swati Mohan (Collaborator - JPL)
- Jim Crockell (STP)
- Sasha Weston (STP)



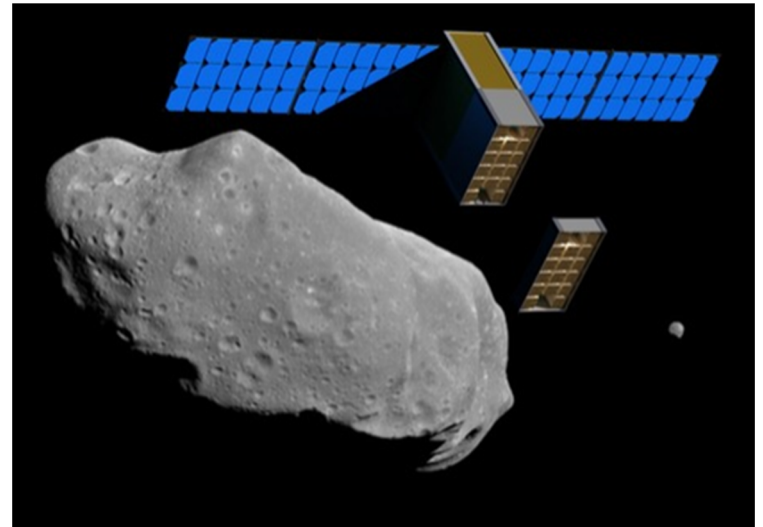
MIT Team:

- Oliver Jia-Richards
- Gustav Pettersson



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

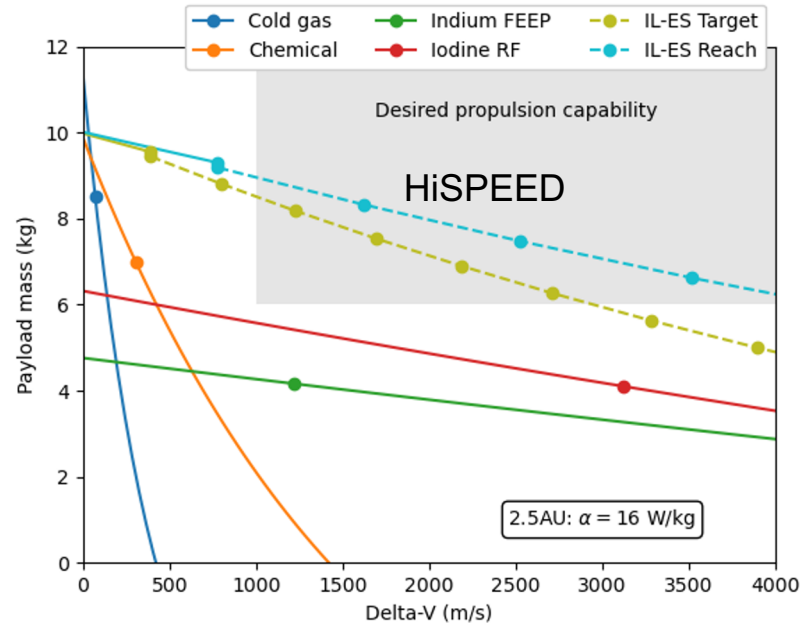
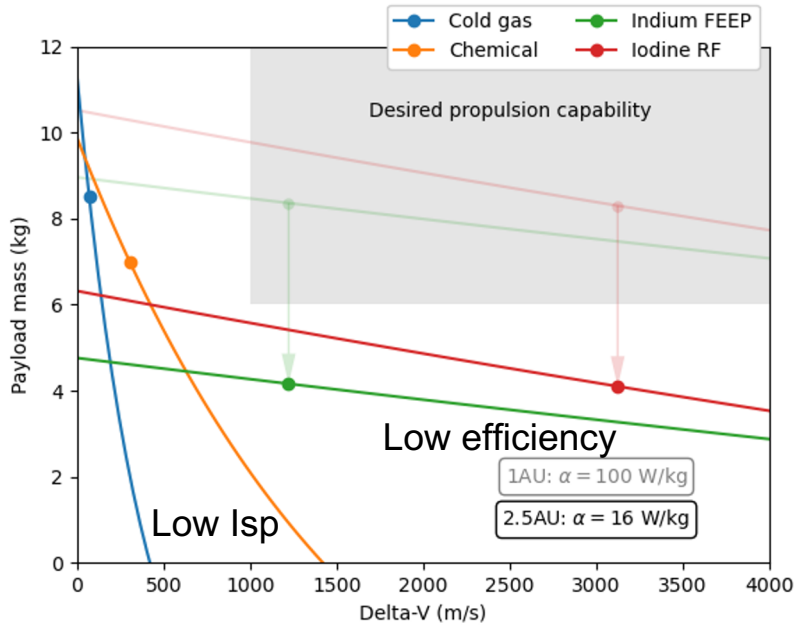
Propulsion (MIT)
Staged Ionic-Liquid
Electrospray

