Science Mission Directorate

2018 Technology Demonstration Industry Day

Technology Demonstration MO

Technology Title: Micro Satellite Solar Electric Propulsion

Affiliation: ExoTerra Resource

Assumptions: Technology required to be at TRL 5 by 2021

Technology Description, Current Performance Metrics, and Performance Goals

Micro Hall Effect Thruster
4-33 mN Thrust, 700-1500 s Isp, .65 kg, 7.2 cm OD, 85-450 W, 200 kNs Impulse

CubeSat PPU
95-98.5% Efficiency, <.4 kg, PC104 form factor

135W Deployable Solar Array
130 W/kg, .16 W/cm^3, scales to 500 W.

Current TRL

4-5

TRL By May 2021

7

Industry State of the Art Technology Performance

Hall Effect Thruster
12.8 mN, 1375 s Isp, 1.2 kg, 10.1 cm OD, 200W, ~50 kNs Impulse

PPU
92-94% Efficiency, ~1 kg

Solar Arrays (Microsat Scale)
<100 W, 60-90 W/kg

Technology Development Challenges to Meet TRL Goal

Hall Thruster:
Lifetime Testing, Vibration Testing

CubeSat PPU
Radiation Testing, SEE Testing

Solar Array
Vibration Testing, 0g Deployment

Potential HPD Science Application (Optional)

High delta-V missions with micro satellites

Delivery from LEO or GTO to LaGrange Points or Earth Escape at reduced launch cost or more frequent rideshare opportunities.

Increased power availability for instruments, cryo-coolers, or telecommunications.

Contact Information

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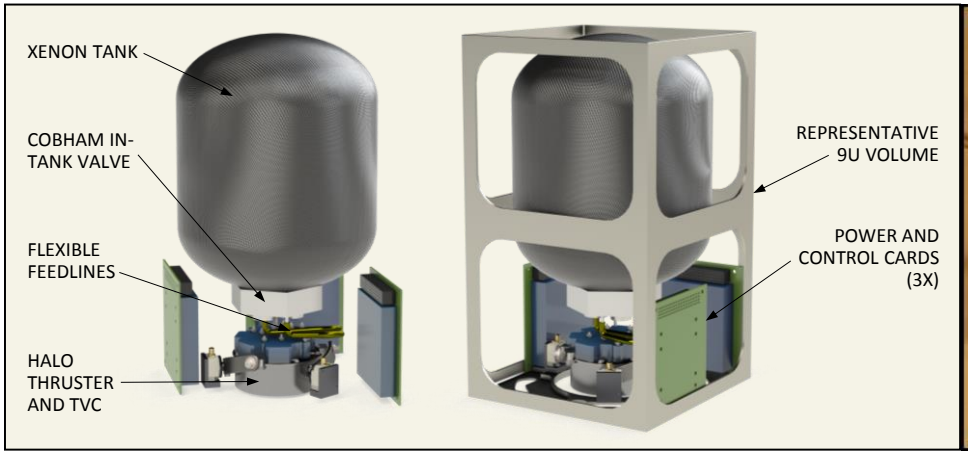
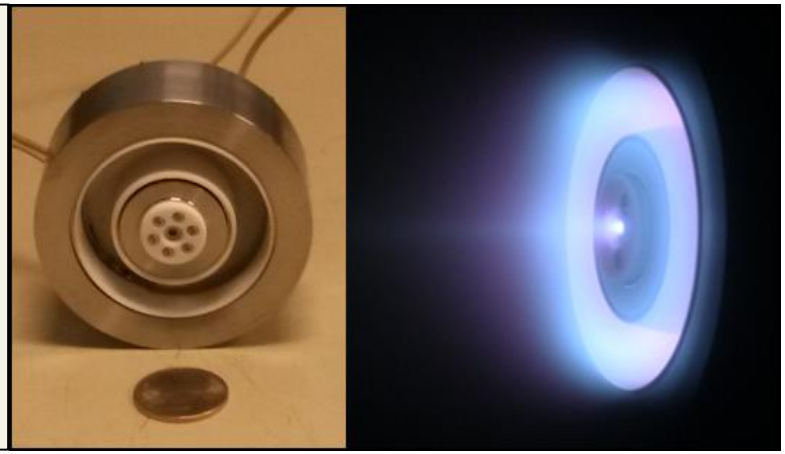
Additional Comments

