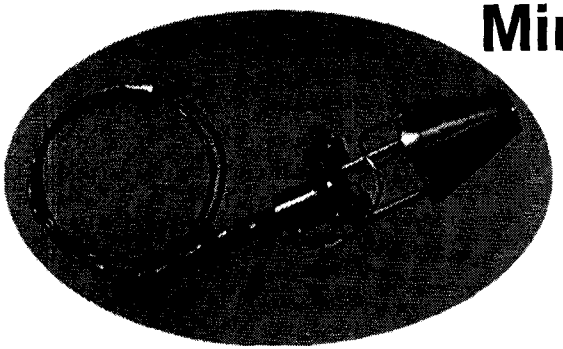
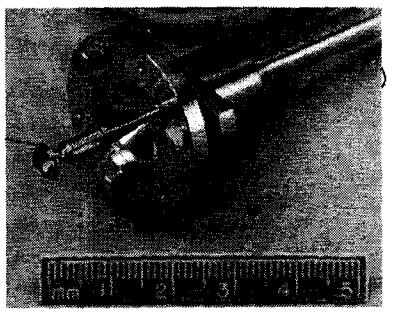
Minimum Impulse Technologies
for
Precision Attitude Control



Minimum Impulse Thruster (MIT)
(Flight Qualified by Feb 04)

&

Hydrazine milliNewton Thruster (HmNT)
(future development)



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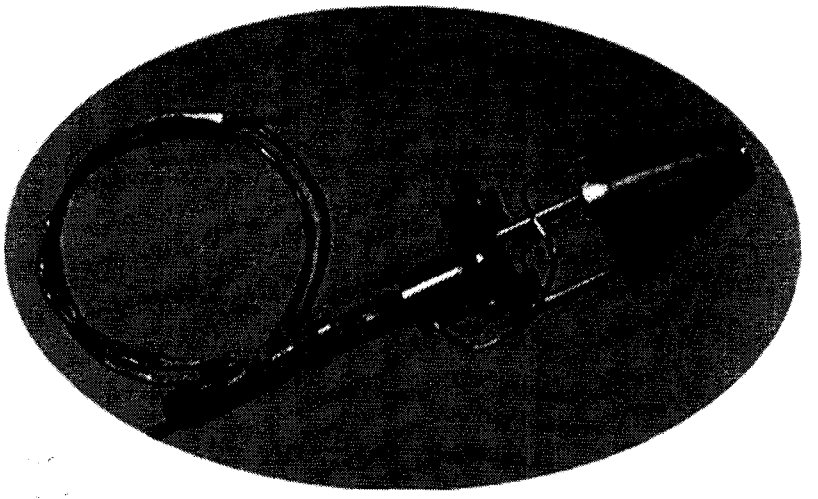
15 Apr 03

Minimum Impulse Thruster (MIT)

What is a MIT?



• The 0.9 N MR-103 thruster, developed in 1975 -77 for Voyager, is the current flight qualified state-of-the-art thruster for attitude control.

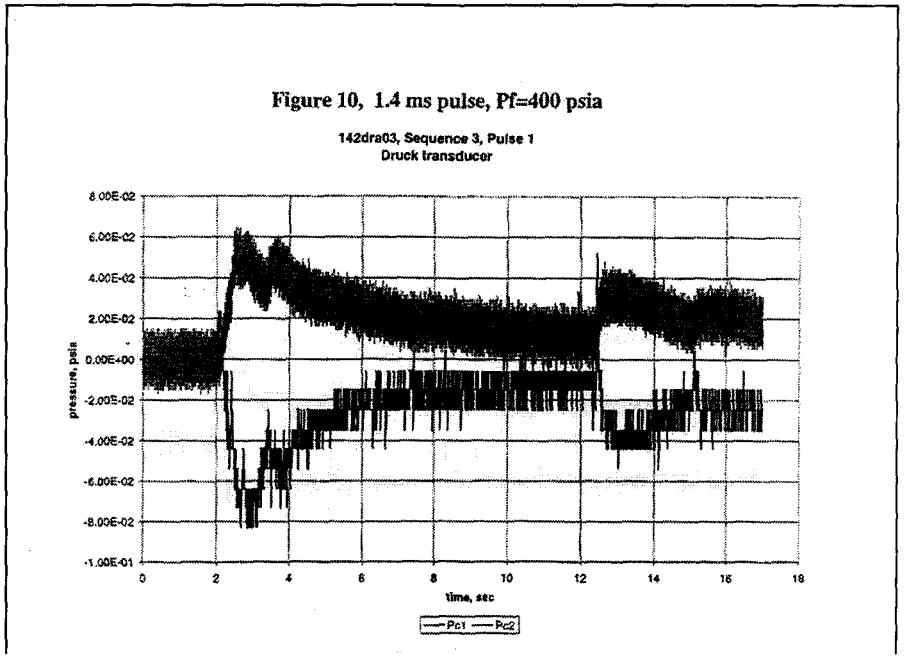
• The MIT, being developed with X-2000 funding, is a new fast valve that will be mated to the MR-103 thruster.

> After the valve is qualified (Aug 03), the MIT thruster / valve assembly will be Δ-qualified to formally document it's new and extended capabilities. MIT flight qualification completed by Feb 04.

