An Accessible CubeSat Hall Effect Thruster for Interplanetary Missions

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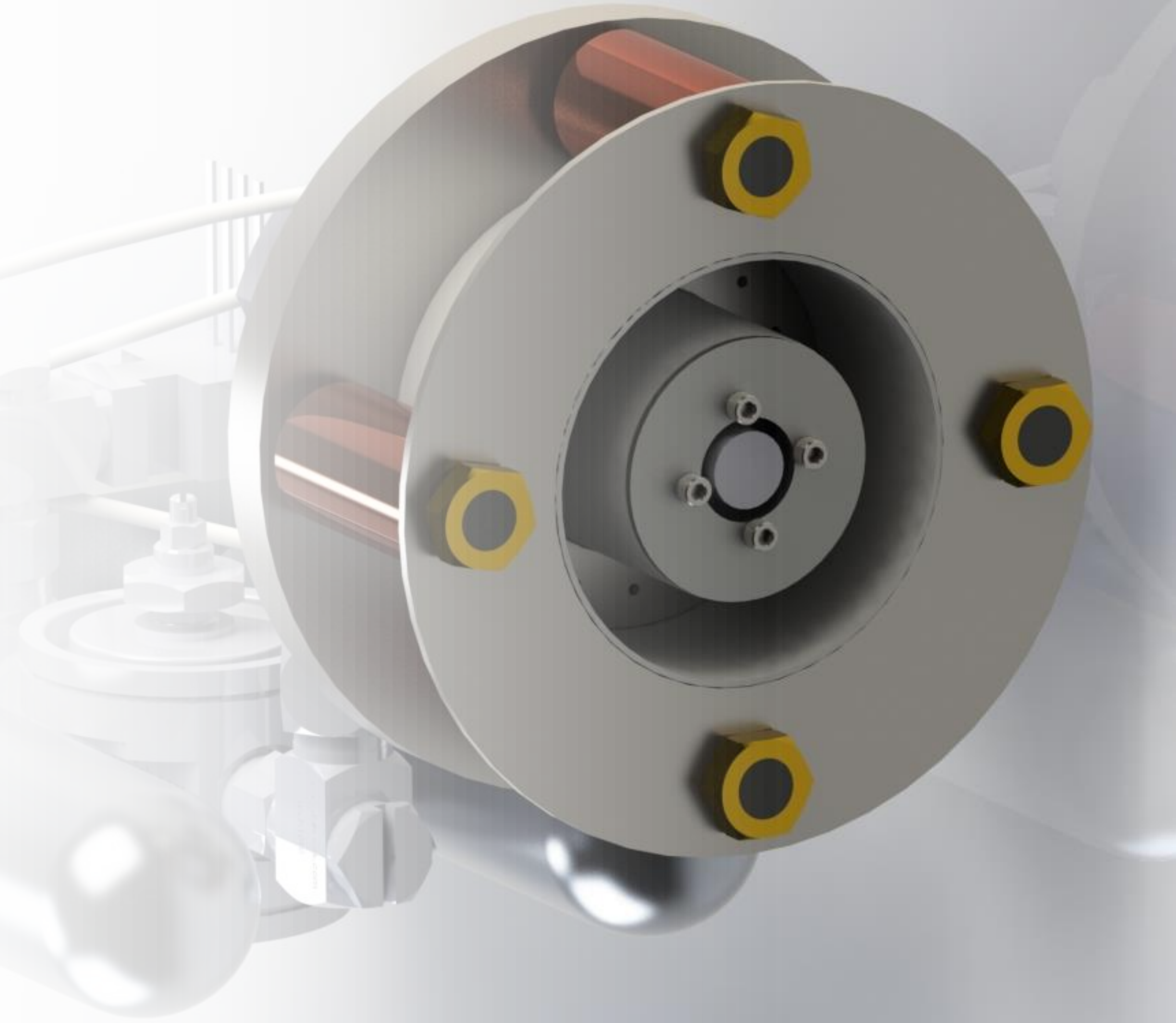
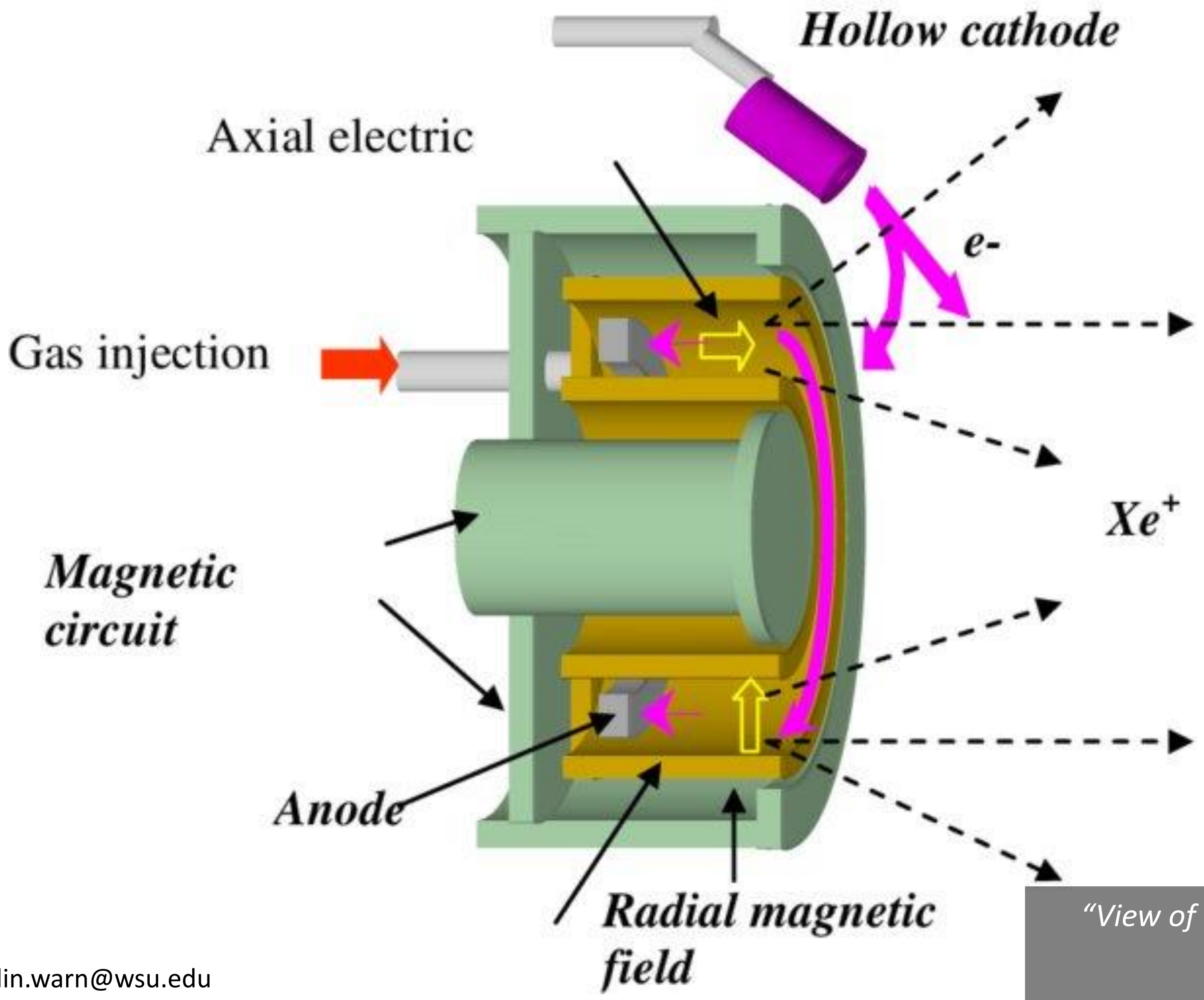
Interplanetary Small Satellite Conference

Online Web Conference



Hall Effect Thrusters



- Sea of circulating electrons ionizes inert gas.
- Historically used for orbital insertion, station-keeping and de-orbiting.
- Has seen use in interplanetary missions. European Space Agency's "Smart-1."
- Problem: Flight-ready versions are historically very expensive to procure.

