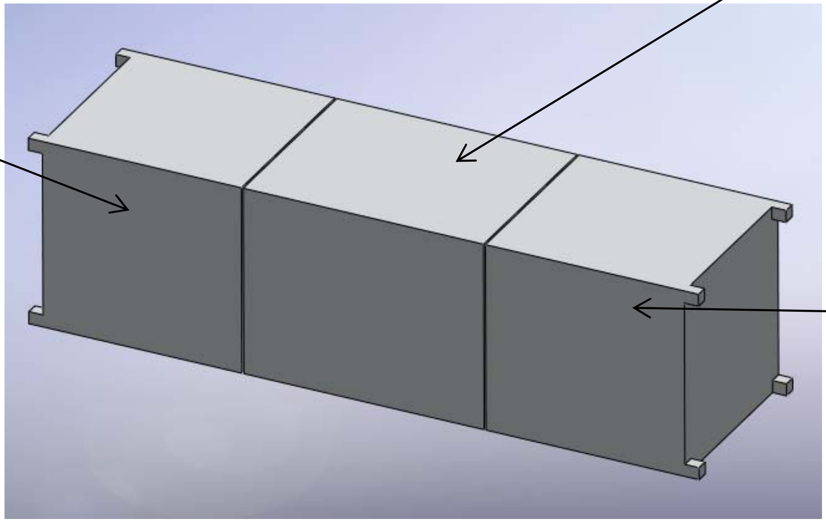
Monopropellant Micro Propulsion system for CubeSats

By Chris Biddy

174 Suburban Rd Suite 120
San Luis Obispo CA 93401
(805) 549-8200
chris@stellar-exploration.com

Introduction

- High Performance CubeSat Propulsion will open up many opportunities
  - Decoupling of secondary payload (CubeSat) with primary payload orbit
  - Quick deployment of global constellations
- Goal is to develop 1U propulsion system to be integrated in 3U satellite



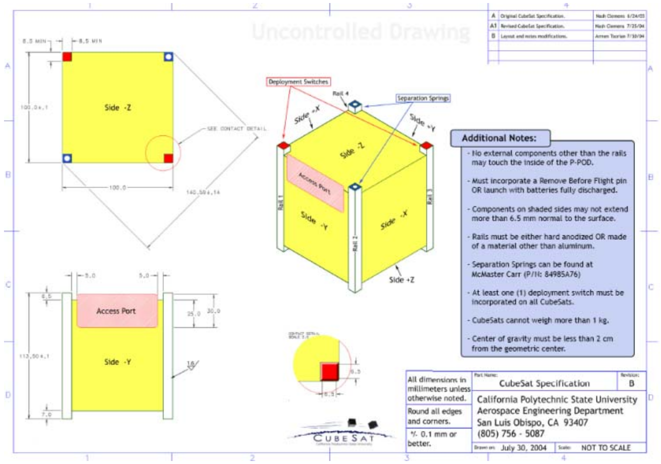
3U CubeSat with description for each unit

Why Monopropellant?

- Significantly higher performance (delta V) compared to cold gas
- Larger Thrust vs. Electric Propulsion
  - Needed for Orbit transfer
- Mature technology
  - Hydrazine is a known and mature hazard
  - New “Green” propellants still require analysis for range safety
- Less complicated than Bipropellant
  - Two separate tank and plumbing systems for fuel and oxidizer
- More volume efficient than Bipropellant

Requirements

- Meet CubeSat Standard
  - <1kg/unit
  - Aluminum 6061-T6, 7075 recommended
  - 75% of length must have rails with hard anodized surface
  - Not endanger primary payload
- Low Cost
  - ~$250k complete unit
- Address Range Safety constraints up-front
  - Small Propellant Quantity
  - Low operational pressure enables P-POD containment
  - Off site fueling/ Defueling as single integrated P-POD
- High Performance
  - Large delta V (~ 400m/s)
  - Thrust to weight ratio of 0.25