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

Controls (JLP)
Small Satellite
Dynamics Testbed

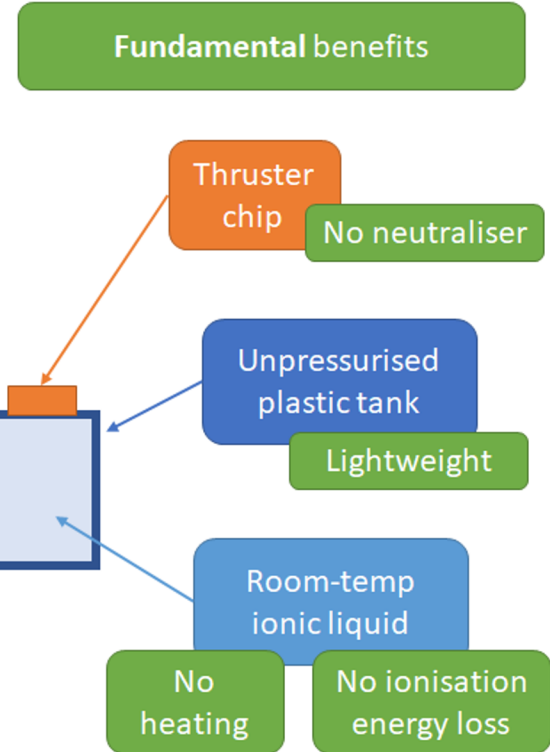
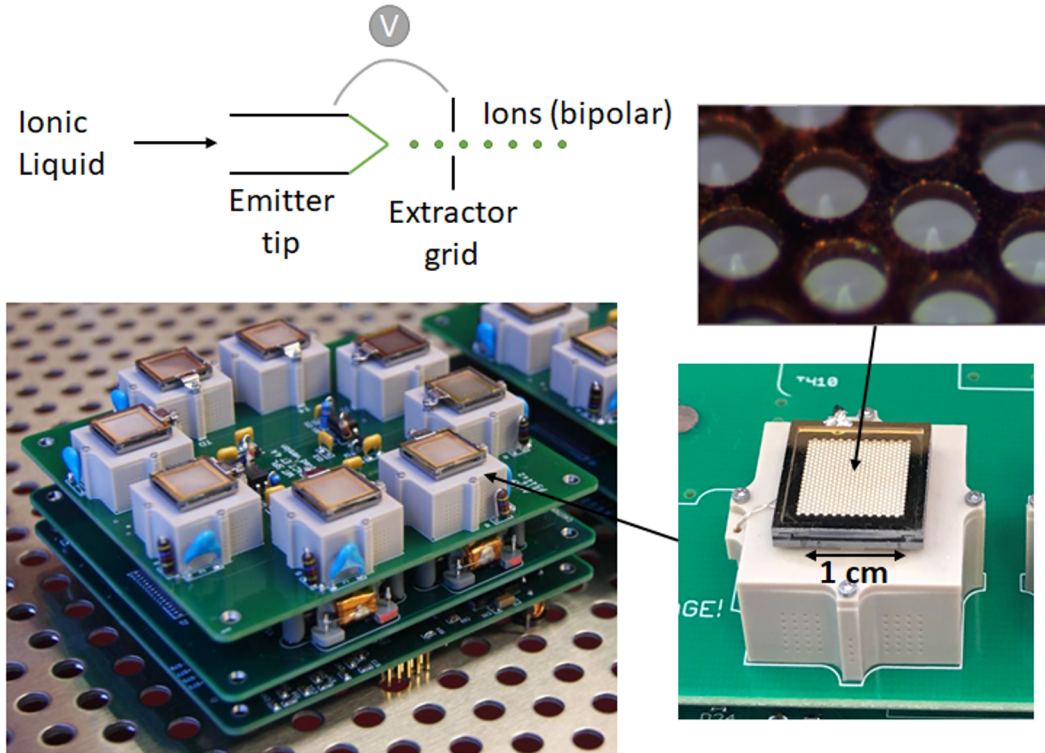
Systems (JPL)
Team Xc Study

Staged Electrosprays Fill the Propulsion Gap



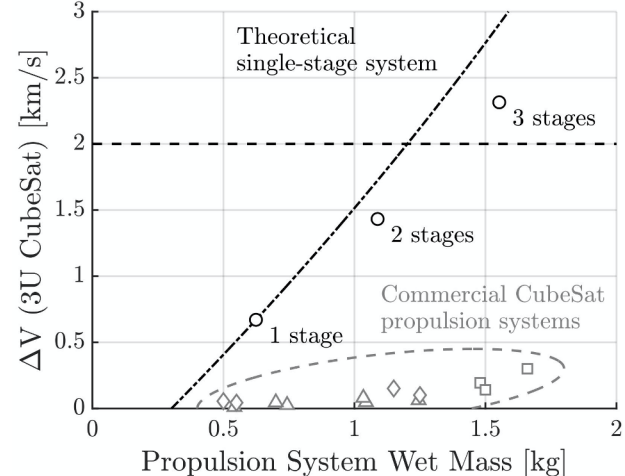
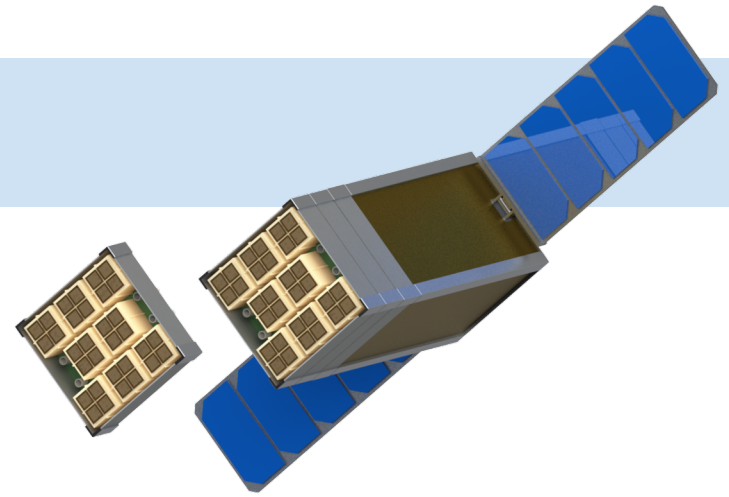
Deep-space (asteroid belt) payload vs delta-V for a 6U CubeSat.