"View of a Hall Effect Thruster," M Dudeck, Plasma propulsion for geostationary satellites for telecommunication and interplanetary missions

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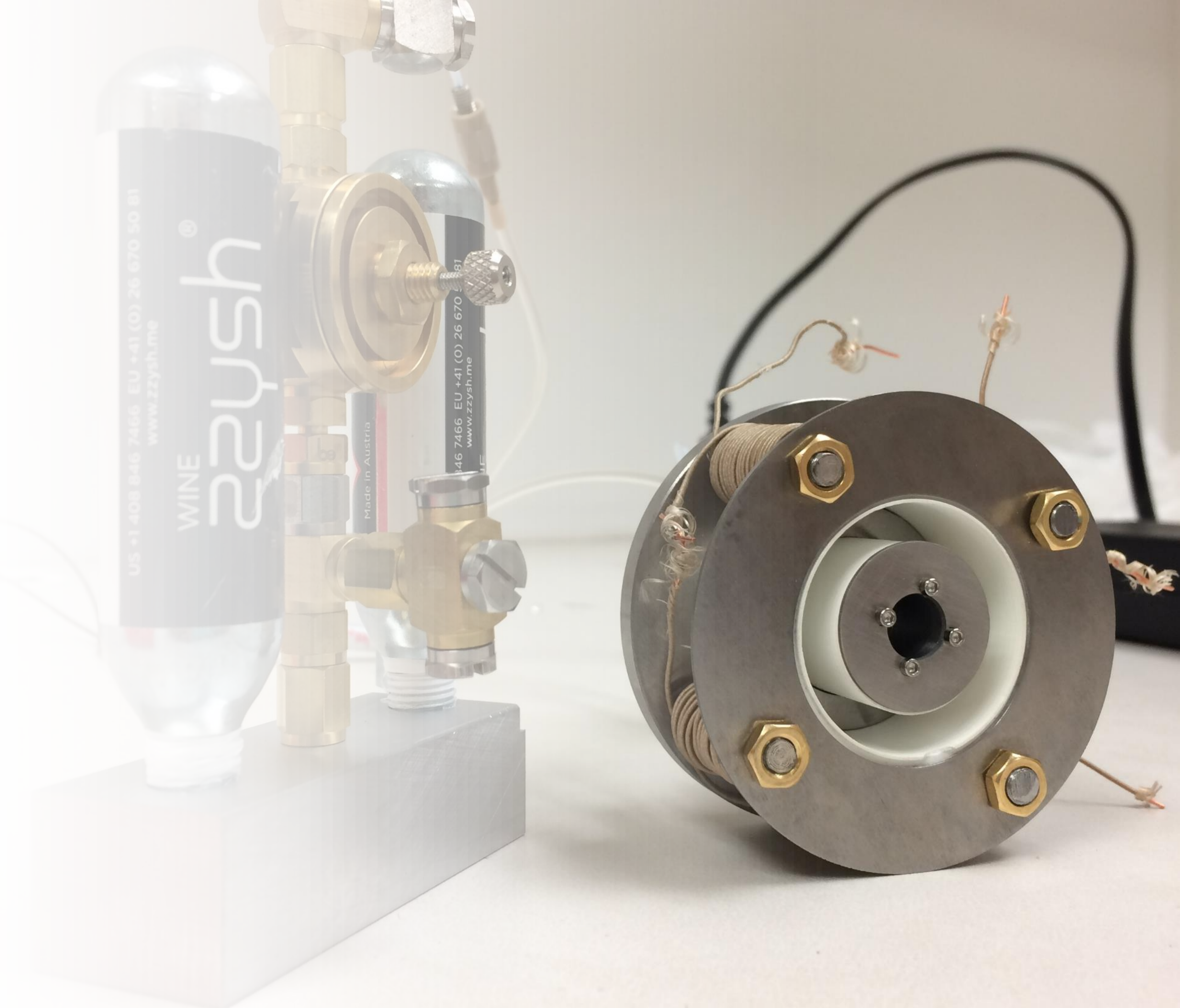
Accessible CubeSat Hall Effect Thruster CougDrive-I