Design Philosophy

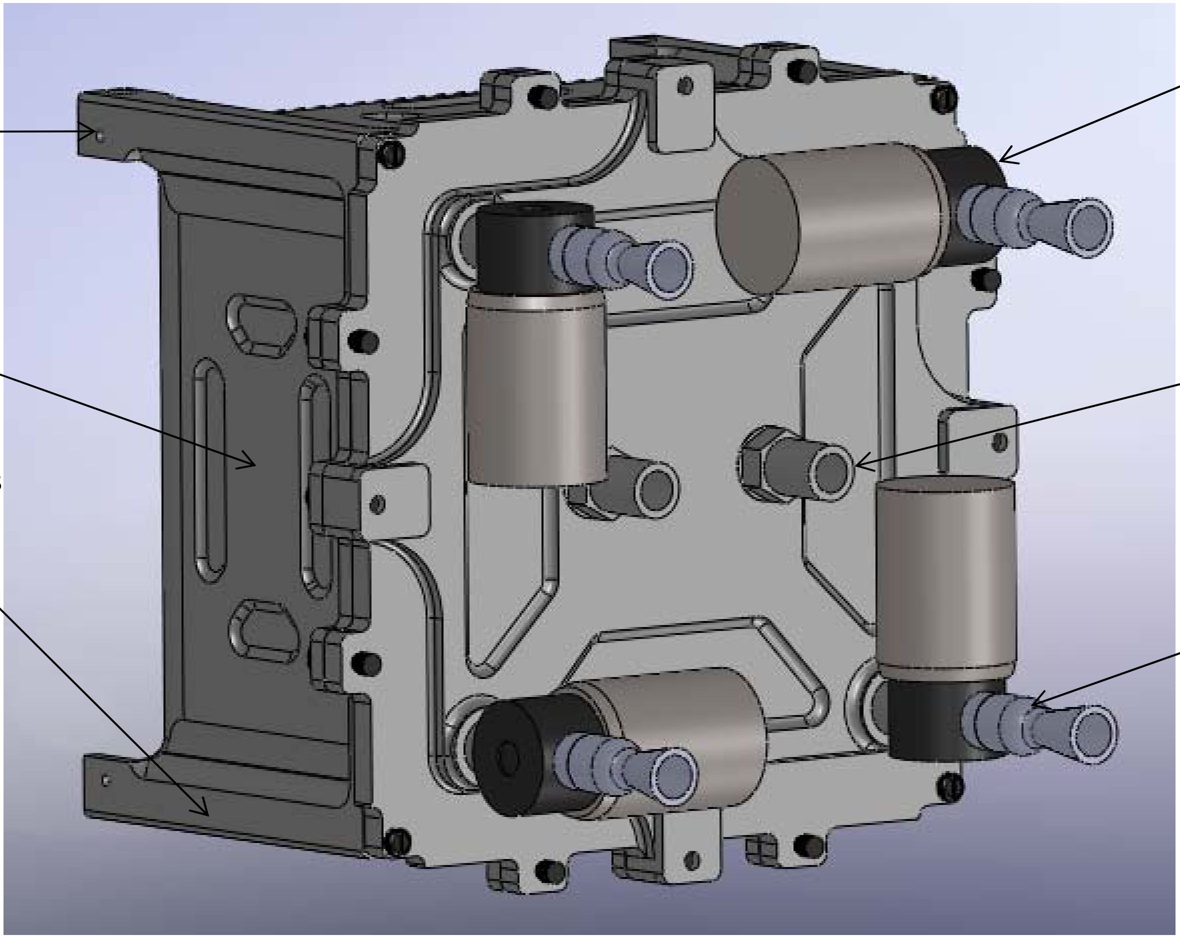
- Start with COTS components
  - Test and modify if necessary/possible
- Simplify
- Start with Thruster valve and design around it
- Develop cubic tank and cylindrical tank structure paper design in parallel
  - Compare theoretical performance of each
  - Continue design with best theoretical performance