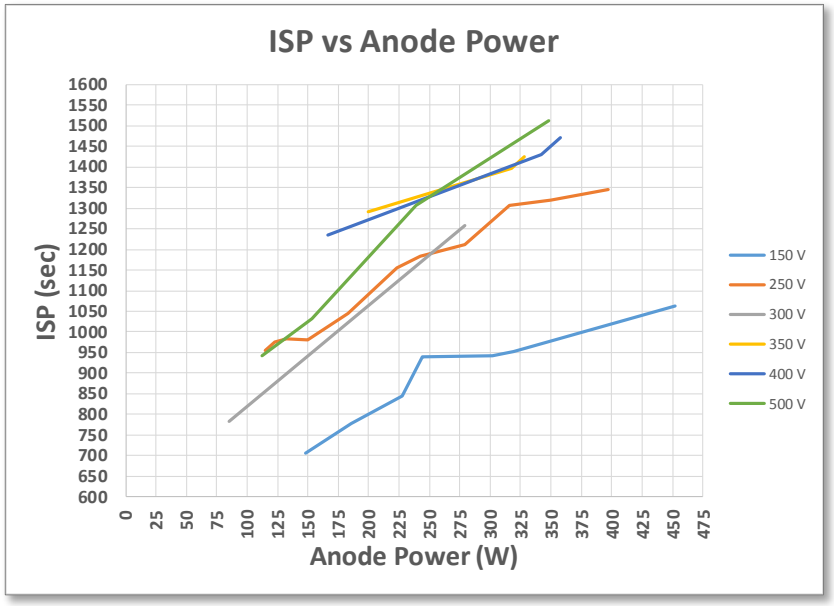
Halo Hall Effect Thruster

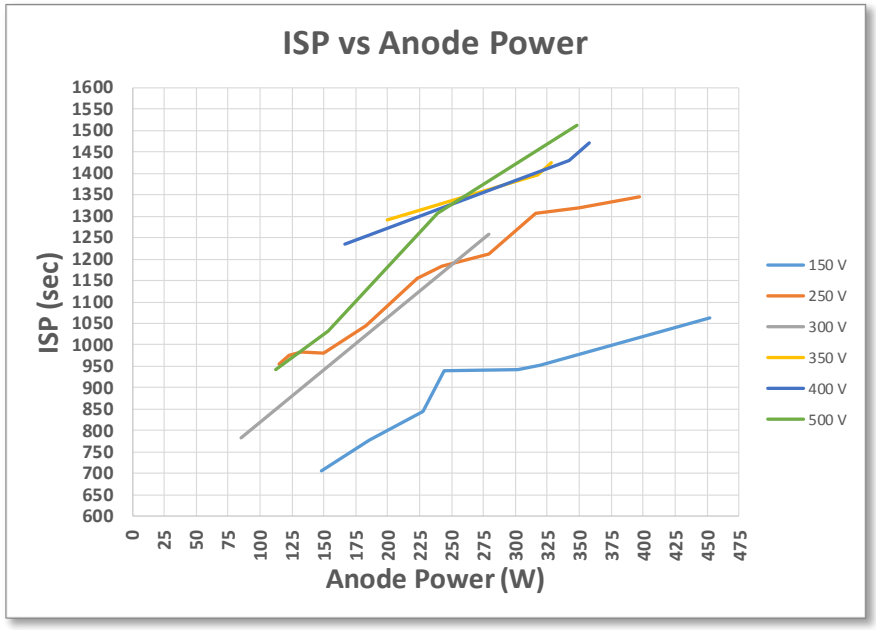
- 72 Hrs of testing to date
- Currently in Life Testing. Test Target: 500 hr. Lifetime target >2000 hr.
- Measured mass <.65 kg
- 7.2 cm OD x 5 cm
- Centerline Cathode
- Recently awarded NASA SBIR to qualify and deliver a flight test unit by Q1 2020