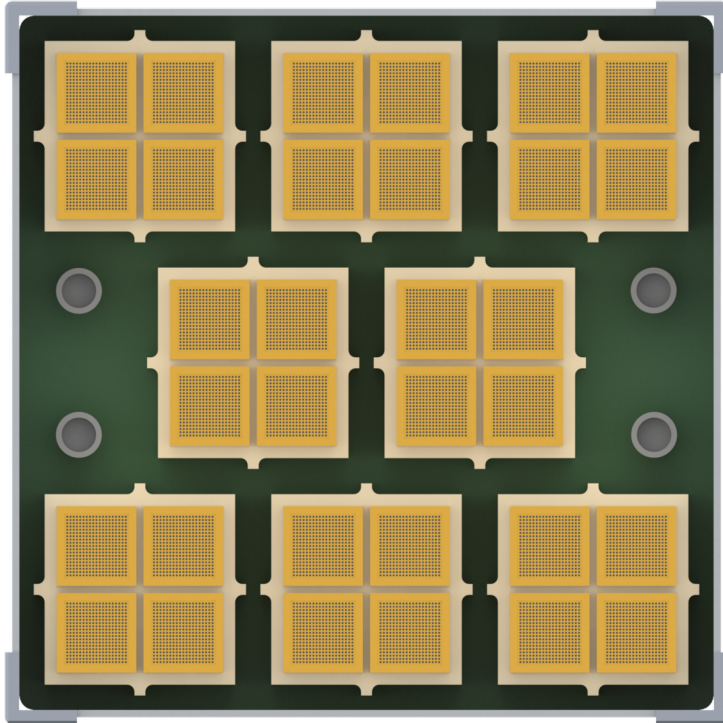
Ionic-Liquid Electrospays are Fundamentally Efficient



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 (HiSPEED and STEP-1)

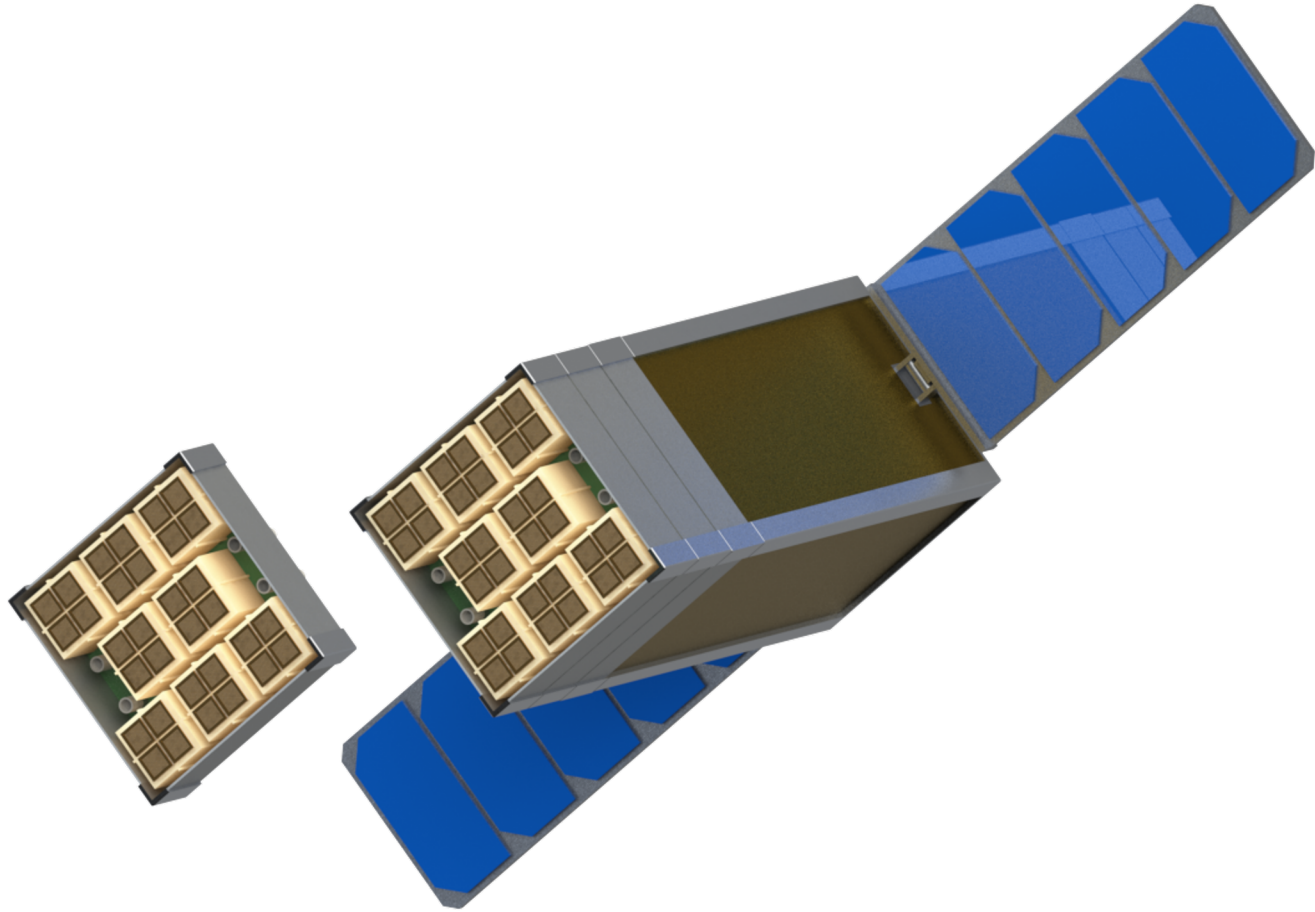




32 electro spray thrusters

- Compatible with 3U form factor
- 1 mN thrust
- 1000 s specific impulse
- 6 W power requirement
- 500 hr operational lifetime