Safety to personnel is highest priority

Micro Propulsion Details

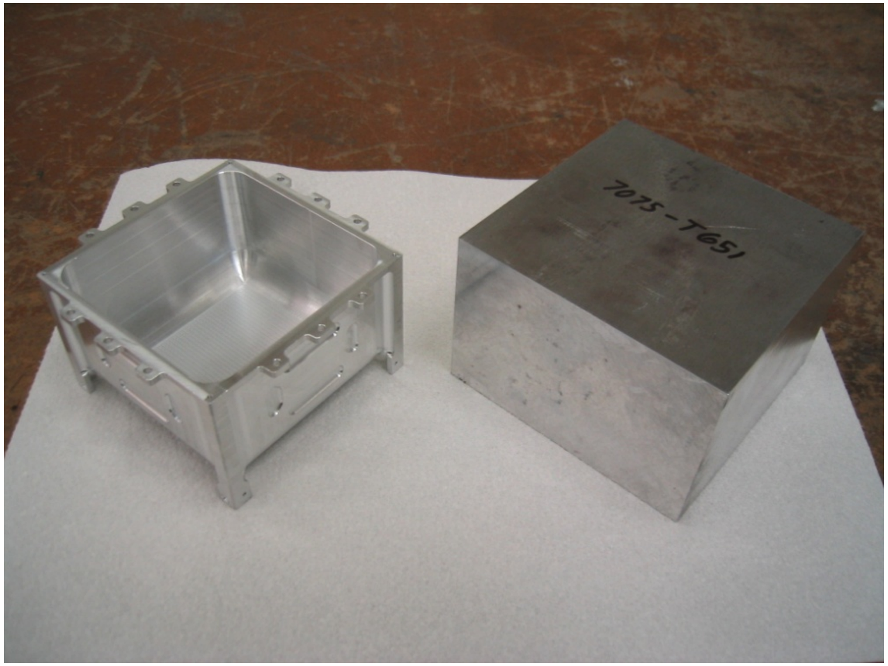
- Miniature solenoid valve used for thruster valve
- 2 port design with a #10-32 threaded interface
- Mass = 37g
- Max operating pressure = 110psi (758kPa)

Micro-Propulsion Unit

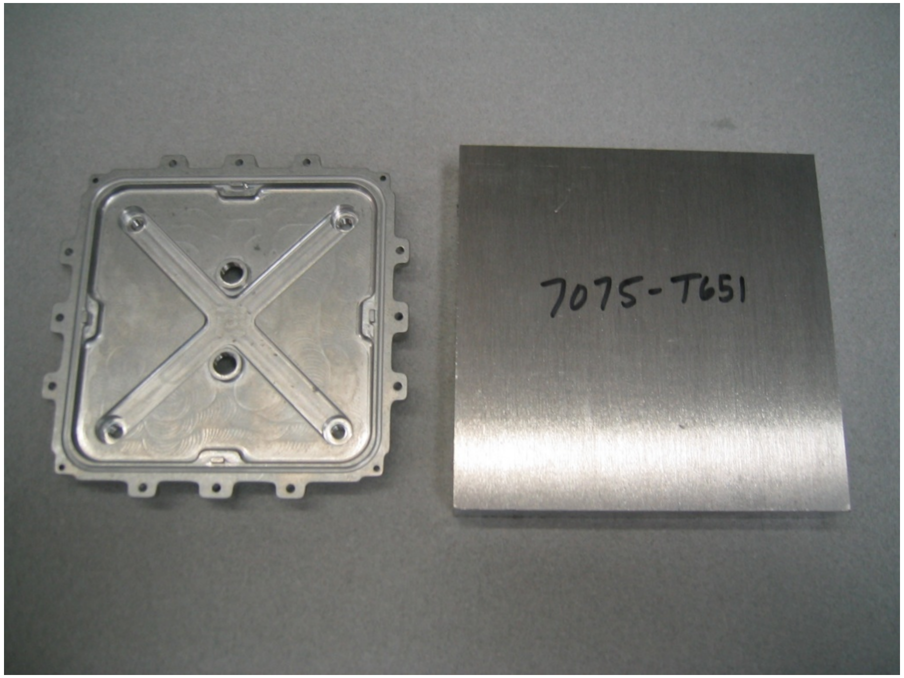


Propulsion System Details

- CNC machined tank and cap
- P-POD rails integrated into tank structure
- Mounting Flange protrudes 6.5mm from tank edge



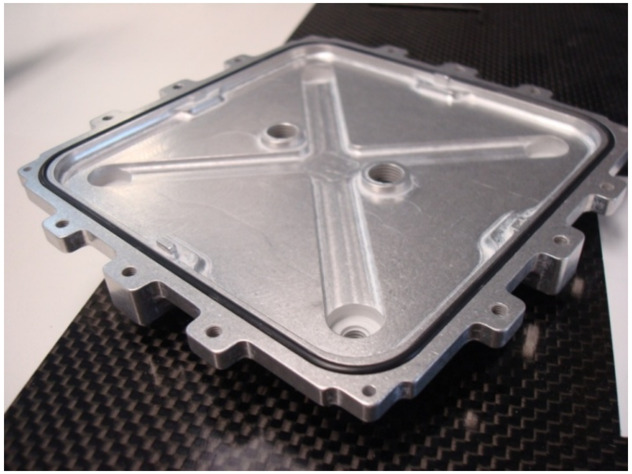
Propulsion system tank and billet blank.



