

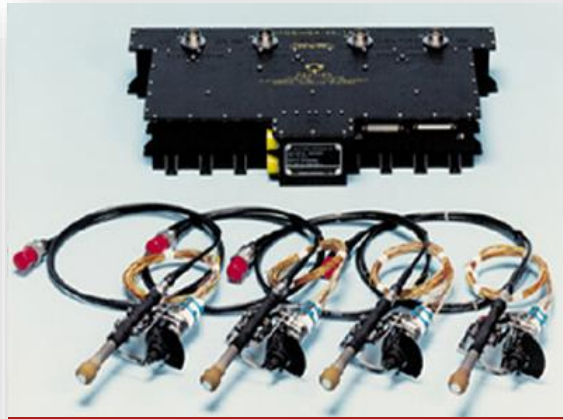


# Electric Propulsion

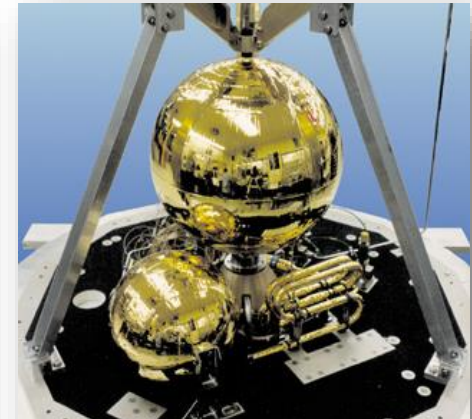
# AR has delivered over 550 electric propulsion devices



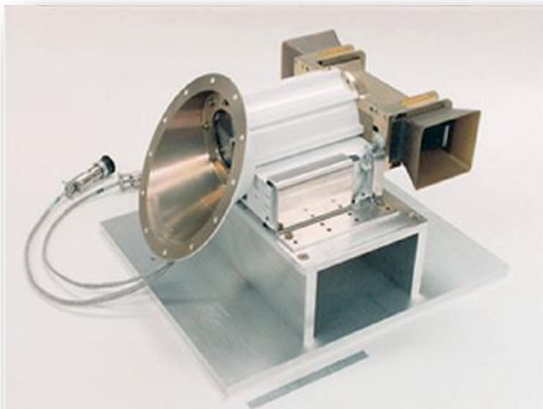
Electrothermal Hydrazine Thruster  
And PPU / Arcjet and Feed System



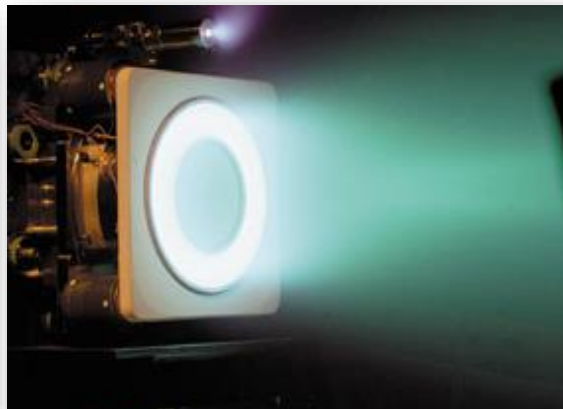
Hydrazine Arcjets  
and Power Processing Unit /  
Arcjet and Feed System



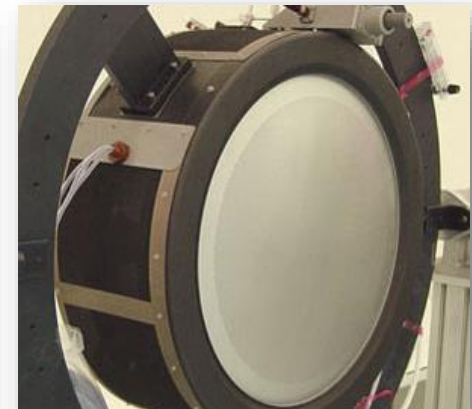
High Power Ammonia  
Arcjet and Feed System