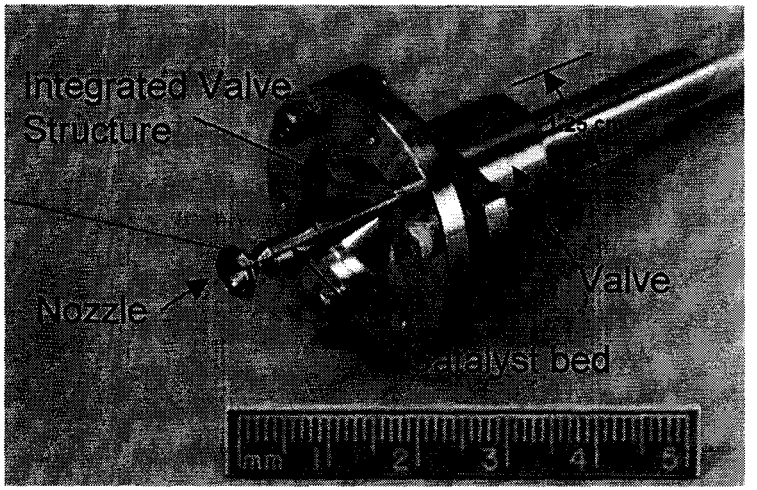
• The MIT recently demonstrated the smallest impulse bit ever achieved by a hydrazine thruster

>This 1.4 millisecond pulse is approximately ≈ 1 milliNewton-second (1 mN-s), ~ 5 times smaller than the smallest impulses produced by the state-of-the-art thruster!

• The MIT is a stepping stone to even greater precision enabled by the HmNT ...



Hydrazine milliNewton Thruster (HmNT)



What is an HmNT?

• The HmNT is a new technology (TRL 2) that builds on the progress of the MIT. The HmNT targets a much lower thrust and minimum impulse, by ...

> developing a revolutionary hydrazine thruster,

> mated to the same fast valve used with the MIT.

❖ Detailed design and fabrication of the HmNT testbed elements is complete.

❖Proof of Concept tests are the next step.

Industry Participants

Valve developed by EG&G, PerkinElmer, & Moog

MIT Δ Qualification by Aerojet RRC

HmNT development coordinated by JPL with support from several companies including Alltech, National Jet,General Dynamics, Wire Cut Inc, & consultant Dr Eckart Schmidt

Technology:

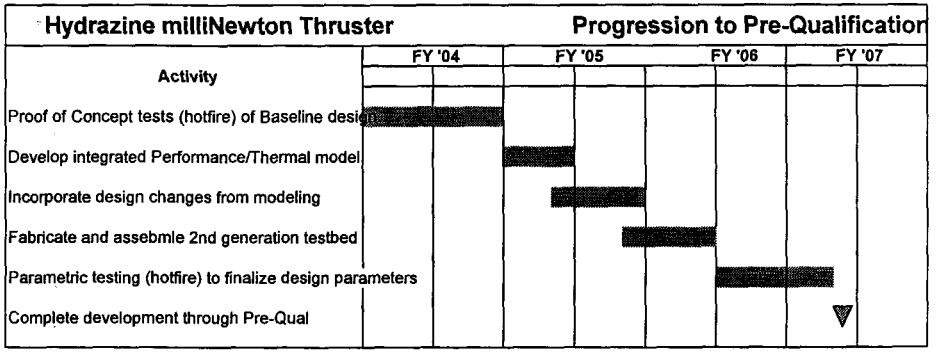
•Minimum Impulse for Precision ΔV & Precision Pointing

Objectives:

- **45 X reduction in steady state thrust**
- **100 X reduction in minimum impulse bit**
  - **capable of a wide range of operation**
    - **➢ 50 μN-s up to steady state (HmNT version)**
    - **➢ 0.1 μN-s with addition of a Vapor Plenum**
- **5 X mass reduction, 10 X volume reduction vs. SOA**

Comparison Parameter	Voyager MR103 Current SOA	MIT	HmNT	VP HmNT
Thrust	0.9 N	0.75 N	0.020 N	0.0001 N
Envelope Volume	94 cc	55 cc	8 cc	14 cc
Power	7 W	8 W	8 W	11 W
Mass	195 g	116 g	40 g	55 g
Min. Impulse	5,000 μNásec	**1000 μNásec**	**50 μNáSec**	**0.1 μNáSec**
Pointing Stability Europa Class S/C	1000 μrad/sec	200 μrad/sec	10 μrad/sec	0.02 μrad/sec

(Schedule pending appropriate funding)



Minimum Impulse Thruster (MIT) and Hydrazine milliNewton Thruster (HmNT)

Military Applications:

- Precision pointing for high resolution observing platforms.
- Precision positioning (translation) for larger formation flyers
- Steady state thrust for quick turns and maneuvers.
- Replacement for reaction wheels when jitter is a concern

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The table & graph (right) compare the current SOA Voyager MR 103 thruster to the MIT, HmNT & VP HmNT

- The MIT takes precision attitude control a significant step forward.

- The HmNT takes a giant leap forward; targets a range of thrust & impulse higher than most Electric Propulsion or micro ACS thrusters, but far lower than existing chemical capabilities..
  - ➢ 100 X reduction in minimum impulse
  - ➢ wide range of operation
  - ➢ tighter deadband pointing
  - ➢ less fuel used (wet mass savings)

- Both the MIT & the HmNT are easily added to any existing hydrazine system, (e.g. a dual mode biprop, or a monoprop hydrazine system) for < 1 Kg of dry mass