- Based on previous work done by Cal Poly and Western Michigan University.
- $10,000 to build goal.
- Release design and build guide.
- Aiming for flight-ready.



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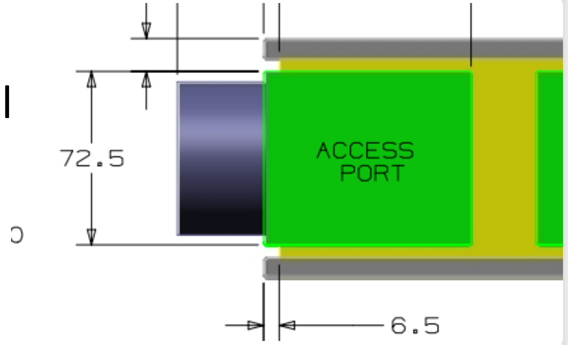
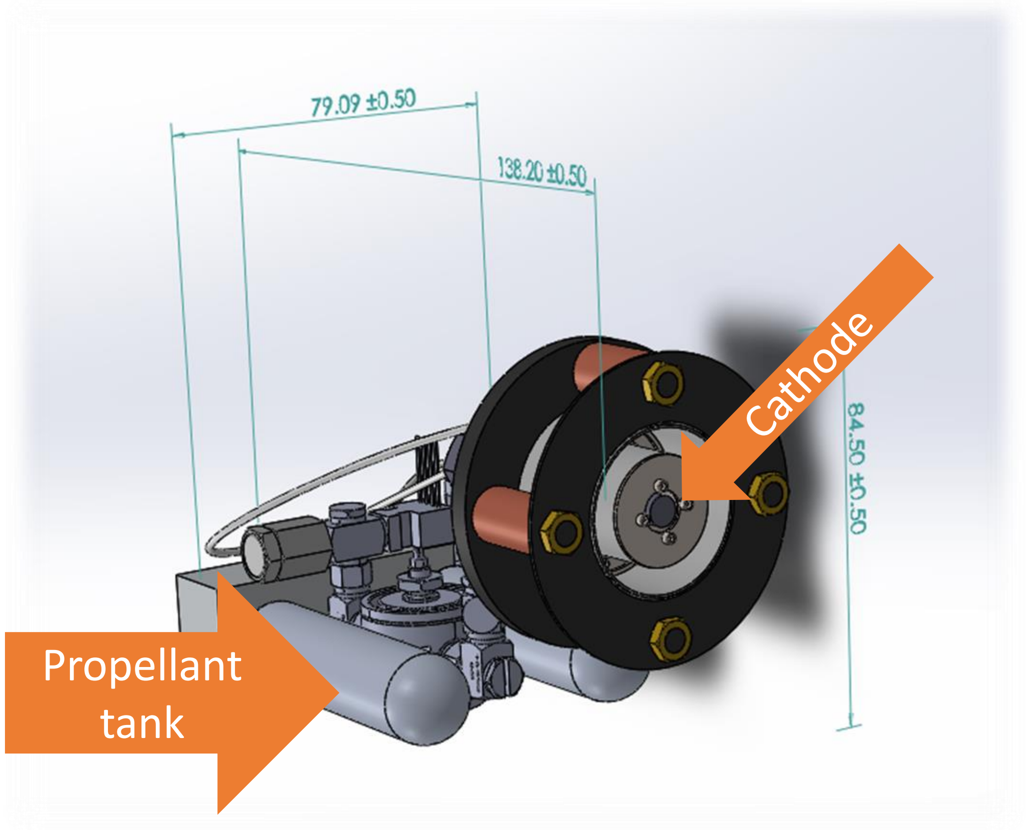
CougDrive-I Design Parameters