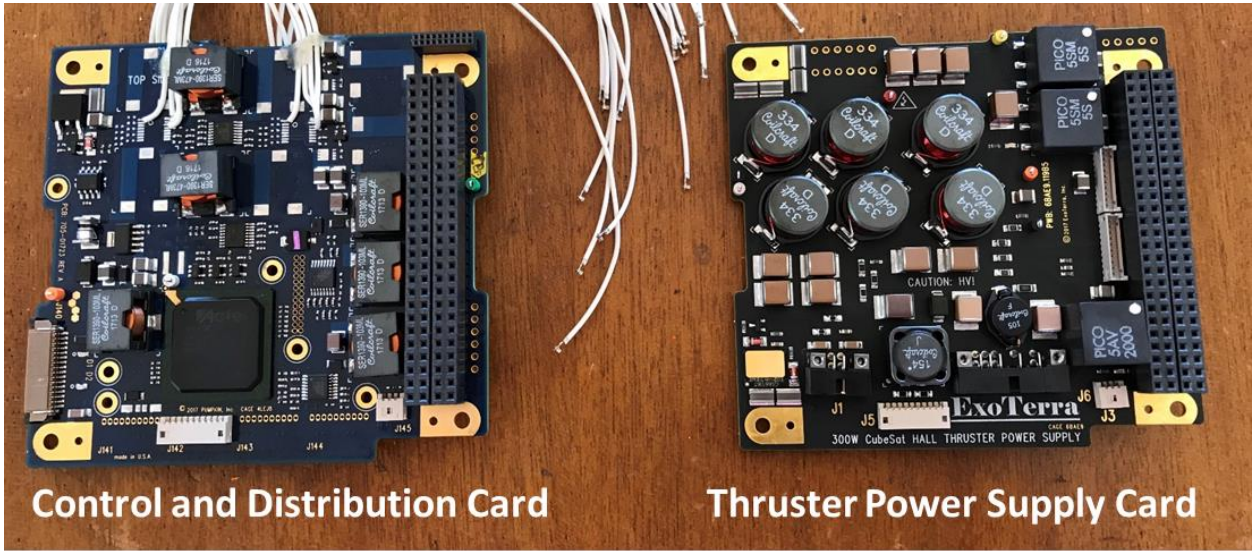
Hall Thruster Performance





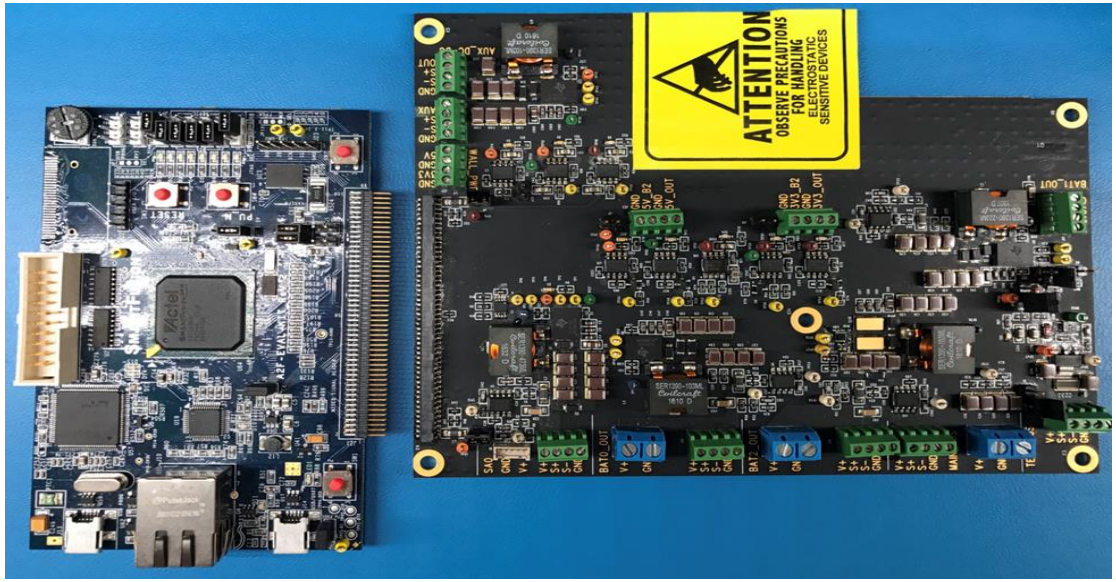
Power Processing Unit

- Measured Efficiency of 96-98.5%
- Completed integrated testing with thruster
- Measured mass below .25 kg/card
- Designed for 100 krad w/ 300 krad upgrade option
- To be qualified as part of NASA SBIR award



Radiation Tolerant CubeSat Power Distribution

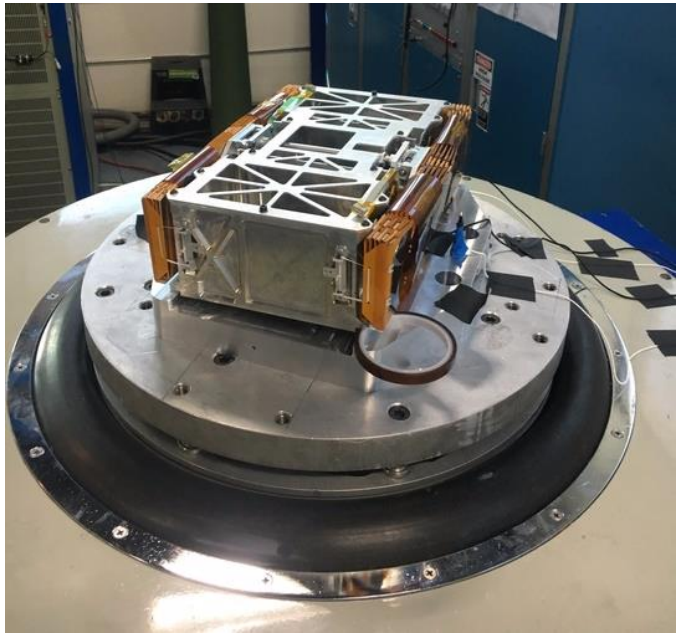