Scalable to larger spacecraft sizes



Laboratory Demonstration

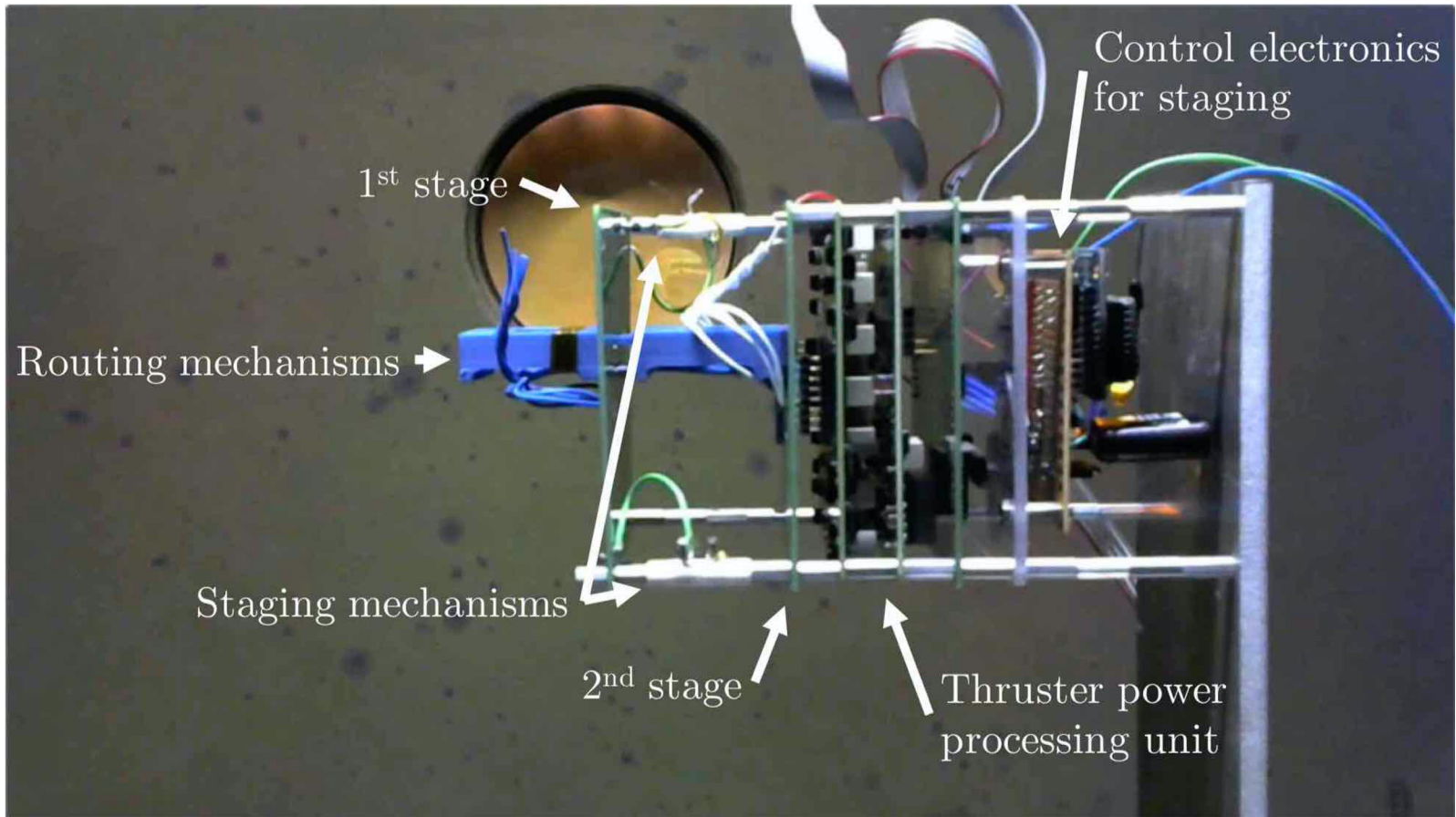
Demonstrate the prototype hardware for a staging system