- 80mm wide, 138mm long, 85mm tall
- Optimized for 3U+ configuration





Nominal Power	100-200 W
Target Thrust	6-8 mN
Target Specific Impulse	1000-1400s
Target Discharge Voltage	200-300 V
Mass Flow Rate	0.6-0.7 mg/s
Propellant	Xenon, Argon
Dry Mass	350 g
Cathode	HeatWave Hollow Cathode

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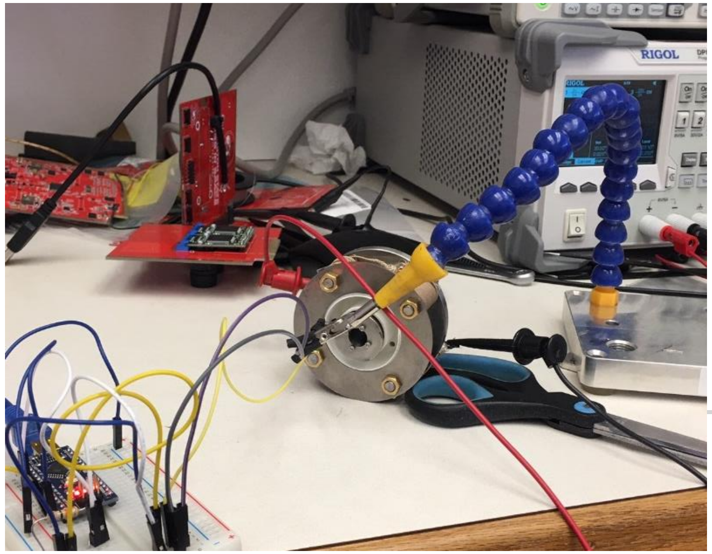
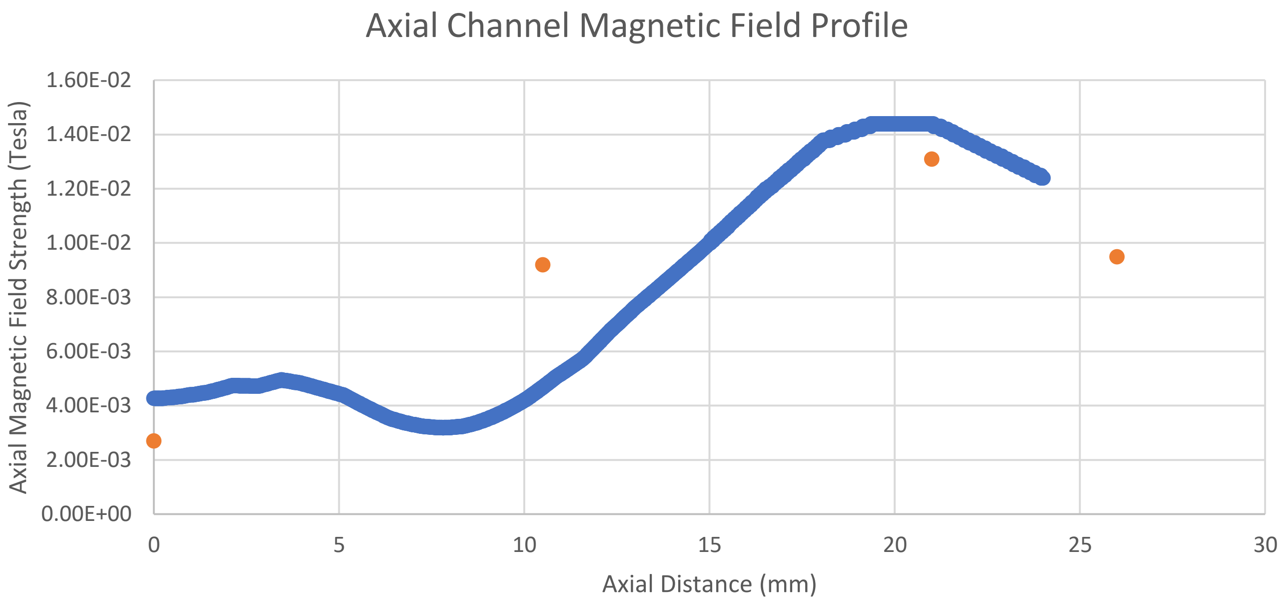
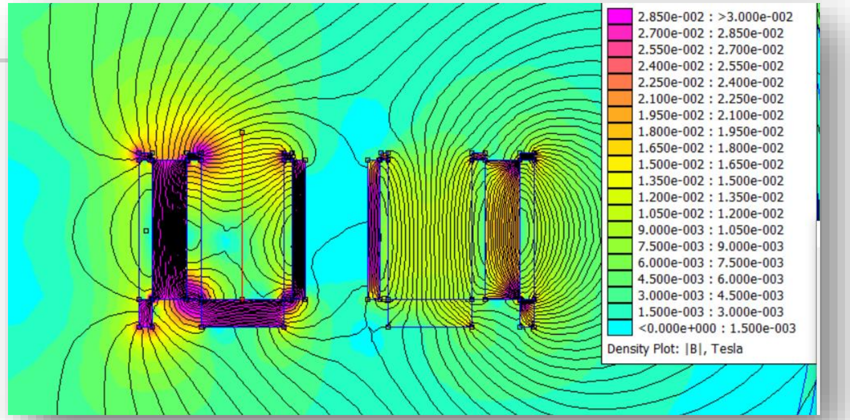
Magnetic Field Testing







