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SPACE PROPULSION

CubeSat Propulsion using Electrospray Thrusters

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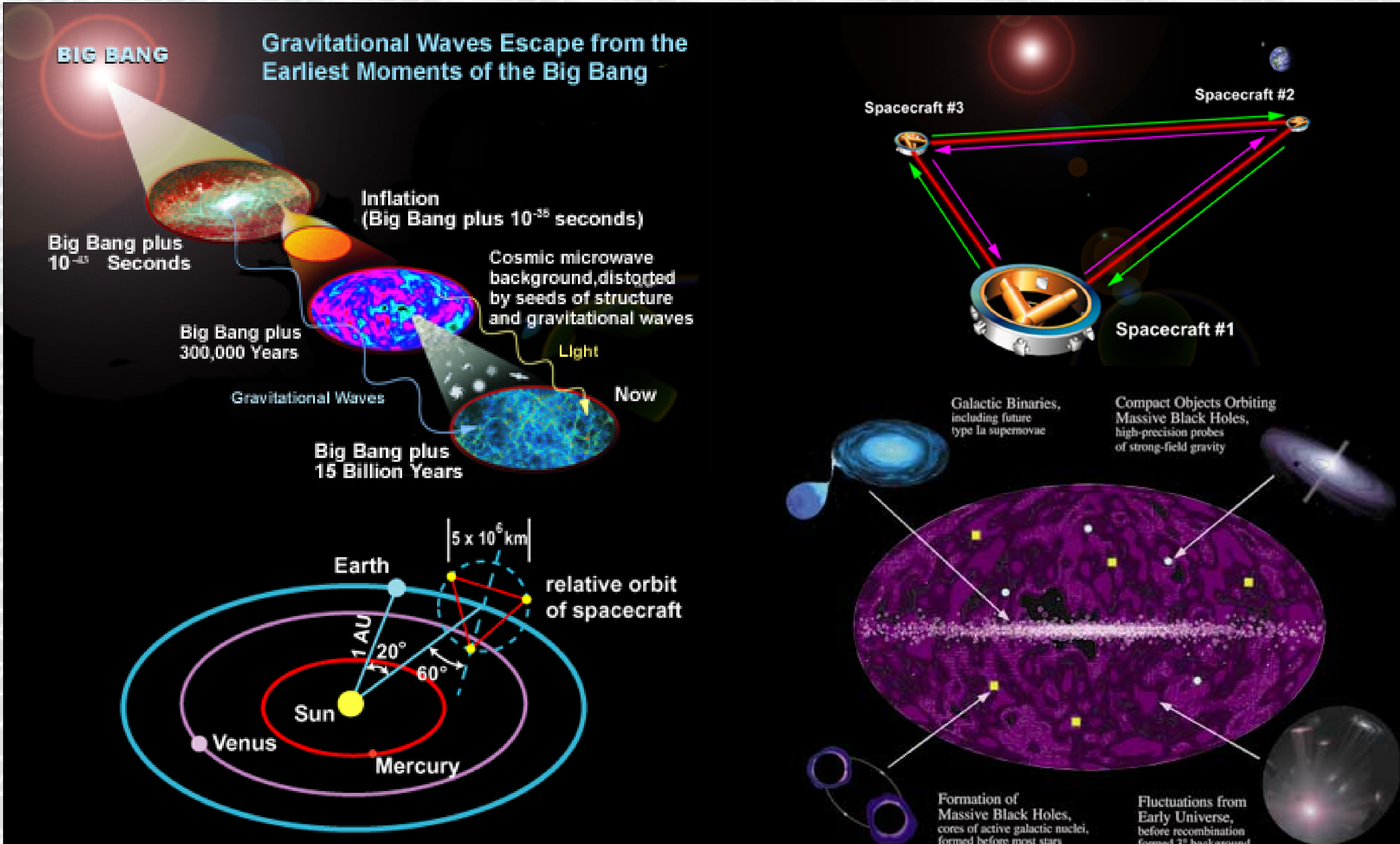
Paper SSC09-II-6

