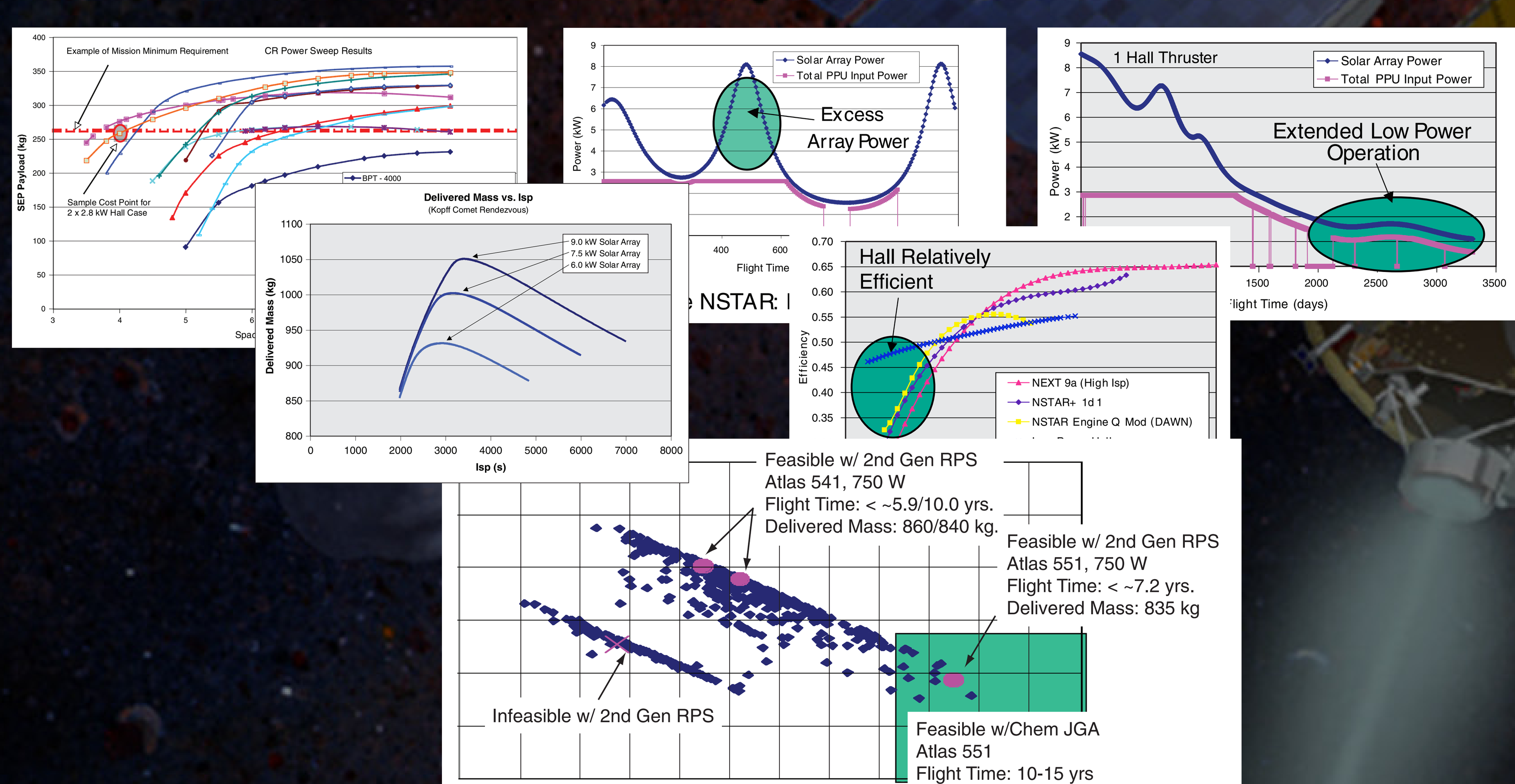
National Aeronautics and Space Administration

In-Space Propulsion Technology Program
Solar Electric Propulsion Technologies

In-Space Propulsion Solar Electric Propulsion Technology Overview

NASA's In-space Propulsion (ISP) Technology Project is developing new propulsion technologies that can enable or enhance near and mid-term NASA science missions. The Solar Electric Propulsion (SEP) technology area has been investing in NASA's Evolutionary Xenon Thruster (NEXT), the High Voltage Hall Accelerator (HiVHAC), lightweight reliable feed systems, wear testing, and thruster modeling. These investments are specifically targeted to increase planetary science payload capability, expand the envelope of planetary science destinations, and significantly reduce the travel times, risk, and cost of NASA planetary science missions. Status and expected capabilities of the SEP technologies are reviewed in this presentation.