Pulsed Plasma Thruster

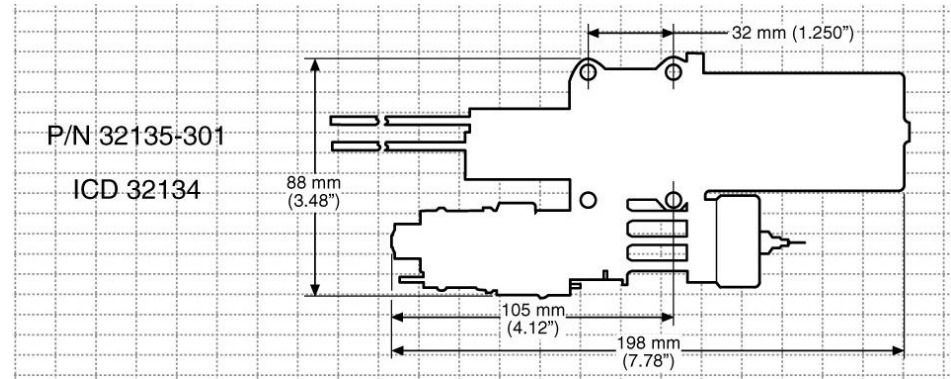
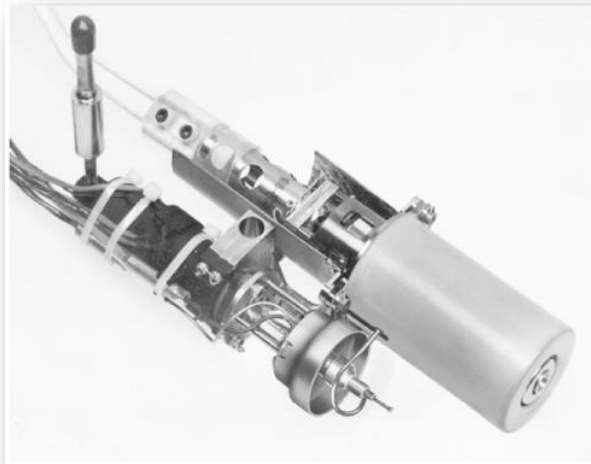


Hall Thruster



Xenon Ion Engine

# MR-502A Improved Electrothermal Hydrazine Thruster (IMPEHT)



## Design Characteristics

Propellant.....	Hydrazine
Catalyst.....	S405
Thrust/Steady State.....	0.80 – 0.36N (0.18 – 0.08 lbf)
Feed Pressure.....	26.5-6.2 bar (285 – 90 psia)
Flow Rate.....	0.28-0.12 g/sec (0.00026 lbfm/sec)
Valve.....	Dual Seat
Valve Power.....	8.25 Watts Max @ 28 Vdc & 21°C
Valve Heater Power.....	1.54 Watts Max @ 28 Vdc & 21°C
Cat. Bed Heater Pwr.....	3.93 Watts Max @ 28 Vdc & 21°C
Augmentation Heater Pwr.....	885 – 610 Watts
Augmentation Htr Voltage.....	29.5 – Vdc Letdown
Mass.....	0.87 kg (1.92 lbfm)

## Performance

Mission Specific Impulse *	
Steady-State Blowdown.....	303 – 294 sec (lbf-sec/lbfm)
Total Impulse.....	524,864 N-sec (118,000 lbf-sec)
Total Pulses.....	MR-502A not designed for pulsing
Steady State Firing...2 hrs Single Firing / 370 hrs Cumulative	