LISA Mission

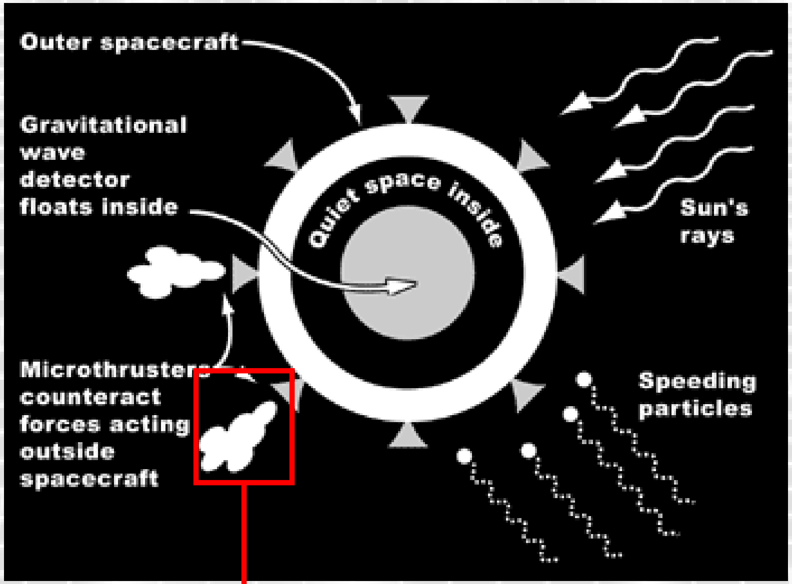


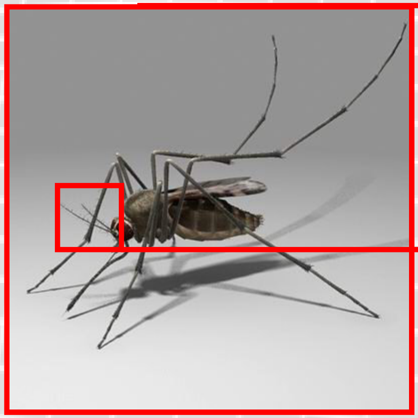
NASA Beyond Einstein Program

Technology Demonstration: ST7-DRS Mission

A demonstration mission for in-space verification of sensor and propulsion technologies required for LISA.

Select ST7 Microthruster Requirements	
Thrust Range	5µN—30µN
Thrust Resolution	0.1µN
Thrust Noise	0.1µN/√Hz (1mHz to 30mHz)
Throttle Time	< 100 sec

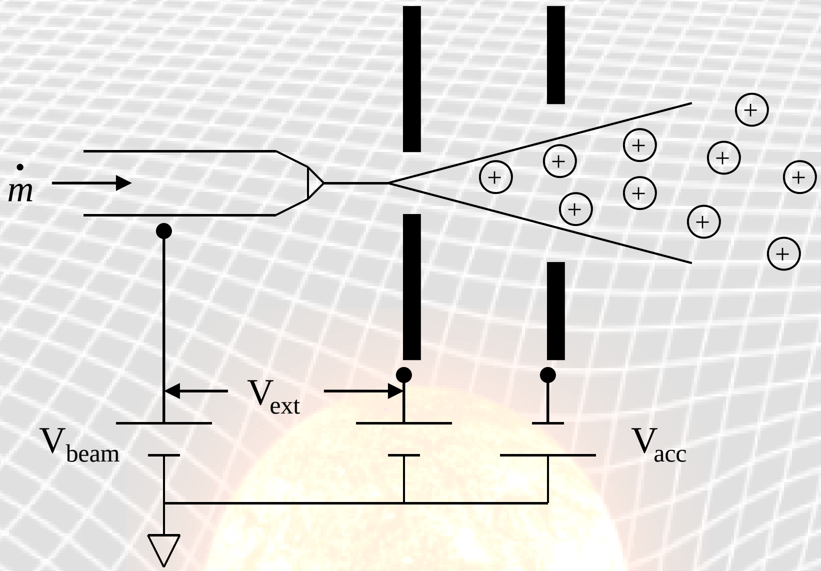




20µN Av Thrust (1 mosquito)

