

# **ChEMS™ Micro-Propulsion System**

## **A Micro-Propulsion System for CubeSats**



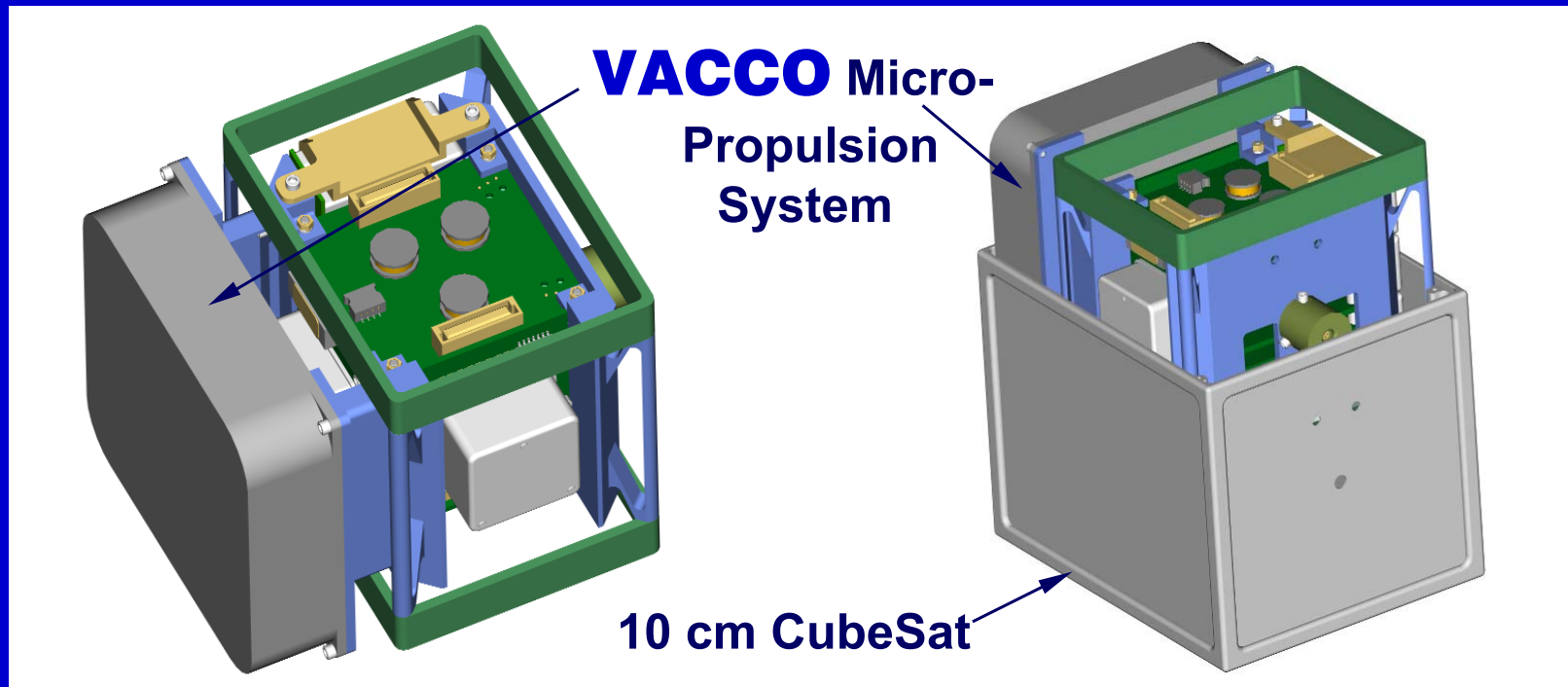
**CubeSat Workshop, April 27, 2006**

*ChEMS™ is a Trademark of VACCO Industries, Patent #6,334,301.*

**VACCO**



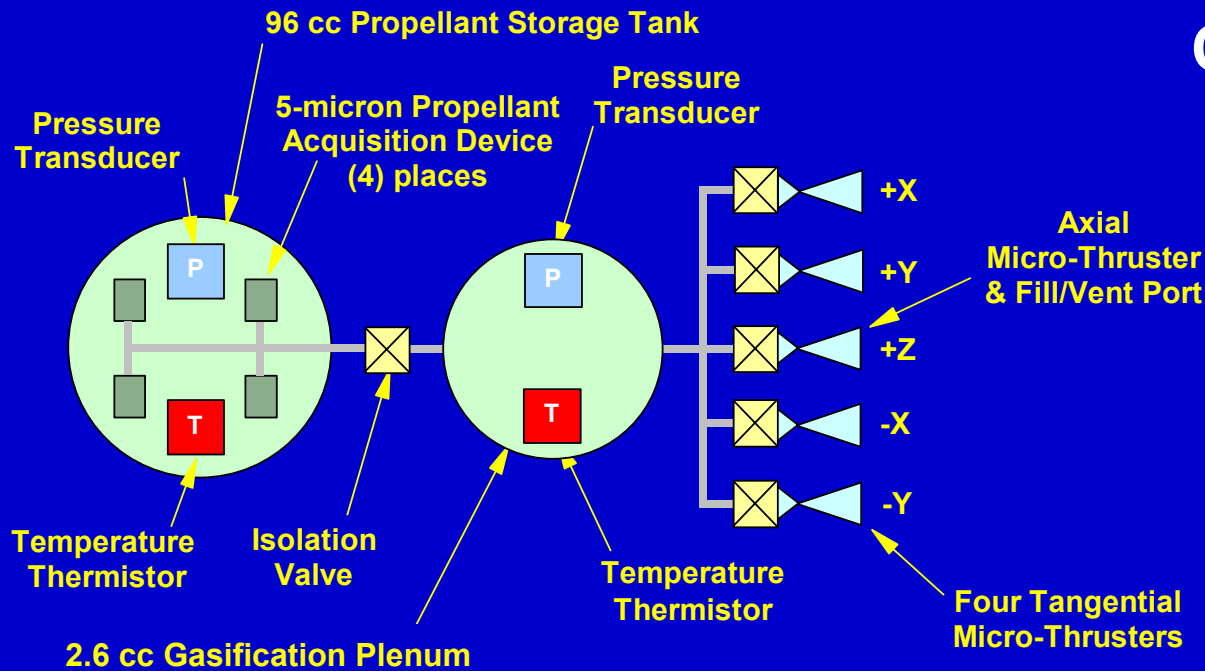