The SEP technology area supports numerous mission studies and architecture analyses to determine which investments will give the greatest benefit to science missions. Both the NEXT and HiVHAC thrusters have modified their nominal throttle tables to better utilize diminished solar array power on outbound missions. A new life extension mechanism has been implemented on HiVHAC to increase the throughput capability on low-power systems to meet the needs of cost-capped missions. Lower complexity, more reliable feed system components common to all electric propulsion (EP) systems are being developed. ISP has also leveraged commercial investments to further validate new ion and hall thruster technologies and to potentially lower EP mission costs.

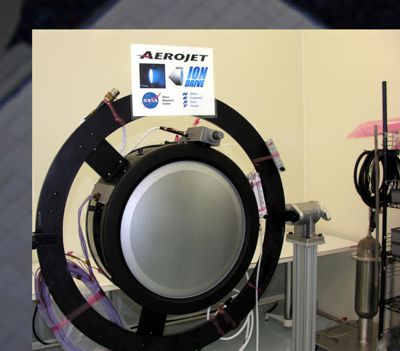


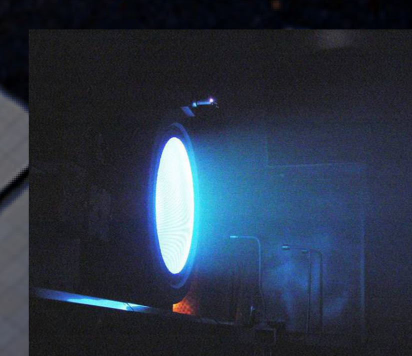
Gridded Ion Propulsion Technology Status: NASA's Evolutionary Xenon Thruster (NEXT)

Led by NASA's Glenn Research Center, a prototype 40-cm ion engine, an engineering model power processing unit, and an engineering model xenon feed system are being developed and tested to provide significantly improved performance over current ion propulsion systems. In collaboration with the NASA Jet Propulsion Laboratory, an on-going test program will advance the NEXT thruster to TRL-6. Milestones for FY 2007 include completion of thruster qualification-level environmental testing, delivery of a second prototype model thruster, completion of fully integrated system tests, completion of the performance evaluation review process, and validation of over 250 kg of propellant throughput capability.

Below is a table illustrating the improvements provided by NEXT over the state-of-the-art NSTAR thruster:

Thruster Attribute	NSTAR	NEXT
Max. Input Power (kW)	2.3	6.9
Throttle Range	4.1	10.1
Max. Specific Impulse (s)	3,170	4,100
Efficiency at Full Power	62%	71%
Operational Throughput (kg)	157	>300
Specific Mass (kg/kW)	3.6	2.5

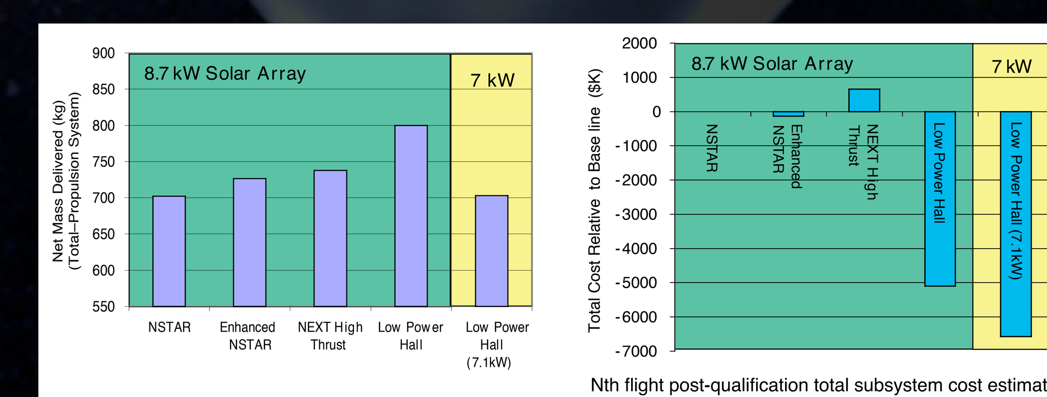




Low Power Hall Thruster Technology Status: High Voltage Hall Accelerator (HiVHAC)