0.1µN Resolution (1 antenna)

Background: Electrospray Thrusters

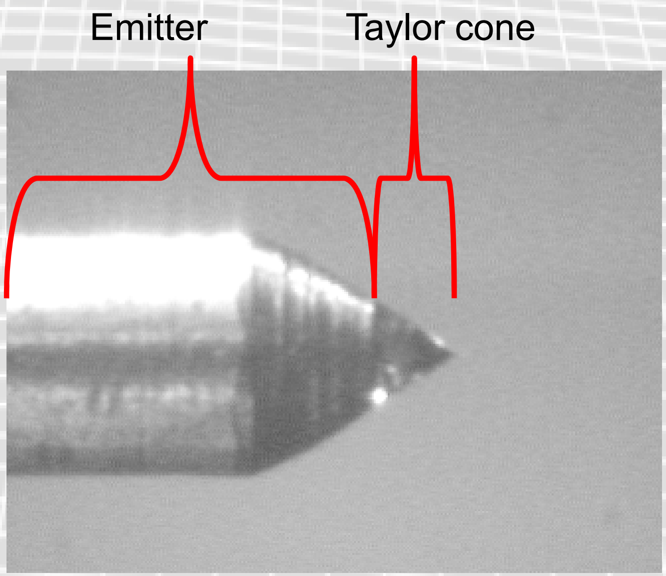


$$T = C_n I^{3/2} V^{1/2}$$

•The electric field between the capillary and opposing electrode (extraction grid) opposes surface tension forming a Taylor cone.

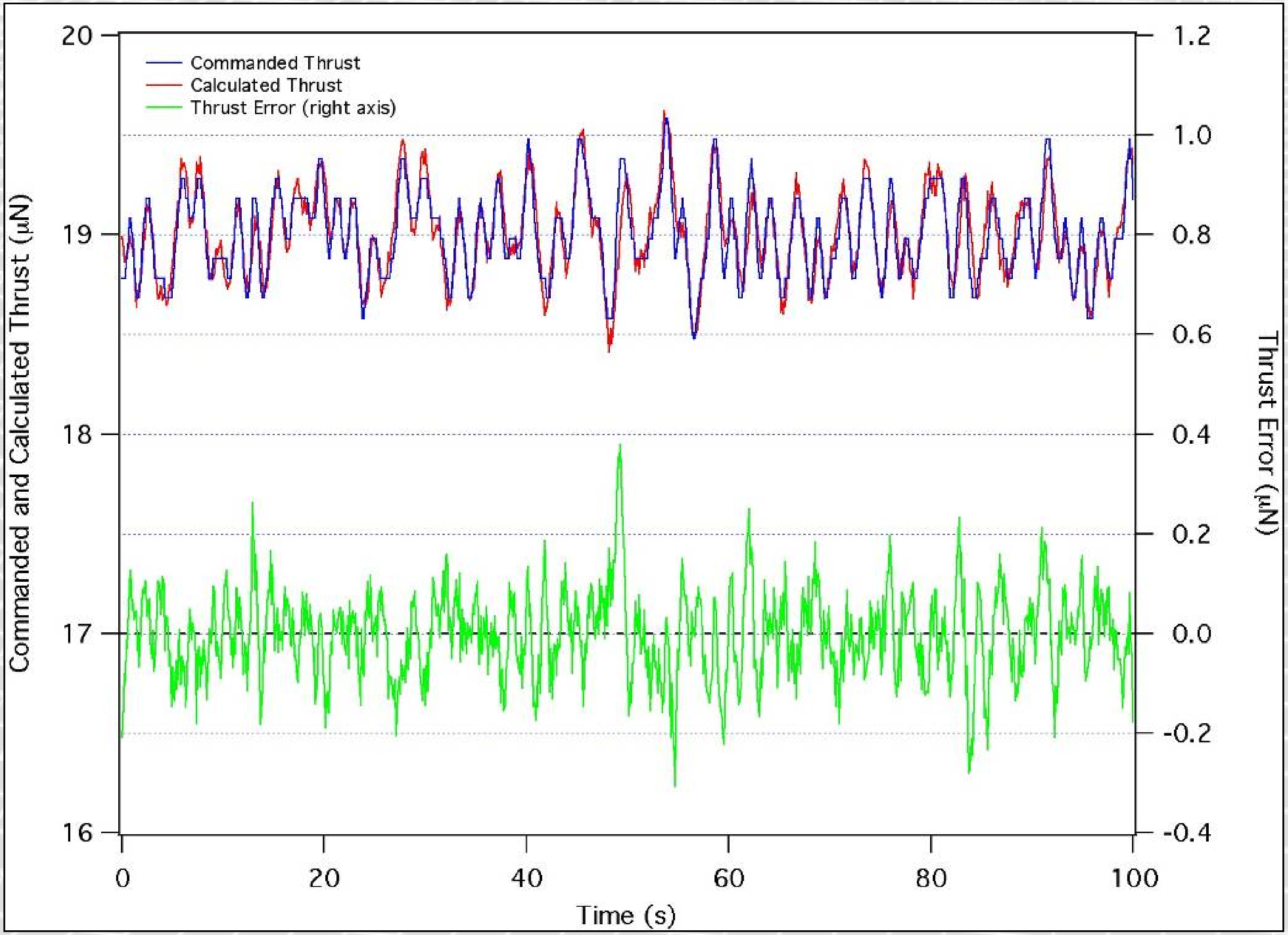
•At the apex of the cone the surface tension is overcome by the electrostatic forces and a thin jet is drawn from the cone.