## Status

Flight Proven  
In Production

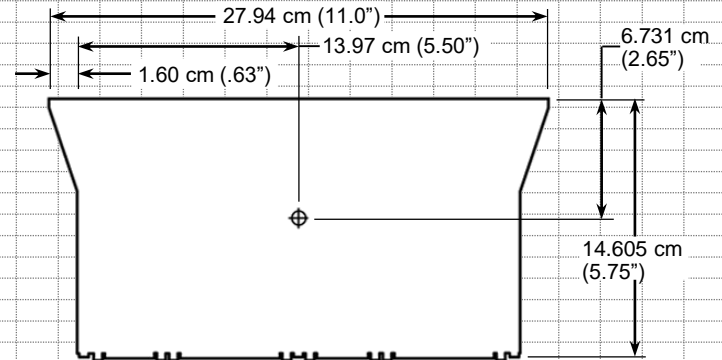
## Reference

A1AA-1987-0996

# MR-502 & MR-502A IMPHET Power Conditioning Unit



Power Conditioning Unit  
P/N 34830



## Design Characteristics

- Mass . . . . . 2 kg
- Envelope . . . . . 27.94 x 9.42 x 14.61 cm
- Input Voltage . . . . . 15-29.9 vdc
- Inrush Current . . . . . 32 Amp Max
- Efficiency . . . . . >97%

## Interface

- Enable/Disable Command . . . . . Latch Relay Drive
- On/Off Command . . . . . 0V – Off, 14V – On

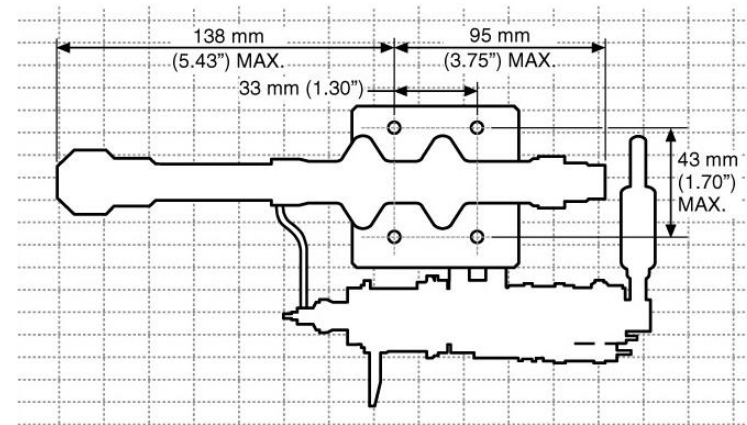
## Demonstrated Performance

- Limits inrush current to the 30 Amps during augmentation heater warm-up
- Two identical independent channels that can be operated either redundantly or simultaneously
- When used simultaneously, the IMPEHT pair should be started one after the other

## Status

- Flight Proven
- Not currently in production

# MR-509 Low Power Arcjet System



## Design Characteristics

- Propellant: High Purity Grade Hydrazine per MIL-PRF 26536G
- Feed Pressure (nominal) 18.6 – 13.8 bar (270 – 200 psia)
- Mass
  - Arcjet thruster + 2000 mm (70") cable 1.4 kg (3.0 lbm)
  - PCU 6.2 kg (13.7 lbm)
- Envelope
  - Arcjet 240 x 125 x 90 mm<sup>3</sup> (9.3 x 4.9 x 3.6 inch<sup>3</sup>)
  - PCU 310 x 220 x 95 mm<sup>3</sup> (12.2 x 8.7 x 3.7 inch<sup>3</sup>)
- Valve: dual seat, electrically actuated
- Valve power (standard) 8.2 W @ 28 VDC
- PCU input power per arcjet 1780 W
- PCU input voltage 65 - 96 VDC
- PCU efficiency, avg. >91%
- Power cable PCU – arcjet < 2000 mm (79 inch)
- Currently available 1575 mm (62 inch)