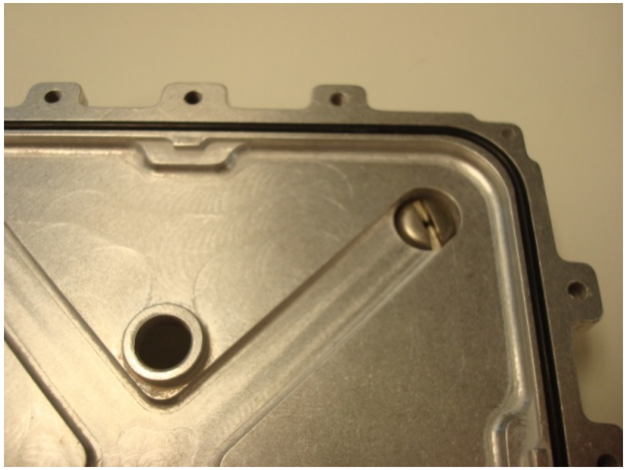
Propulsion system cap and billet blank

Propulsion System Details

- Tank and cap interface sealed with EDPM O-ring
- Stainless stud with laser drilled hole provides fluid path to thruster valve
- Stud uses EDPM o-ring to seal


Underside of cap with o-ring installed

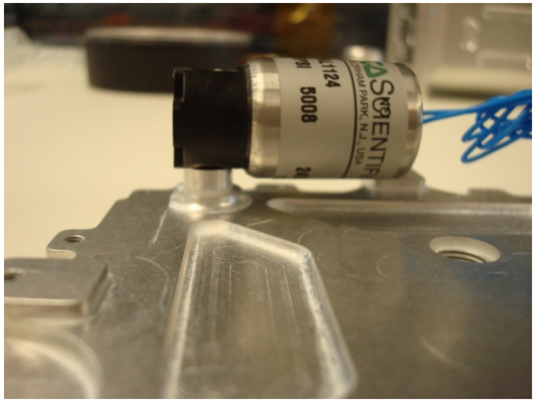

Stainless stud with EDPM o-ring

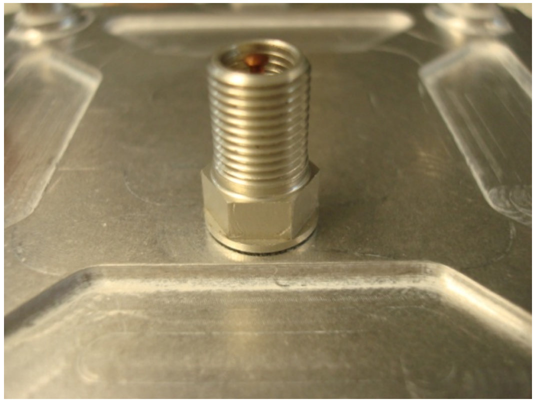

Underside of cap with stud installed

Propulsion System Details

- Thruster valve mounts to stud and seats against cap boss (middle)
- Schrader valve mounted to cap used for fill/drain (right)


Cap shown with valve mounting stud

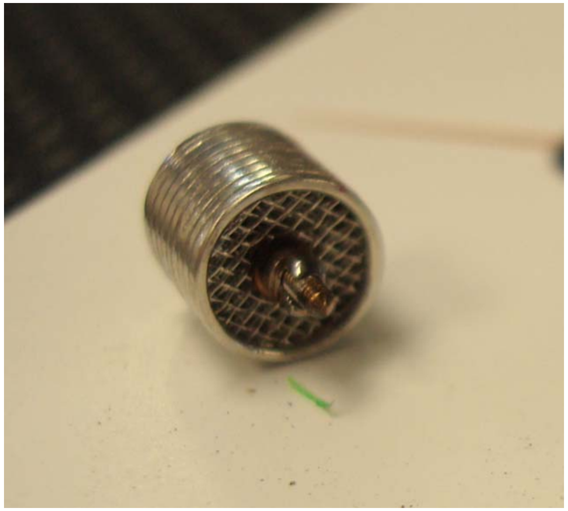

Valve assembled to cap


Schrader valve assembled to cap

Propulsion System details

- Thruster made from stainless steel
  - Prototype (heavy) thruster shown (left)
- Catalyst made from platinum mesh and platinum/iridium wire "screens"
  - Screens are stacked and held by stainless fasteners
  - Number of screens can be varied during testing