The HiVHAC thruster development program is the first thruster program specifically designed for a low-cost SEP option for cost-capped Discovery and New Frontiers missions. The HiVHAC thruster is designed to operate at high efficiency over a throttle range of 0.3 to 3.5 kW. The large throttle range has both cost and performance benefits for planetary science missions. The HiVHAC thruster has a projected throughput of over 300 kg at specific impulses up to 2,750 s; providing significantly greater performance than state-of-the-art Hall thrusters.

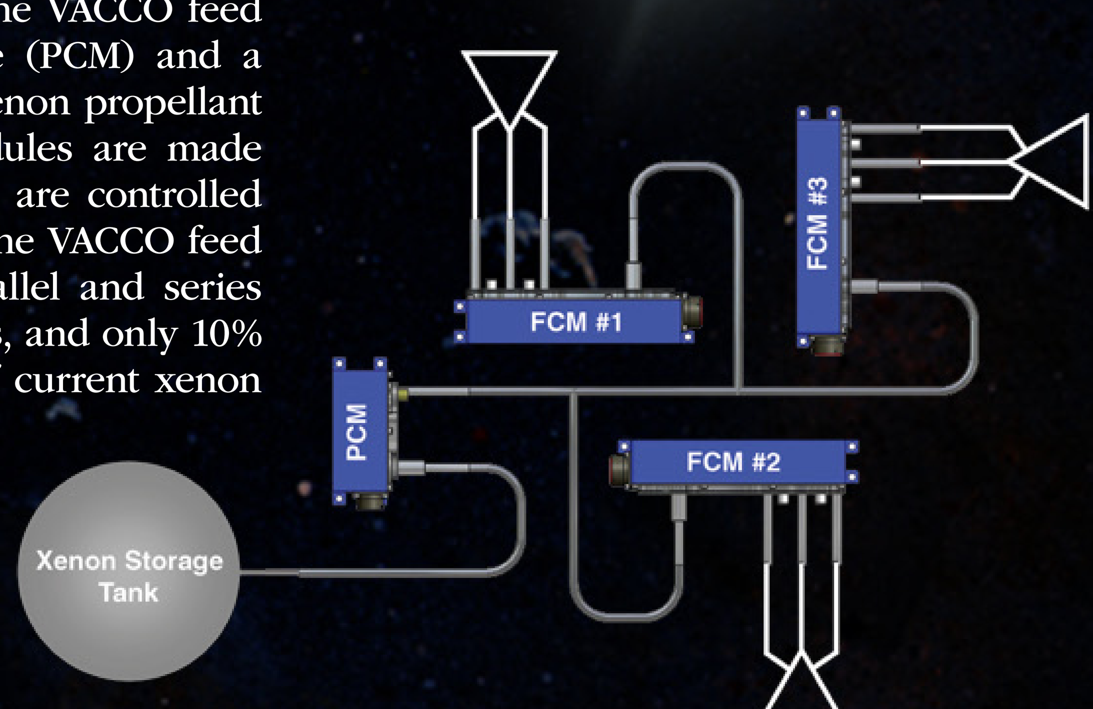
HiVHAC thruster fabrication and initial performance testing was completed in late August at the Glenn Research Center. Long duration wear testing will be conducted throughout FY 2007. Full system development will be undertaken following positive wear test results, with the goal of making HIVHAC available for the Discovery 13 solicitation.