## Demonstrated Performance

- At 1670 W input to the arcjet (1780 W input to the PCU), and 18.6 to 13.8 bar (270 to 200 psia) feed pressure blow down
- Total impulse 866,500 Ns (194,500 lbf s)
- Thrust 254 – 213 mN (57 – 47 mlbf)
- Specific impulse > 502 s
- Firing time during lifetime demonstration test:
  - Duty cycle 1 h on, > 30 min off > 1050 cycles
  - Number of starts > 1170
- Longest demonstrated burn 65 h

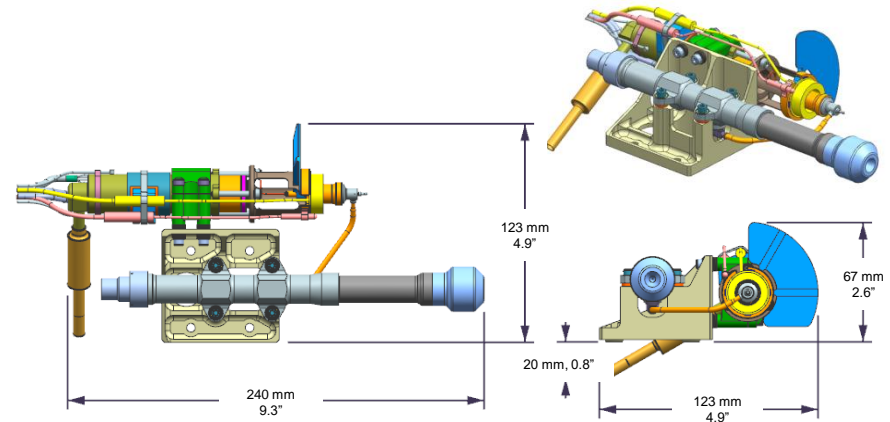
## Status

- Flight proven, no longer in production

## References

- AIAA-1998-3631
- IEPC-1997-081
- Power Conditioning Unit (PN 1000)
- Cable Assembly (PN 31168)
- Arcjet Thruster (PN 32240)

# MR-510 Arcjet Thruster and Cable Assembly



## Design Characteristics

- Propellant: High Purity Grade Hydrazine per MIL-PRF 26536G
- Feed Pressure (nominal)..... 18.6 – 13.8 bar (270 – 200 psia)
- Mass:
  - Arcjet thruster + 3175 mm (125") cable ..... 1.6 kg (3.5 lbf)
- Envelope
  - Arcjet..... 240 x 123 x 87 mm<sup>3</sup> (9.3 x 4.9 x 3.4 inch<sup>3</sup>)
- Valve:..... dual seat, electrically actuated
- Valve power (standard)..... 8.2 W @ 28 VDC
- Power cable PCU – arcjet..... < 5590 mm (220 inch)