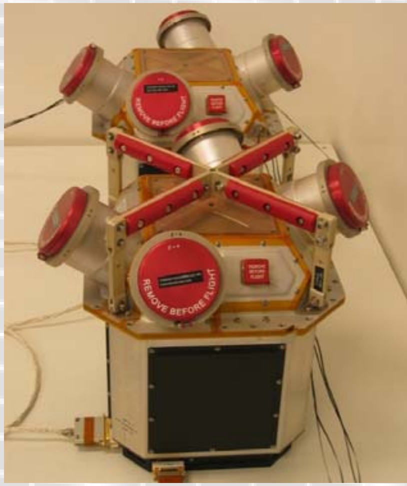
•At some point downstream instabilities cause the jet to break up into a plume of monodisperse droplets.



Electrospray of conductive ionic liquid in vacuum.

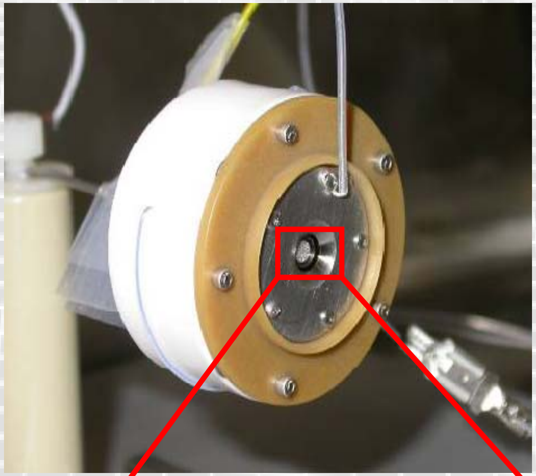
ST7-DRS Functional Testing

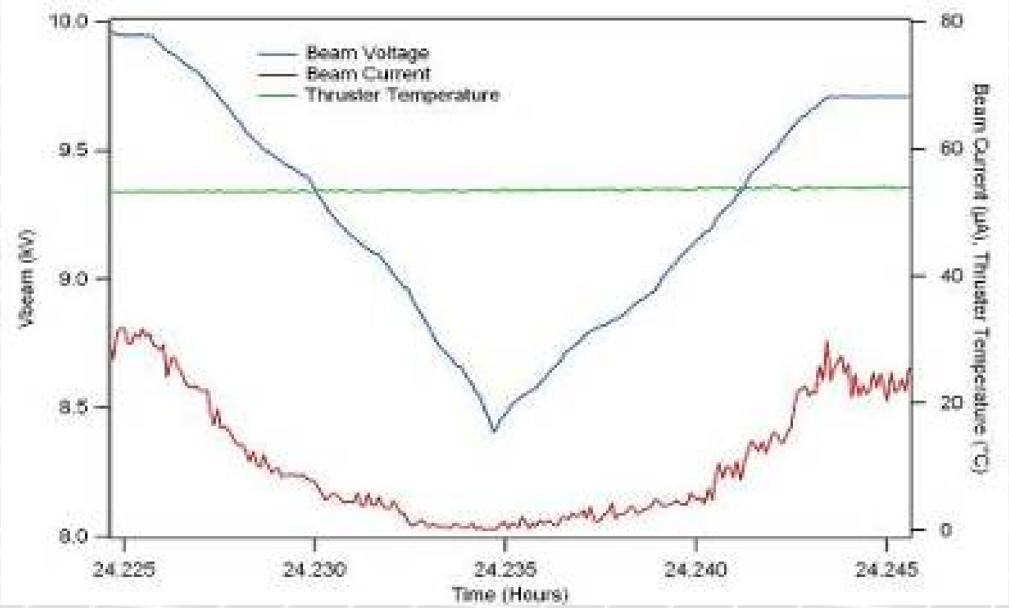


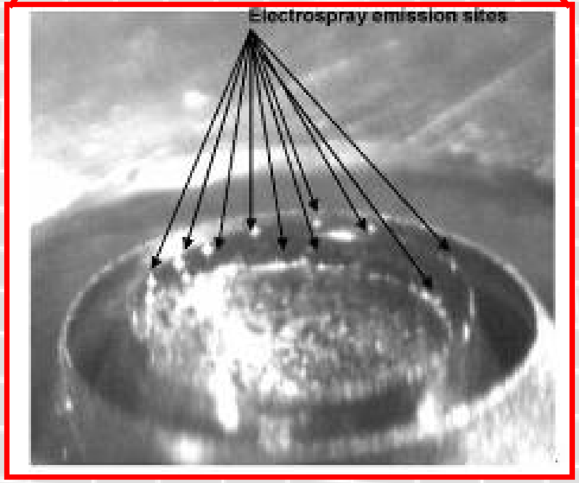


ST7 Thrusters → CubeSats