- Developing a radiation tolerant CubeSat EPS board under NASA SBIR
- >100 kRad TID
- Currently at breadboard level development
- 30 software programmable switches
- 96-98% Efficiency
- >300 W throughput



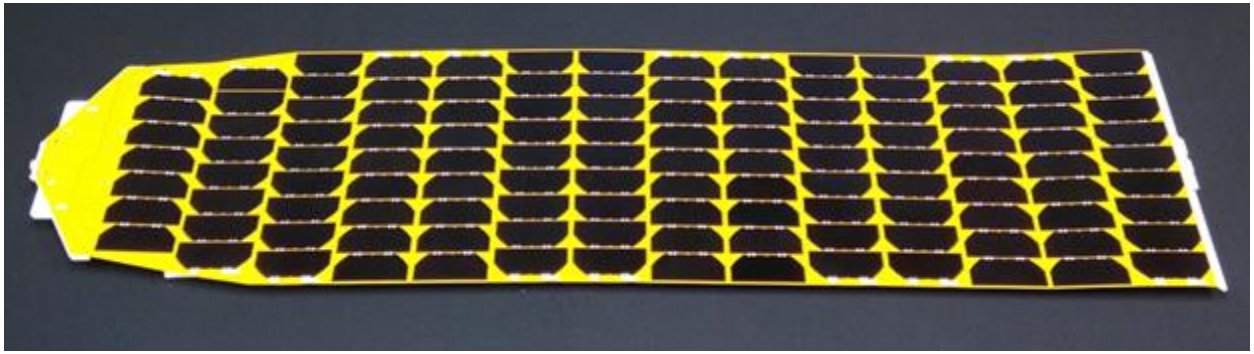
Phase I Rad Tolerant PMAD Breadboard

Deployable Solar Array

- 135 W measured power
- 130 W/kg measured specific power
- Random Vibration, Shock and Thermal Cycle testing conducted under NASA Ph II SBIR.
- .16 W/cm^3 Stowed Power Density