## Status

- Flight proven
- Recent production

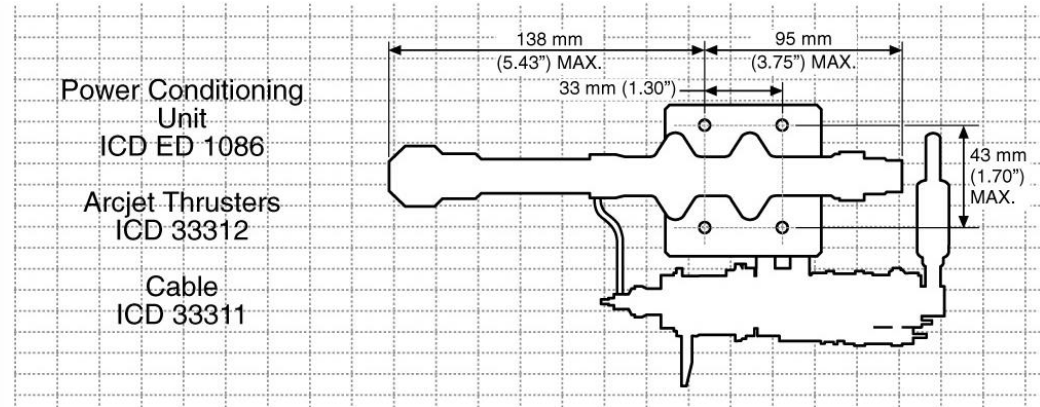
## Demonstrated Performance

- At 2000 W input to the arcjet (2200 W input to the PCU), and 18.6 to 13.8 bar (270 to 200 psia) feed pressure blow down
- Total impulse..... 1,450,000 Ns (326,000 lbf s)
  - Thrust..... 258 – 222 mN (58 – 50 mlbf)
  - Specific impulse..... 585 - 615 s
  - Firing time during lifetime demonstration test:
    - Duty cycle 1 h on, > 30 min off..... > 1730 cycles
    - Number of starts..... > 1960
  - Demonstrated on-time duty cycles:..... 4 min to 20 h

## References

- AIAA-1998-3630, AIAA-1999-2272, AIAA-2001-3901, AIAA-2009-5364, IEPC-1997-082, esa SP2014-2966753, IEPC-2017-305

# MR-512 Low Power Bus Arcjet System



## Design Characteristics

- Propellant:....High Purity Grade Hydrazine per MIL-PRF 26536G
- Feed Pressure (nominal).....17.6 – 13.8 bar (250 – 200 psia)
- Mass:
  - Arcjet thruster + 2000 mm (70") cable .....1.4 kg (3.0 lbm)
  - PCU.....6.2 kg (13.7 lbm)
- Envelope
  - Arcjet.....240 x 125 x 90 mm<sup>3</sup> (9.3 x 4.9 x 3.6 inch<sup>3</sup>)
  - PCU.....310 x 220 x 95 mm<sup>3</sup> (12.2 x 8.7 x 3.7 inch<sup>3</sup>)
- Valve:.....dual seat, electrically actuated
- Valve power (standard).....8.2 W @ 28 VDC
- PCU input power per arcjet.....1780 W
- PCU input voltage.....33 – 51.5 VDC
- PCU efficiency, avg.....>91%
- Power cable PCU – arcjet.....< 2000 mm (79 inch)
- Currently available.....1575 mm (62 inch)

## Demonstrated Performance

- At 1670 W input to the arcjet (1780 W input to the PCU), and 270 to 200 psia feed pressure blow down
- Total impulse .....866,500 Ns (194,500 lbf s)
  - Thrust.....254 – 213 mN (57 – 47 mlbf)
  - Specific impulse .....> 502 s
  - Firing time during lifetime demonstration test:
    - Duty cycle 1 h on, > 30 min off .....> 1050 cycles
    - Number of starts.....>1170
  - Longest demonstrated burn:.....65 h

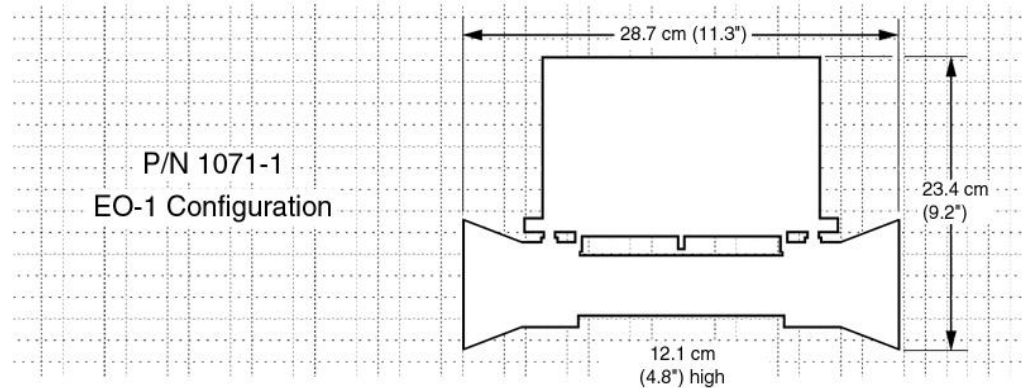
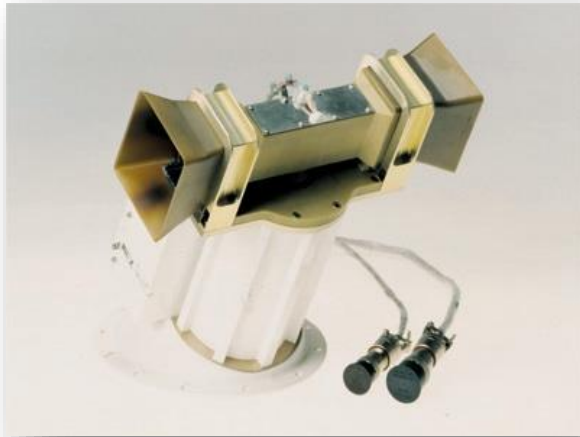
## Status