- Two dimensional emitter, with self distributing emission points.
- No moving parts (e.g. valve) (mass, volume, power and cost savings)
- High thrust density (100x more current than ST7 capillary)
- Benefits from extensive ST7 characterization
- Multiple start / stop capability







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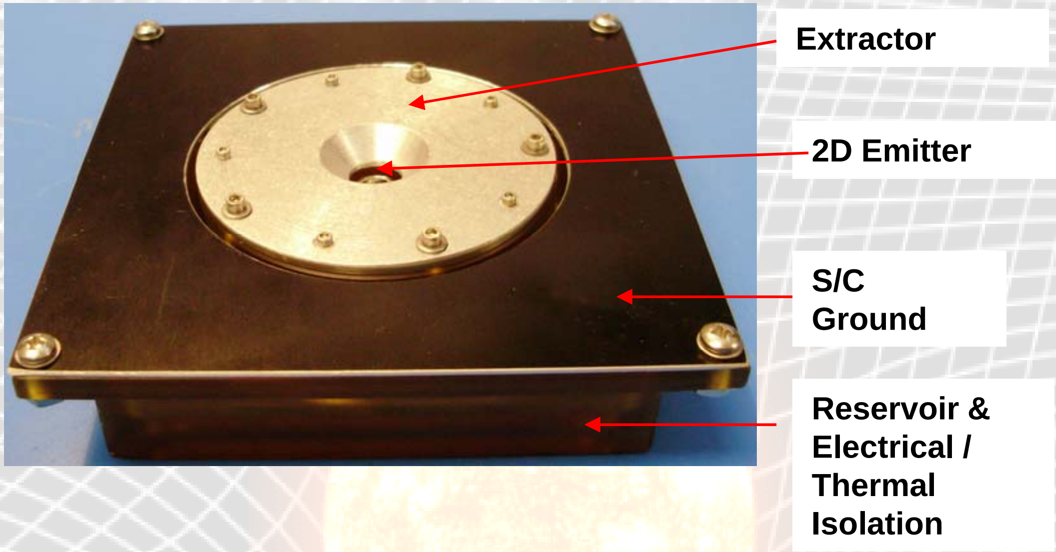
Thruster Prototype