Solar Array Vibration Testing



Solar Array Blanket
Test Article

ExoTerra Team

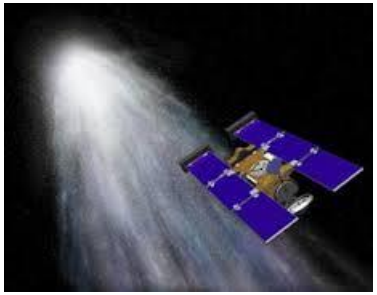
- **Michael VanWoerkom** – Founder, MBA, 20 yrs Experience. System Design, SEP, Mechanical Design. XSS11, Genesis, Orion
- **Greg Hegemann –** Systems Engineer, 20 yrs Experience at Lockheed & Sierra Nevada. Stardust, Orbcomm, Classified
- **Tom James** – Mechanical Lead, 18 yrs Experience on Shuttle, Orion and X-33
- **Carl Gross** – Mechanism Design, 10 yrs Experience on Orion, Dream Chaser
- **Mike Krohn** – Stress Analysis – 30 yrs Experience, Atlas, Orion
- **Jake Hogan** – Thermal Analysis – 4 yrs Experience, Orion
- **Heather Swenson** – Guidance & Nav – 11 yr Experience

XSS-11 MicroSat

Space Shuttle

Orion

Dream Chaser

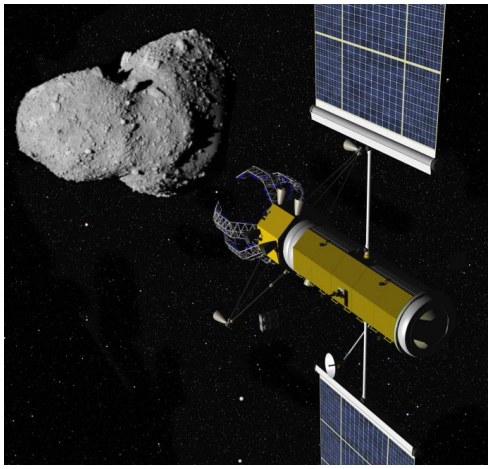


Stardust

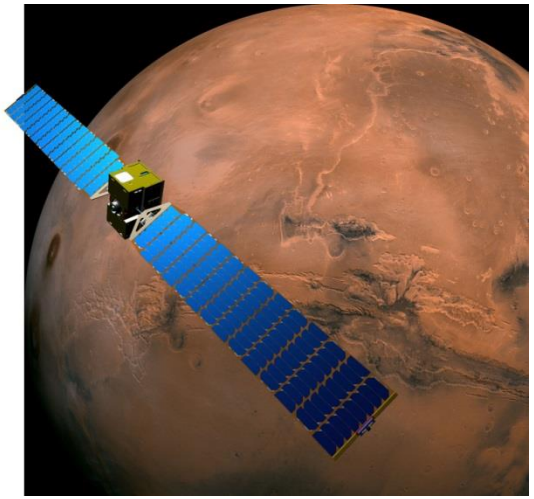
Genesis

ExoTerra History

SBIR History		
Year	Sponsor	Title
2013	NASA	Direct Drive SEP Microsatellite
2014	NASA	EPIC: Electrically Propelled Interplanetary CubeSat
2015	NASA	SEP CubeSat Power Module
2016	NASA	SEP CubeSat Power Module (Ph II)
2017	NASA	Radiation Tolerant CubeSat Power Dist.
2017	Air Force	GEO CubeSat Observer
2018	NASA	Xenon Micro EP Module



Asteroid Redirect Mission Study



Mars Aerosol Tracker