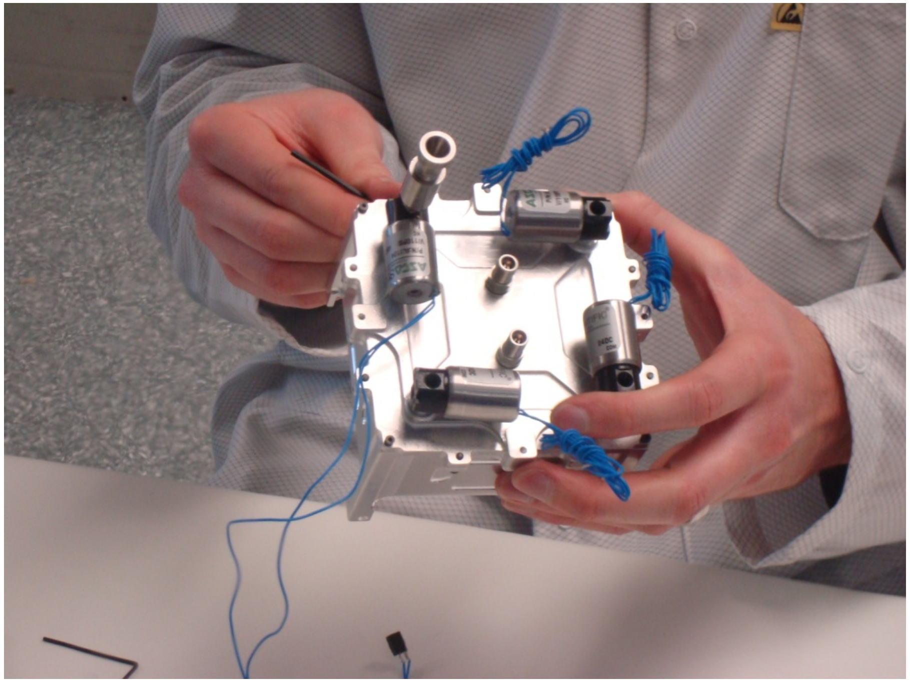
Thruster assembly



Platinum Catalyst

Propulsion System Details

- Dry mass fraction for propulsion system unit = 0.45
- Expected delta V up to 400m/s

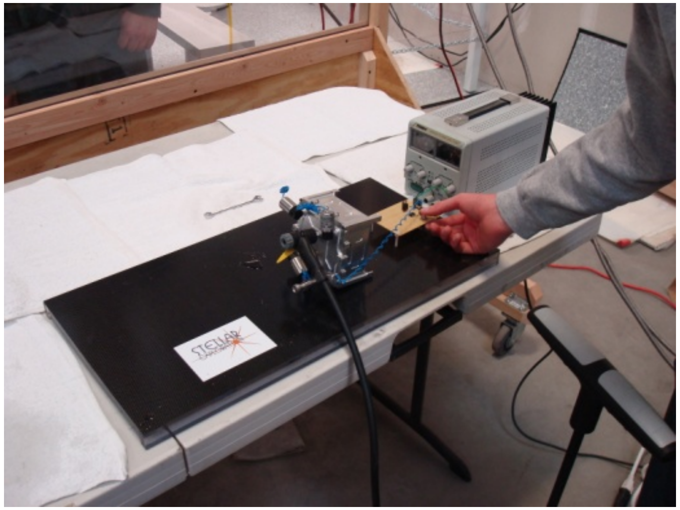


Propulsion system assembly.

Test Plan

- Tank Burst Test
  - Investigate Failure Mechanism
- P-POD Integration
  - Verify smooth operation
- Hot Fire Test
  - Catalyst Function and integrity
  - Minimum inlet pressure for thruster operation
  - Thrust measurements

Micro Propulsion Module and P-POD test fit



Valve Cycling test under pressurization

Future Work

- Propellant Management Device
  - Work in Progress
- Control and Navigation System
- Qualification Testing

Any Questions?

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