Developer: Busek	CubeSat Electrospray Thruster
System Size	< 0.5U
System Wet Mass (Thruster + PPU)	0.5kg
Total Propellant Mass	.06kg (40mL)
Total Typical Power	2W
Isp	800s
Thrust	0.1mN
Propellant	ionic liquid
Total Impulse	480 N-s
Delta-V (initial mass 1kg)	495m/s
Thrust-Power	0.05mN/W
Thrust Efficiency	~80%
TRL	5

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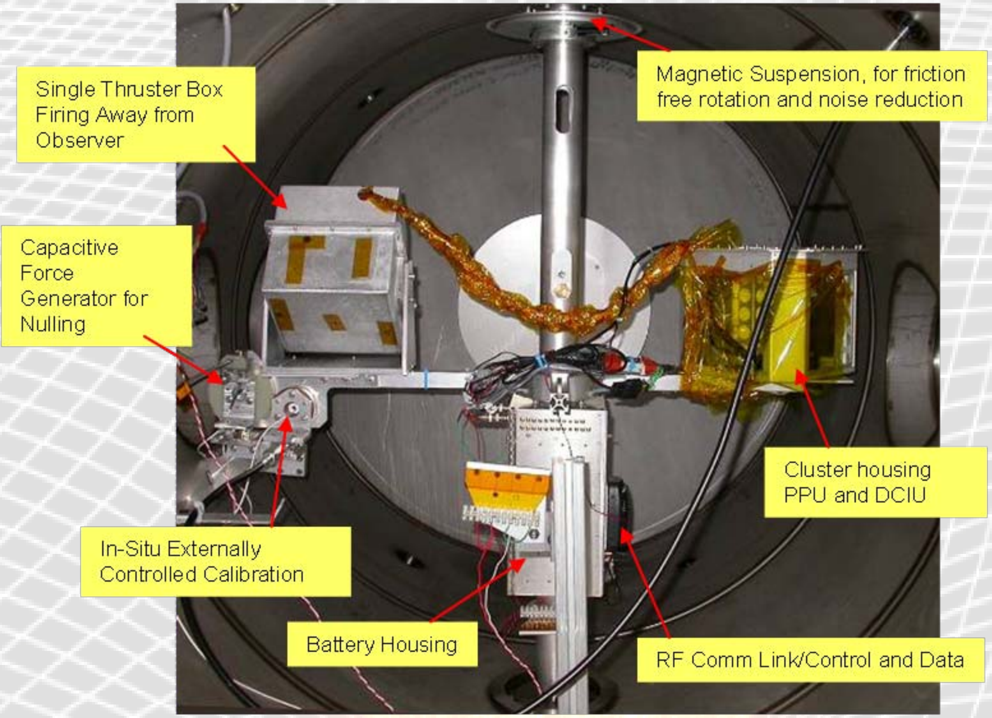
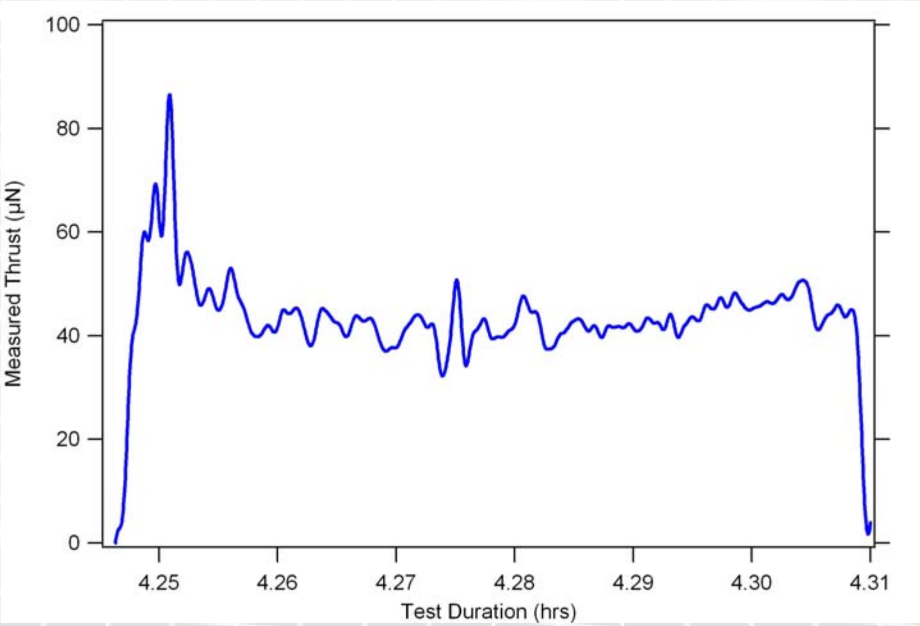
Direct Thrust Validation