- Flight proven, no longer in production

## References

- AIAA-1998-3631
- IEPC-1997-081

# PRS-101 Pulsed Plasma Thruster System



## Design Characteristics

- Propellant . . . . . Teflon® (Solid Bar)
- Max Thrust Level1 . . . . . 1.24 mN @ 100 Watts
- Power Level . . . . .
- . . . . . Up to 100 Watts @ 28 vdc Unregulated
- Compact Solid State Propulsion System
- Ultra Low Minimum Impulse Bit for Precision Control
- Enables All-thruster ACS (No Momentum Wheels)
- Mass (w/o propellant) . . . . . 4.74 kg
- Includes Integral Power Processing Electronics
- Power Efficiency . . . . . >80%

## Performance

- Specific Impulse . . . . . Up to 1350 sec
- Thrust to Power Ratio . . . . . 12.4  $\mu$ N/Watt
- Demonstrated Capability. . . . . 3,000 N-sec/thruster
- Predicted Capability (backed by selective testing) . . . . .
- . . . . . 15,600 N-sec/system (thruster pair)

## Status

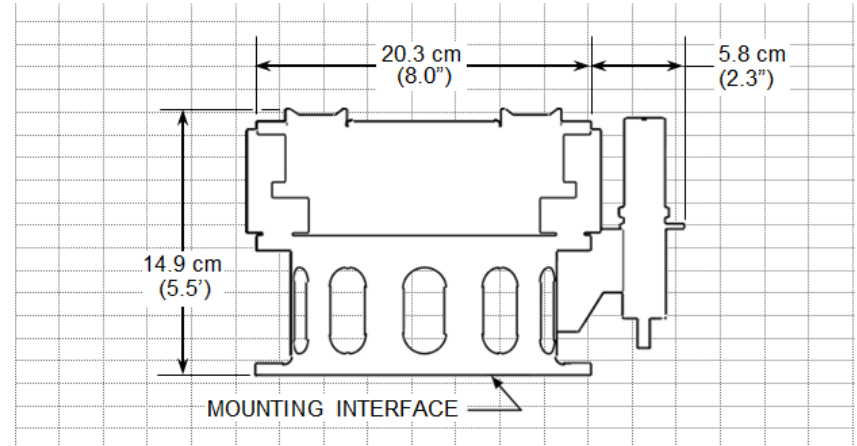
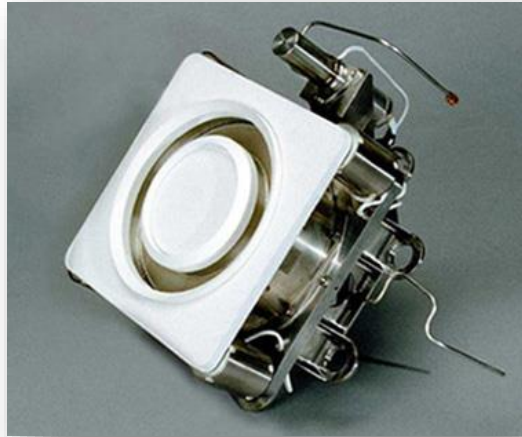
- Flight Proven; no longer in production