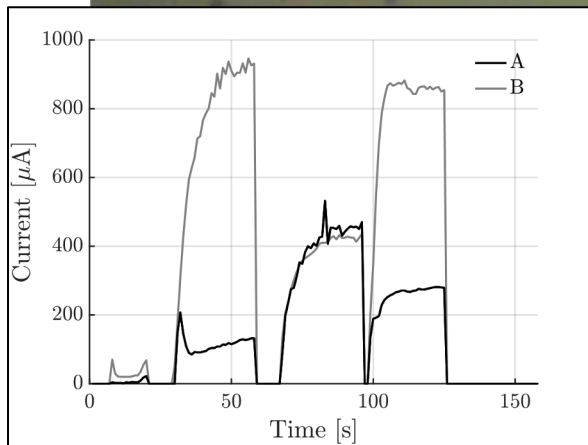
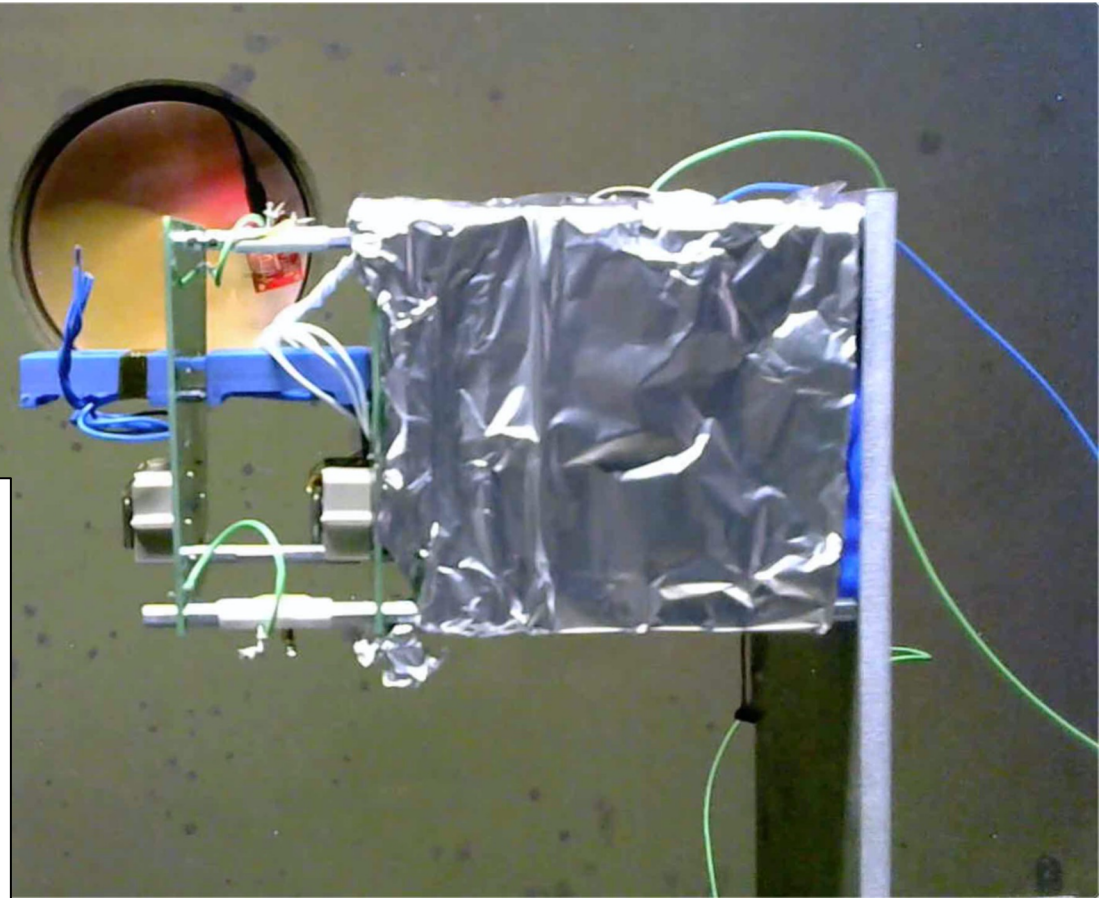
1. Staging mechanism:

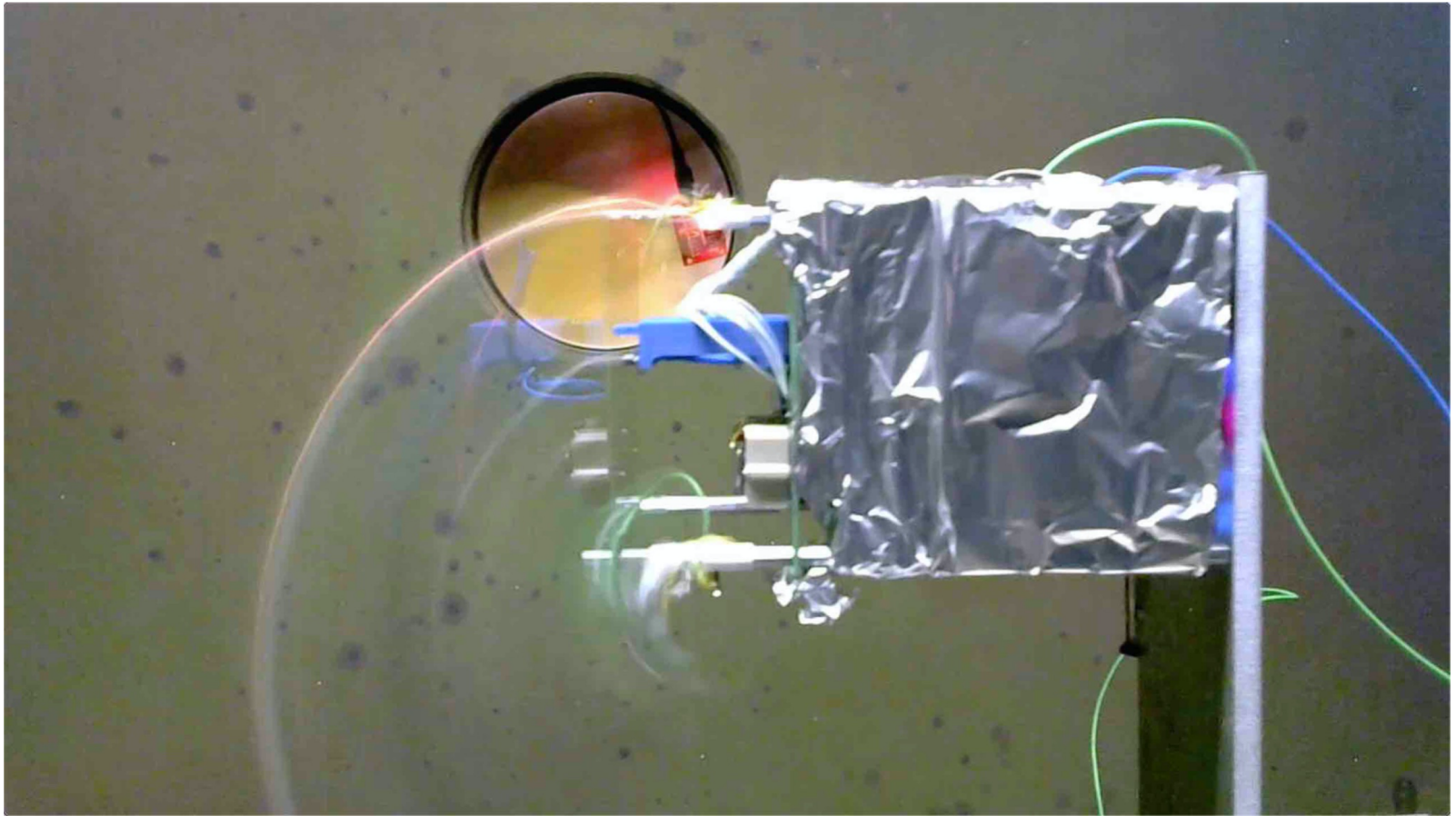
- Connects successive stages together
- Ejects spent stages
- Operates with a fuse wire