# MEPSI with MiPS



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**VACCO**

# MiPS Schematic

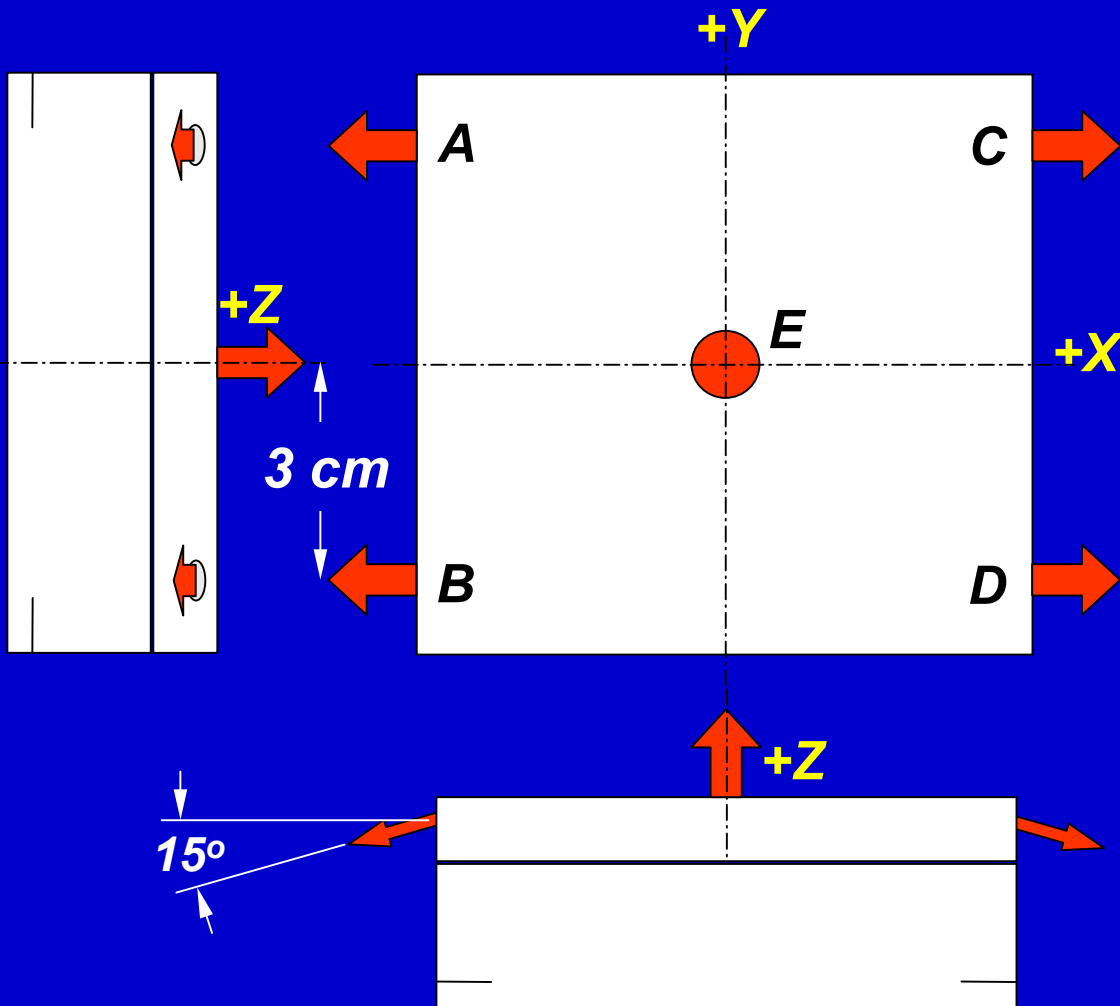


## Complete System:

- (1) Storage Tank
- (2) Pressure Transducers
- (2) Temperature Sensors
- (4) 5 Micron Filters
- (1) Isolation Valve
- (1) Gasification Plenum
- (5) Micro-Thrusters
- (16) Components Total*



# MiPS Thrust Vectoring



Manuver	Thruster(s)
+Yaw (+X)	AB
-Yaw (-X)	CD
+Pitch (+Y)	Roll 90° CW then CD
-Pitch (-Y)	Roll 90° CW then AB
CW Roll	AD
CCW Roll	CB
Delta V (+Z)	ABCD
Delta V (-Z)	E