## Reference

- AIAA-2003-5016
- AIAA-2001-3637
- AIAA-2002-3973
- AIAA-1999-3376



# XR-5 Hall Thruster



## Design Characteristics

- Propellant ..... Xenon
- Mass (Thruster & Cathode) ..... <12.3 kg
- Envelope ..... 14 x 25 x 28 cm
- Input Power ..... 1000 to 4500 Watt
- Input Voltage ..... 200 or 400 Volt

## Status

- Qualification Complete; 24 Thrusters Flown
- First flight system launched in 2010
- Six spacecraft currently flying (4 thrusters per S/C)

## Performance

	<b>2.0 kW</b>	<b>3.0 kW</b>	<b>4.5 kW</b>
• Thrust (300 Volts).....	132 mN	195 mN	290 mN
• Thrust(400 Volts) .....	117 mN	170 mN	254 mN
• Specific Impulse (300 V)	1676 sec	1700 sec	1790 sec
• Specific Impulse (400 V)	1858 sec	1920 sec	2020 sec
• Life Capability .....	Mission Dependent		
• Total Impulse .....	Mission Dependent		
• On/Off Cycles .....	7,316 Cycles		

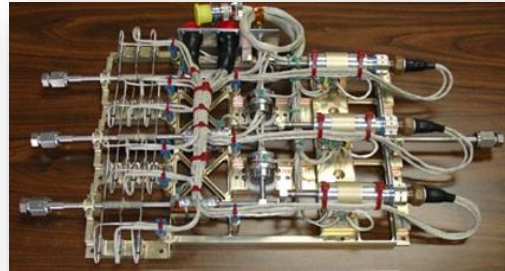
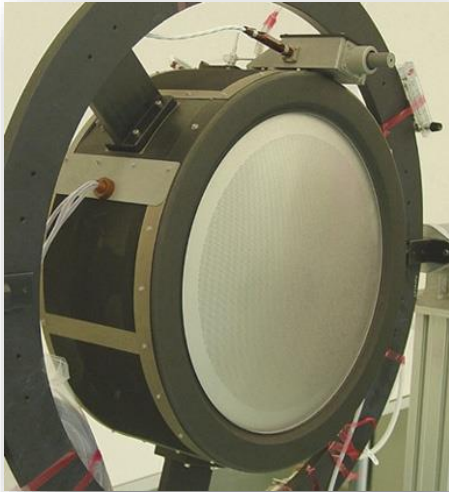
## Status

- Flight Proven, In Production

## Reference

- AIAA-2010-6698

# NEXT 6.9 kW Ion Propulsion System



**Propellant Management System**  
High pressure assembly (below)  
Low pressure assembly (left)



## Design Characteristics

- Propellant ..... Xenon
- Thruster Mass..... <13.3 kg
- Thruster Envelope Dimensions..... 58 dia. x 44 cm  
Active optics area.....36 cm dia.
- Thruster Input Power .....600 to 6900 Watt
- Propellant Management System Mass  
High Pressure Assembly.....< 2.2 kg  
Low Pressure Assembly.....< 4.1 kg
- PMS Volume .....< 11,775 c.c.  
*PMS does not require plenum tanks*
- DCIU interface with Power Processing.....RS-485

## Performance

- Thrust ..... 235 mN
- Specific Impulse..... >4100 sec
- Efficiency @ full power ..... >70%
- Propellant Throughput..... >270 kg
- On/Off Cycles ..... >3650 cycles
- End of Life Xenon Residuals ..... < 1% BOL

## Status

- Qualified and in Production; First Flight DART mission

## Reference

- AIAA-2005-3885
- AIAA-2004-4111



# Aerojet Rocketdyne In-Space Propulsion

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