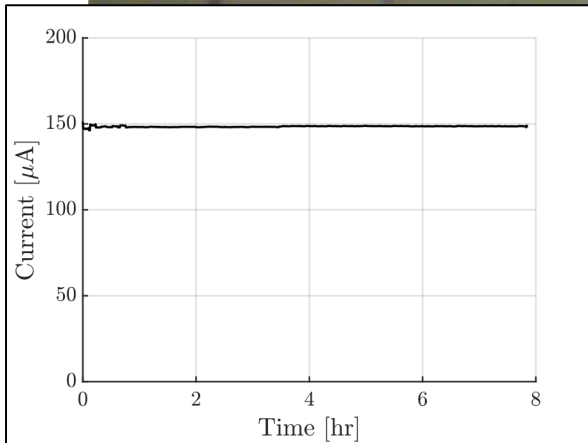
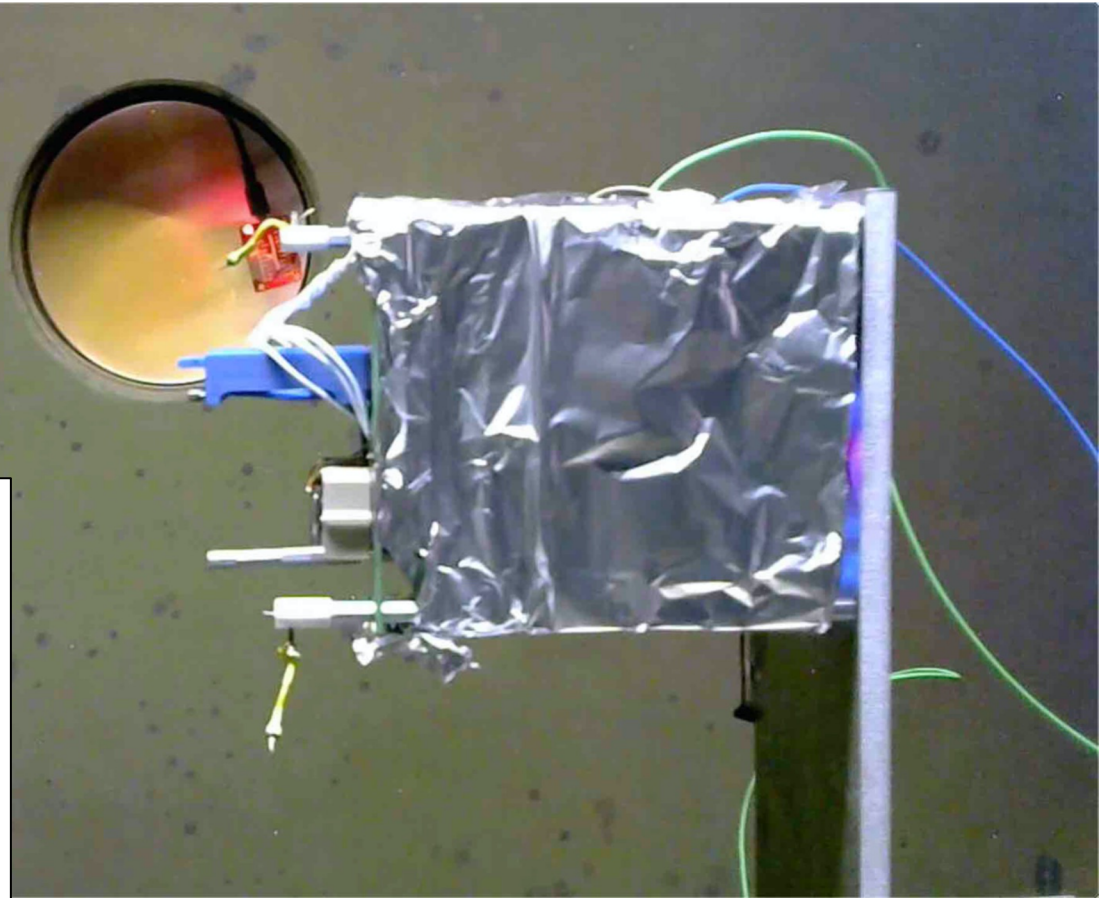
2. Routing mechanism:

- Routes control signals to the active stage
- Allows thruster electronics to remain “stage blind”