CubeSat Mission Expansion

1. FORMATION FLYING

•Cost savings – deliver CubeSats to one location, allowing payloads to self-distribute

•Mission modification (fill in coverage gaps in event of single Sat failure)

2. PLANE CHANGE

•800km circular orbit

•2.7° plane change in just under 1 yr

•Assumes operation 15% of orbit, 100μN thrust / 800s specific impulse, 1U/1kg s/c

3. ORBIT MAINTENANCE

•Can maintain a 1U / 1kg cubesat at 300km for 300 days

•Assumes operation during 50% of the orbit, 10cm x 10cm exposed surface area for drag

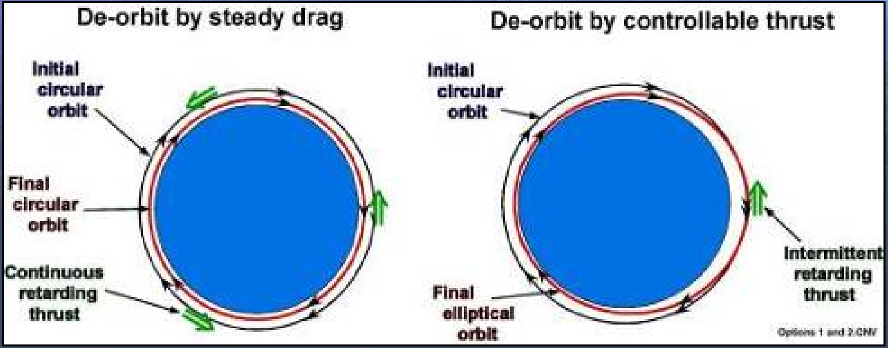
•For example, earth observation mission (300km instead of 800km improves resolution for the same imager)

4. DEORBIT

•800km circ →200km elliptical deorbit

•1kg CubeSat w/ 100uN thruster (x1)

•Requires 34% of std 40mL propellant reservoir



Background image from:
http://www.universetoday.com

Closing Remarks

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•Colloid Thruster technology has been flight-qualified, delivered, and scheduled for launch in 2010 on NASA ST7 mission.

•Planned 90,000 hr. LISA mission system engineering in-process

•Simplified variation has been developed for CubeSats:

- Mechanical simplicity: no moving parts
- Zero pressure propellant storage
- Small volume, mass, power
- Mission-specific tailored performance
- High delta-V unit improves CubeSat versatility and relevance

Come see the prototype of the CubeSat electrospray thruster at the Busek booth

Acknowledgements

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