Performance and Cost Comparison for Dawn Mission

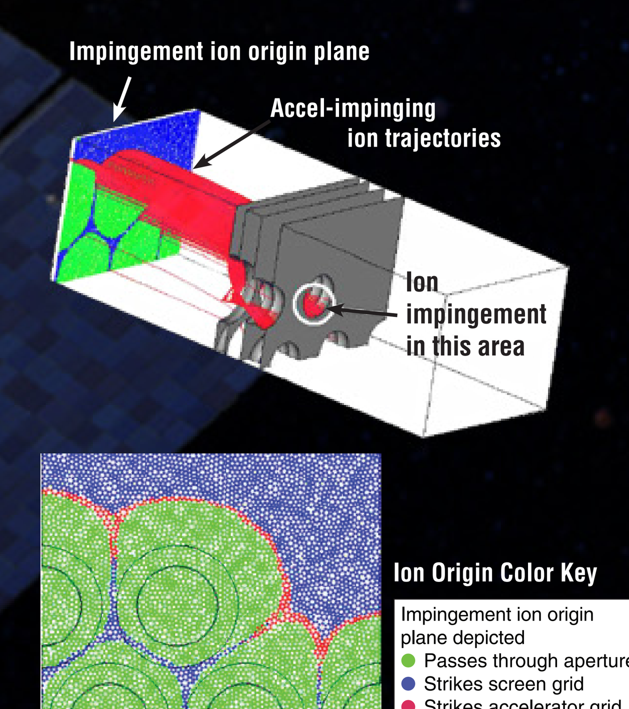
Lightweight, Reliable Feed System Components

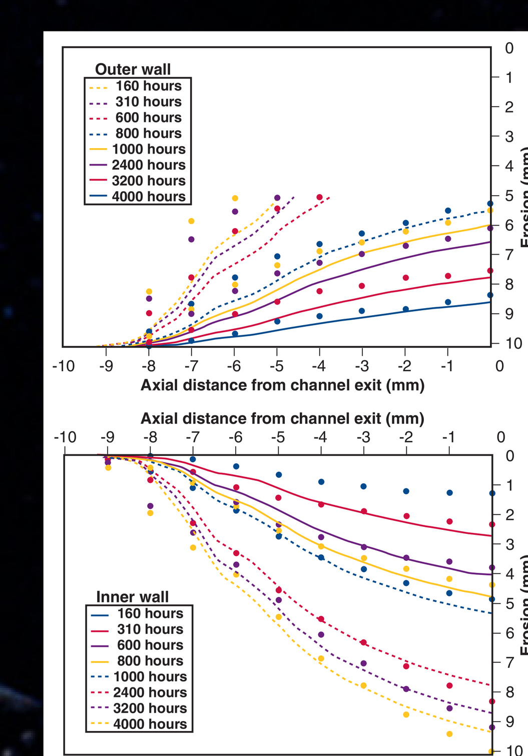
VACCO Industries is developing lightweight feed system components with improved reliability. The VACCO feed system uses a pressure control module (PCM) and a flow control module (FCM) to provide xenon propellant flow with an accuracy ± 3%. The modules are made using diffusion bonding techniques and are controlled by piezoelectric actuated micro valves. The VACCO feed system will have 30% fewer parts, parallel and series redundancy, reduced propellant residuals, and only 10% of the footprint and 20% of the mass of current xenon flow control systems.



Thruster Modeling and Wear Testing

The erosion and wear modeling of EP engines is a critical step in both the design and qualification of new thrusters. The physics of gridded ion engine erosion is very well understood, and numerical models are used to design new ion optics and to accurately predict the life of existing ion optics. For example, models predict a reduction in erosion rates of the existing NSTAR thruster by modifying magnetic fields, and have predicted a lifetime limit for the NEXT thruster at over 700 kg of throughput (considerably more than can be practically demonstrated by ground tests). Hall thrusters also benefit from erosion modeling by predicting which magnetic field topologies provide sufficient operational life, without requiring wear tests of multiple thruster designs. Coupled with numerical models, thruster wear testing is required to validate model predictions and to reduce the risks to future missions. A combination of numerical analysis and limited wear testing can significantly reduce the cost and time for electric thruster life qualification.





For more information, please contact: NEXT—michael.j.patterson@nasa.gov, HiVHAC—david.h.manzella@nasa.gov, Feed System—jcardin@vacco.com, General Information—john.dankanich@nasa.gov

www.nasa.gov

Background by William K. Hartmann Courtesy of UCLA

S-43923