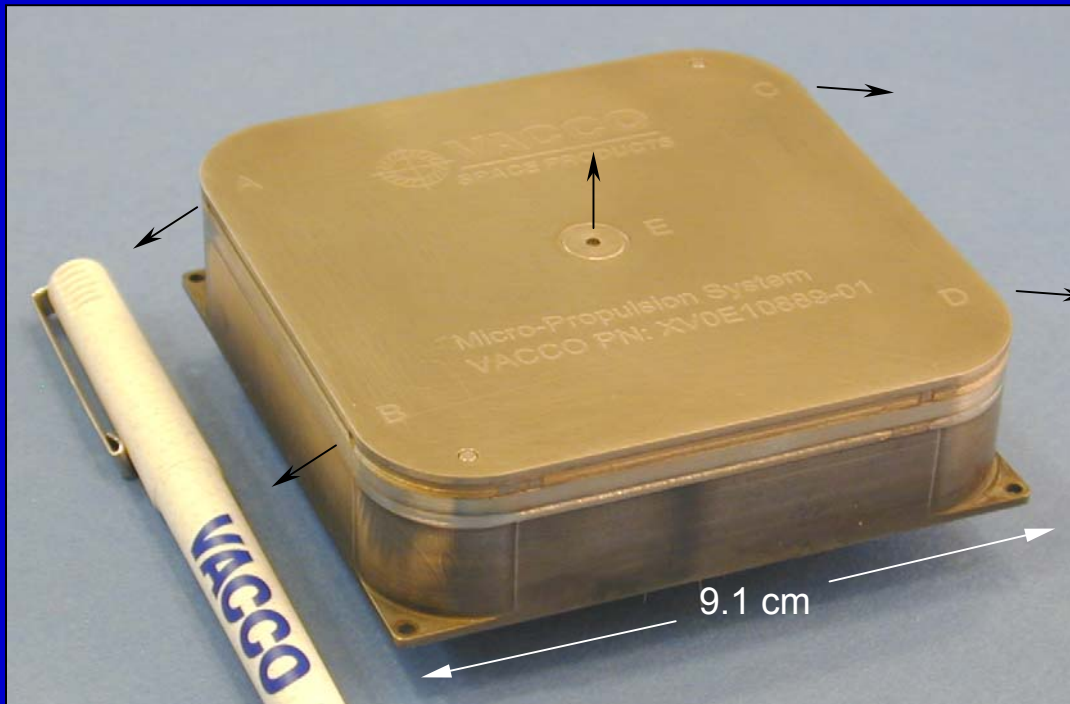
# Micro-Thruster Performance

- **Fuel:** Isobutane ( $C_4H_{10}$ )
- **Typical Flow:**  
2240 sccm  $GN_2$  @ 40 psid (to ambient)  
Equivalent to 1574 sccm  $C_4H_{10}$
- **Specific Impulse:** 50 sec. (est)  
Minimum Impulse Duration: 10 mS  
Min Impulse Bit: 0.21 to 0.46 mN-Sec
- **Calculated Thrust:**  
40 mN (40 psia Plenum Pressure)
- **Thrust Resolution:**  
Variable between 21 (18 psia) to 46 mN (40 psia) @ 20°C  
21 to 120 mN (126 psia) @ 60°C



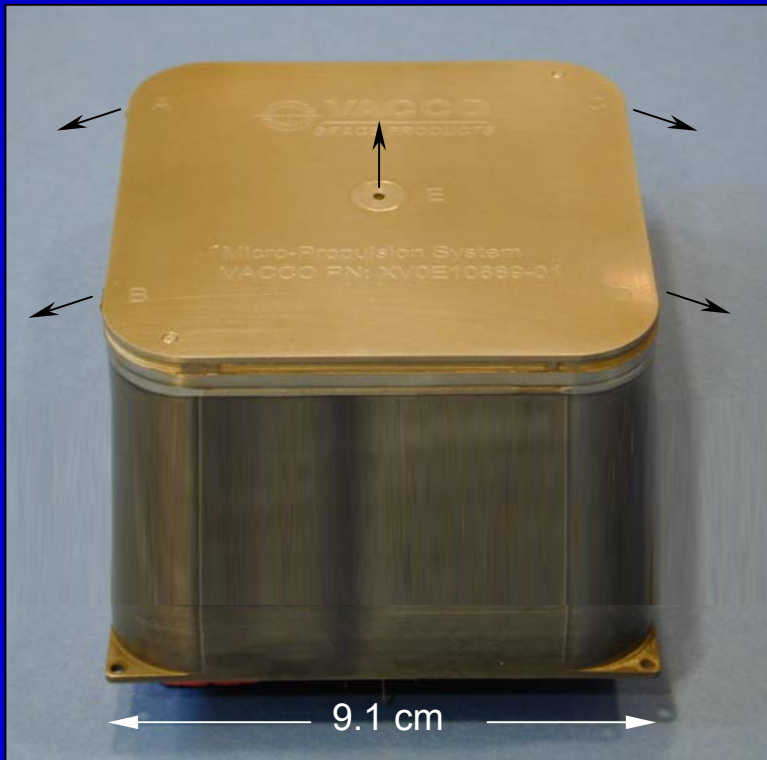
# Micro-Propulsion System Capability

- **Thrust:**
  - 40 mN (40 psia Plenum Pressure)
- **Propulsion System Mass:** 510 g
  - Dry Mass: 456 g
  - Propellant Mass: 55 g (liquid)
- **Thrust / Propulsion Wt.:**
  - 0.090 to 0.100 N/Kg
  - 74 N-Sec/Kg
- **Number of thrust cycles:**
  - Up to 96,000 Minimum Impulse Bit Firings
- **Total Impulse:** 34 N-Sec
- **Total  $\Delta V$ :** 34 m/s
  - 26 m/s ( $-Z$ )
  - 1 m/s ( $+Z$ )
  - 3 m/s Pitch/Yaw
  - 4 m/s Roll & Un-Spin Reaction Wheels