Experimental Measurements
FEMM Theoretical Values

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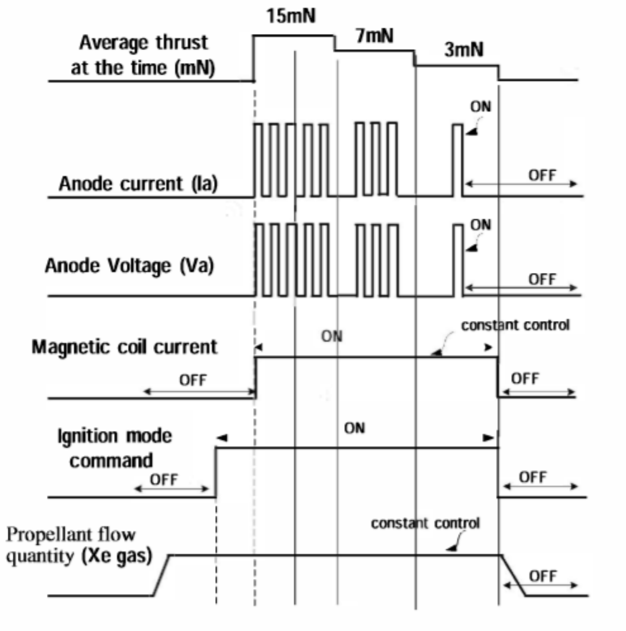
Power Processing Unit

- Work is underway, but help needed.
- Preliminary work based on Mitsubishi Electric Corporation work.[1]