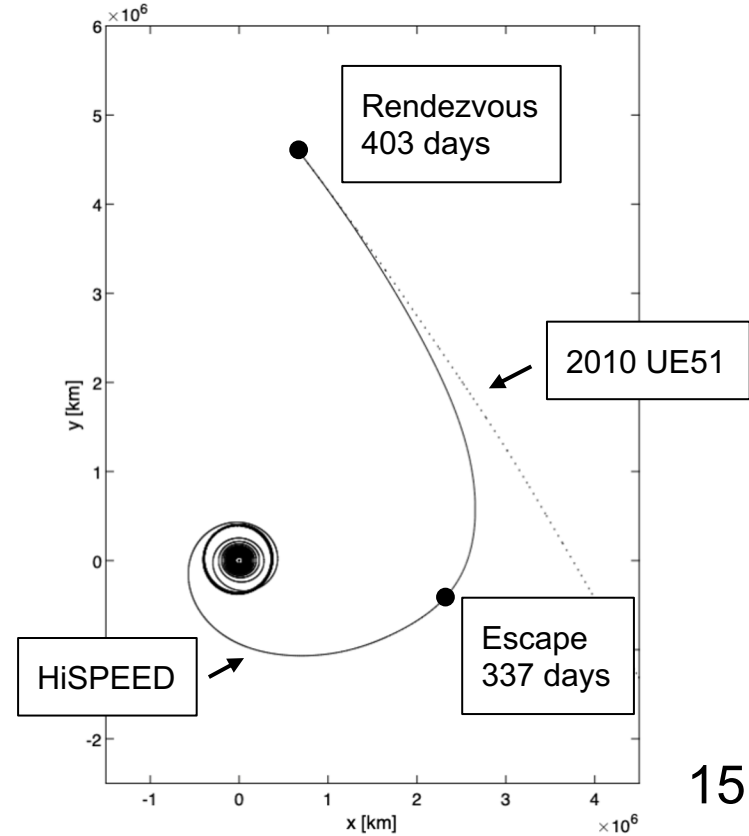
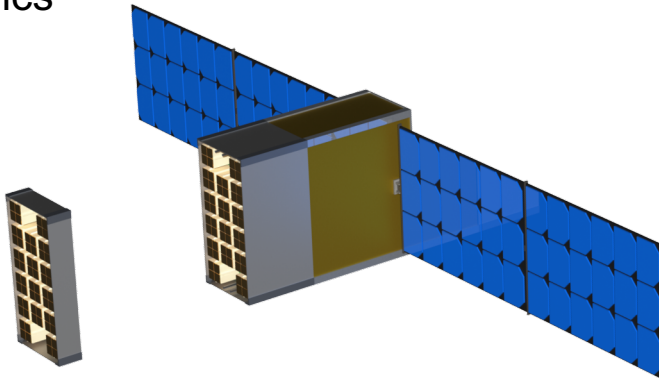


Feasibility Study

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

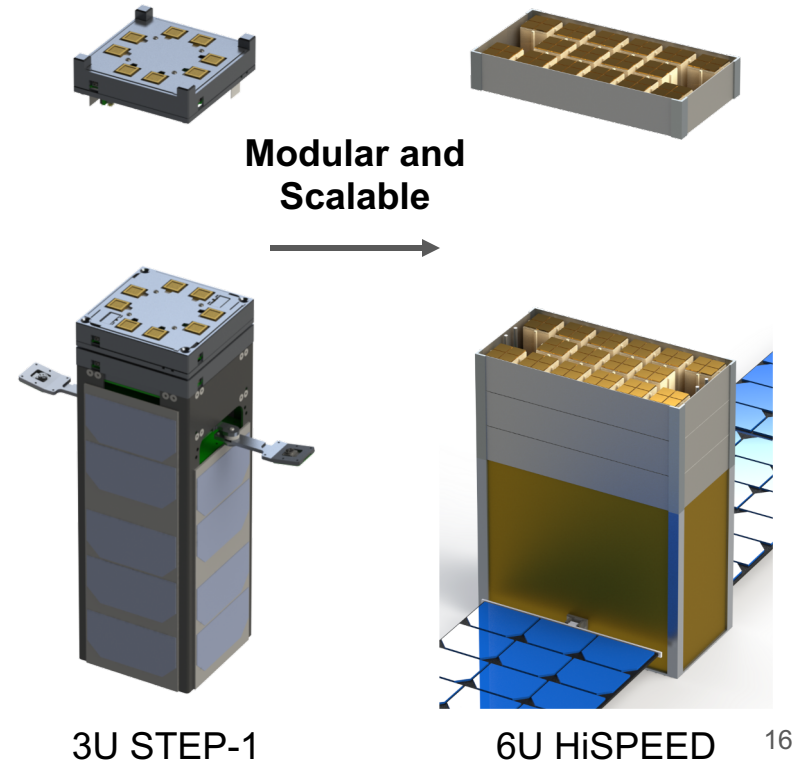
STEP-1 Demonstrates:

- Last major technology step for HiSPEED
- Propulsion scaling and modularity
- Trajectory and attitude control
- Core technology efficiency
- Propellant microvalve operation

STEP-1 Provides:

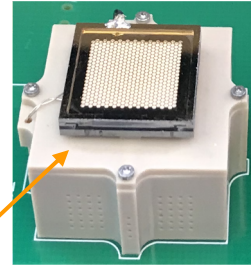
- Thruster flight qualification
- Staging flight qualification
- Student training in design/build/test

STEP-1 was selected for NASA CSLI



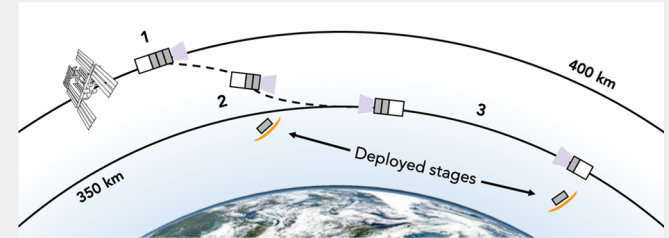
STEP-1 Design and Operations

$\Delta V \sim 10$ m/s per stage in STEP-1 scales to HiSPEED with $\Delta V \sim 1$ km/s per stage and $\sim 60\%$ efficiency