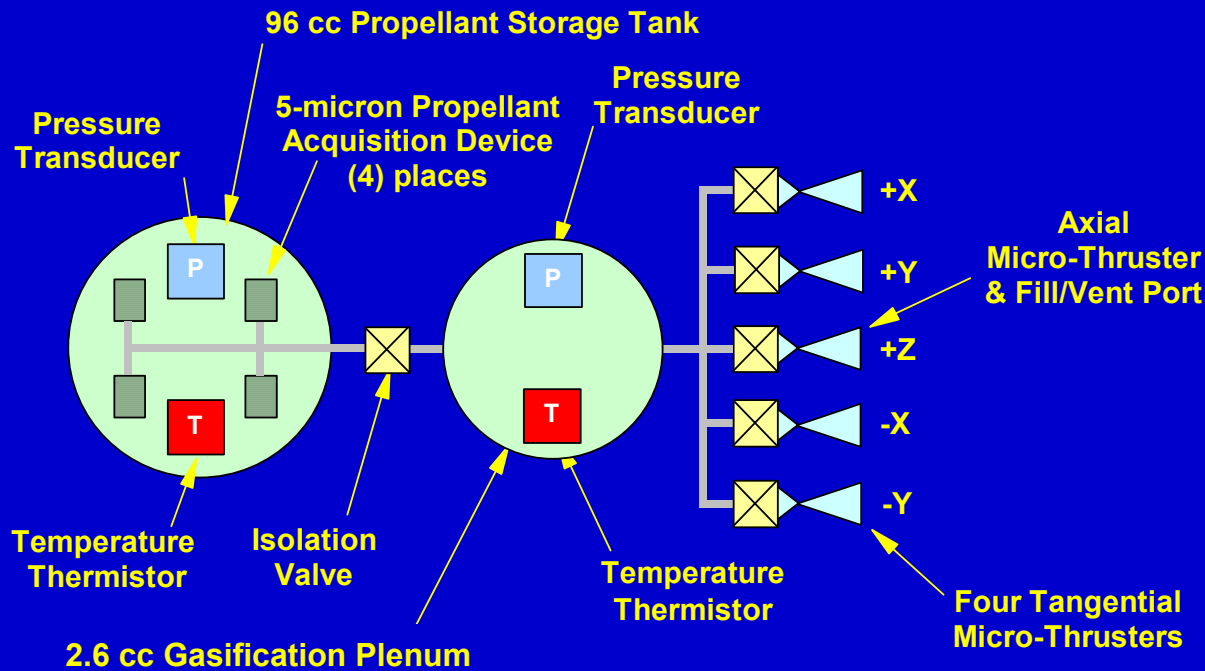
# High Capacity Isobutane MiPS

- **Thrust:**  
40 mN (40 psia Plenum Pressure)
- **Thrust / Propulsion Wt.:**  
0.033 to 0.044 N/Kg  
172 N-Sec/Kg
- **Number of thrust cycles:**  
>650,000 Min Impulse Bit Firings
- **Total Impulse:** 239 N-Sec
- **Thrust resolution:**  
Variable between 21 (18 psia) to 46 mN (40 psia) @ 20°C  
120 mN (126 psia) @ 60°C
- **Fuel:** Isobutane (C<sub>4</sub>H<sub>10</sub>)
- **Specific Impulse:** 50 sec. (est)  
Minimum Impulse Duration: 10 mS  
Min Impulse Bit: 0.21 to 0.46 mN-Sec
- **Mass:** 980 g  
Dry Mass: 620 g  
Propellant Mass: 350 g (liquid)





# MiPS as an Educational Tool



**MiPS for University  
CubeSats**

**Allocated by Funding  
Agency**

**Machined Parts Stocked**

**Customized Bonded Core:**

**Interconnections**

**4 of 5 Thrusters**

**(4) Month Delivery**





# Conclusions

- **Novel Design Based on patented ChEMS™ Technology.**
- **Robust & Reliable:**
  - All-Welded Against External Leakage.
  - Redundant Valves Against Leakage.
  - “Solid-State” Design (no sliding parts).
  - Reliable Soft-Seat Valve Design.
- **Simple, Self-Pressurizing Design.**
- **34 N-S Total Impulse and 96,000 Max Firings.**
- **Extremely Flexible and Expandable:**
  - Easily “Stretched” for Increased Propellant Capacity.
  - Adaptable to High Performance “Green” Monopropellants such as N<sub>2</sub>O.

