NASA Facts

National Aeronautics and
Space Administration

Marshall Space Flight Center
Huntsville, Alabama 35812

Advanced Chemical Propulsion

Chemical propulsion has provided the basis for rocket system transportation since Dr. Robert Goddard, known as the father of modern rocket propulsion, successfully launched the first liquid fuel rocket in 1926. As NASA prepares for future space exploration, the Agency must continue to improve and develop new chemical propulsion systems. In doing so, there is the opportunity to reduce the mass of launch vehicle systems and the cost of space exploration and provide greater opportunities for science investigations.

Seeking to fulfill these goals, researchers are investigating and developing advanced forms of in-space propulsion technologies to meet future space exploration needs and to enable more ambitious deep space exploration. The In-Space Propulsion Technology Office at NASA's Marshall Space Flight Center in Huntsville, Ala., is investigating innovative chemical formulations and the benefits of new cryogenic systems that capitalize on the potentially high specific impulse (Isp), or performance, of cryogenic propellants; and developing advanced propulsion systems with lightweight materials and optimized components.

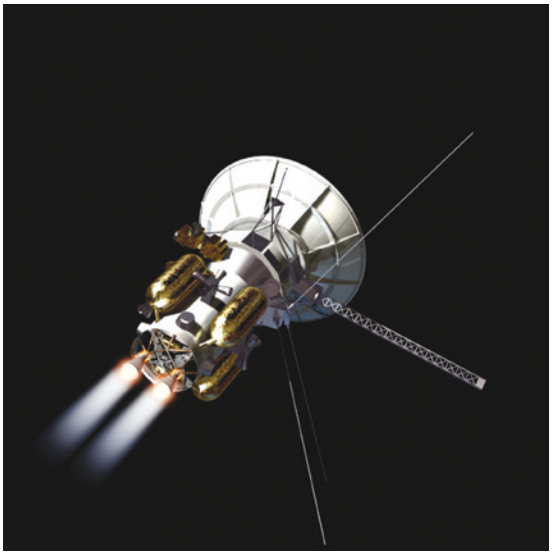
The Marshall Center implements the In-Space Propulsion Technology Program on behalf of NASA's Science Mission Directorate in Washington. NASA fuels discoveries that make the world smarter, healthier and safer.

Advanced Propellant Formulations

NASA scientists and engineers are continually seeking methods to develop high-energy propellants and improve propulsion systems. The challenge facing these researchers is the ability to further improve current chemical formulations that are already approaching their theoretical limits of performance.

Development of innovative gelled propellant formulations is underway. By adding a gelling agent to an appropriate liquid propellant, the requirements for handling, conditioning and storage of the propellant could be reduced, resulting in a more compact system. This also may reduce the number of system components and the amount of power required to maintain the propellant in a useable state.

However, researchers face additional challenges, such as a reduction of propellant performance, when



Artist concept of spacecraft powered by advanced chemical propulsion.

adding gelling agents. To offset this loss in fuel efficiency, energetic particles—usually in the form of metal powders—are added. Unfortunately, additional wear on the fuel injectors and engine is introduced, warranting the need for new engineering designs.

NASA researchers are addressing these issues by investigating and developing new system concepts to produce a useable gelled propellant system with reduced complexity and weight.

Cryogenic Propellants

The development of cryogenic systems and propellants—ones requiring extremely low temperatures for storage—offers the potential for a significant increase in specific impulse. The In-Space Propulsion Technology Office at the Marshall Center is currently investigating cryogenic propellant performance and system concepts that may be beneficial to long-duration science missions. The study is looking at proposed innovative system concepts that will significantly reduce or eliminate the boil-off—loss of vapor from cryogenic propellants during long duration storage in space—avoiding the need to carry excessive amounts of propellant in large tanks.

Advancements in subsystems and components required to contain, thermally condition and deliver these propellants for long-term durations must be accomplished before cryogenic propellants are practical for in-space propulsion applications. Mass optimization through lightweight and improved materials is being pursued in concert with systems and components advancement. Innovative refrigeration and insulation systems also are being identified and advanced, resulting in a reduction in the power and the number of system components required.

Future cryogenic systems may enable some of NASA's most ambitious outer planet investigations, as well as provide in-space support systems for Mars or lunar destinations.

Lightweight/Optimized Propulsion Systems and Components

Most rocket propulsion is accomplished by mixing two liquid chemical propellants. In the space environment, maintaining the propellants in a liquid state requires efficient systems that condition and maintain the fuel and oxidizer at suitably low temperatures.

Active systems—valves, gauges or regulators—are required for refrigeration and thermal control of the propellants. Passive insulation systems such as multi-layer blankets are used as well. Both insulation systems add hardware complexity and weight to the space transportation system. New and improved systems will be required to maintain propellants in the long-term. NASA scientists are addressing these needs.

In the area of lightweight and optimized components and systems, NASA scientists are researching ways to advance component, material and manufacturing technology. This work includes advancing composite materials for propellant tanks to greatly reduce the weight of these essential propulsion system elements, possibly by as much as 50 percent as compared to state-of-the-art titanium tanks, as well as improvements in shield and insulation technology with the potential to replace heavier multi-layer insulation blankets, while also providing optimum meteoroid protection.

Improvements in these areas could result in substantial reduction of the overall systems weight and allow for more payload and scientific instrumentation, resulting in greater scientific return.

More about the Advanced Chemical Propulsion Program

Research for advanced chemical and thermal propulsion for in-space applications focuses on near-term products that can build on the long and proven heritage of state-of-the-art chemical propulsion systems. In-space technologists aim to optimize current technology, such as pressurization and mixture-ratio control, to improve propulsion systems performance—yielding more cost-efficient exploration of the space frontier.

The Marshall Space Flight Center in Huntsville is partnering with other NASA centers—Jet Propulsion Laboratory in Pasadena, Calif.; Glenn Research Center in Cleveland, Ohio; Ames Research Center in Moffett Field, Calif.; and Johnson Space Center through its White Sands Test Facility in Las Cruces, N.M.—for advanced chemical and thermal propulsion research. Industry partners include Boeing Space Systems in Huntington Beach, Calif., and Carleton Technologies Inc., Pressure Technology Division in Glenn Burnie, Md.

Research in the technology area is being funded by the In-Space Propulsion Technology Program, which is managed by NASA's Science Mission Directorate in Washington and implemented by the In-Space Propulsion Technology Office at the Marshall Space Flight Center in Huntsville, Ala. The program's objective is to develop in-space propulsion technologies that can enable or benefit near and mid-term NASA space science missions by significantly reducing cost, mass and travel times.

For more information, visit:
http://www.nasa.gov
http://www.inspacepropulsion.com

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