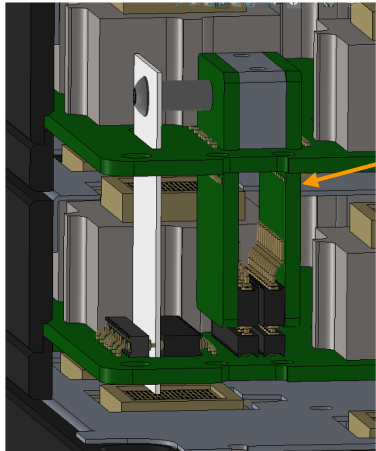


Thruster (~ 1 cm)

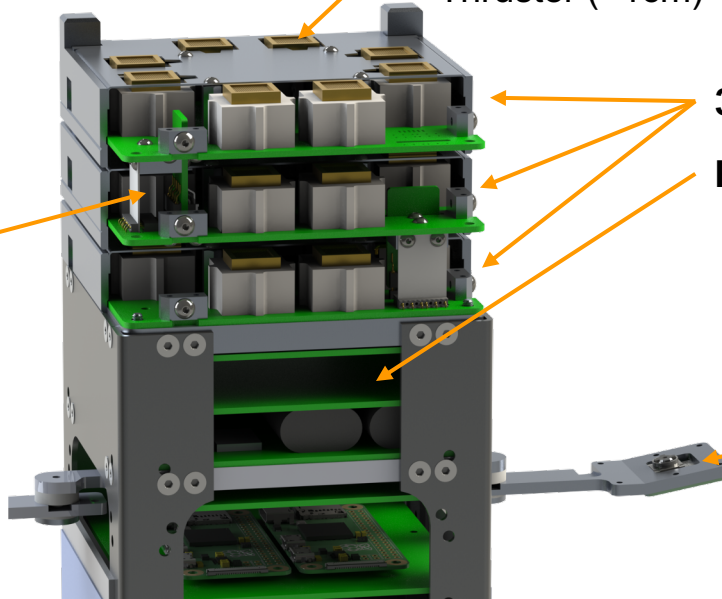
STEP-1 CONOPS from ISS launch



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

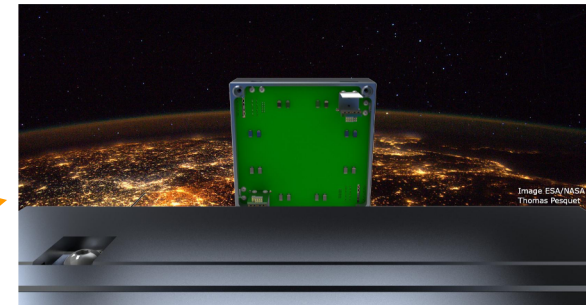


Interstage



3-Stage electro spray propulsion

Flight-heritage PPU



High frame rate recording

STEP-1 Team and Status

Principal Inv.

Prof. Paulo Lozano
MIT AeroAstro - SPL

PhD Students

Gustav Pettersson
Oliver Jia-Richards

Undergrads

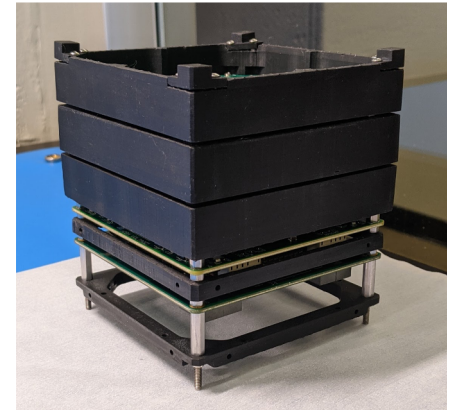
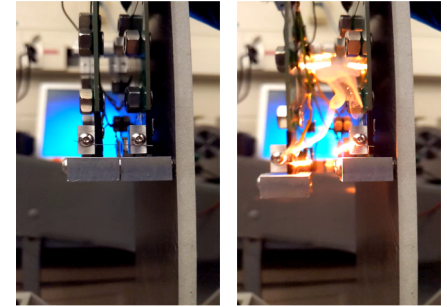
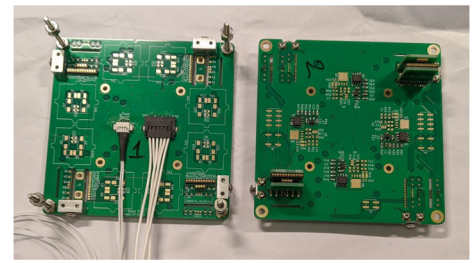
Over 5 involved in early stage, many more soon!

Review Team

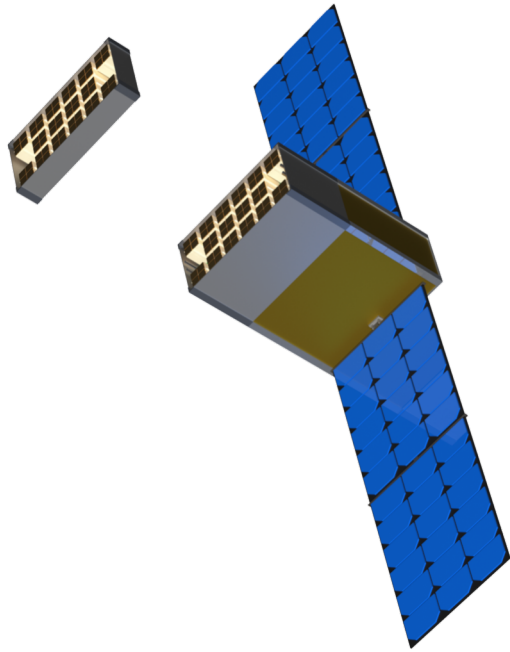
NASA JPL
MIT Lincoln Labs
MIT Haystack
Irvine CubeSat
KTH Stockholm



Dedicated Lab Space



Payload Development 18



Thank You

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