Current System Requirements

Unit	Voltage (V)	Current (A)	Power (W)	Tolerance
Anode	200-300	0.5	100-200	C.V ± 5%
4x Inductor Cores	1	2	2	C.C ± 3%
1x Central Core	1	2	2	C.C ± 3%
Keeper	48-50	1.5	72-75	C.C ± 5% C.V ± 5%
Heater	1.5-1.6	14-16	21-25.6	C.C ± 3%
1x Solenoid	1.6-12	.025-0.160	0.250	C.V + 5%
		Total	197-300	

1- Hiroyuki Osuga and Fujio Kurokawa, “Power Processing Unit for the Next Generation Satellite”

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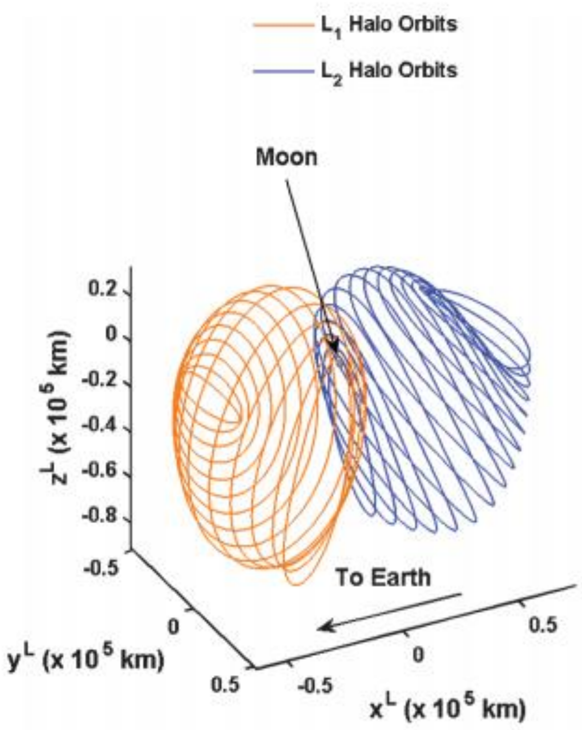
Potential 3U Lunar Relay Communication Application



Starting in Earth Parking Orbit (20,000 km).

Maneuver to halo orbit for Lunar south pole communications relay.[2]

Orbit	m_f/m_0	Coast time, days	Total time, days	ΔV, km/s
12-day L_1 halo 1	0.944	14.72	182.8	3.020
12-day L_1 halo 1[a]	0.940	17.95	191.2	3.111
12-day L_1 halo 1[b]	0.881	13.44	84.02	3.261
12-day L_1 halo 2	0.927	24.29	155.5	3.151
14-day L_1 vertical	0.935	31.21	169.2	3.121
16-day L_2 vertical[a]	0.935	43.92	176.5	3.158
14-day L_2 butterfly	0.937	50.24	189.7	3.178

[a]Lunar flyby
[b]Realistic I_{sp}

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2 - Howell and Ozimek, “Low-Thrust Transfers in the Earth–Moon System, Including Applications to Libration Point Orbits”

3U Communication Hardware Cost Assessment

- Assumes Isp ranges from 1000-1400s
- Target dV ≈ 3.3 km/s
- Estimated hardware cost: $109-400k

Component:	Mass (g):	Cost ($):
3U Structure	1100	3,000
CougDrive-I	300	10k-50k
Xenon	900-1200	2,000
Batteries	300-400	50
Power Processing Unit	100	1,000
Gemini Space Panel Double Deployable Solar Panels for 3U	420	(30,000?)
NanoAvionics Reaction Wheels	155	(30,000?)
Endurosat X-Band Communications	350	30,000
EnduroSat Computer	75	3,000
Payload	0-300	N/A
Rocket Launch Cost	-	60k-240k
Total	**4 kg**	**$109k-400k**

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To-Do

- Lab test for first plasma.
- Develop flight-ready power processing unit.
- Flight-ready configuration lab tests.
- Demonstration mission.
- Look for grants and collaboration opportunities.

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Thank You

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