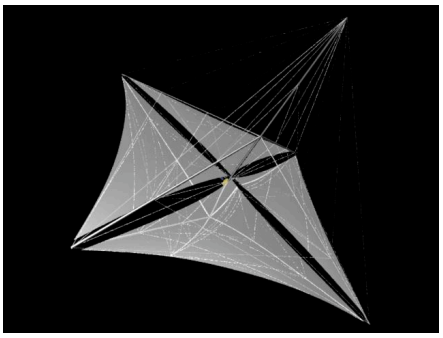
The ST9 Solar Sail and the Exploration Vision



Solar sails are envisioned as a cost-effective means of propelling small spacecraft in the inner solar system to very high velocity ($\Delta v > 50$ km/s). Due to their potential high performance, solar sails enable missions that seek to study the Sun and its effects on the planets from unique vantage points. Relying on the Sun's continuous supply of photons to provide low-thrust propulsion, solar sails are ideal for station-keeping and would also enable missions in non-Keplerian orbits, which are currently not feasible by other means.

Direct Benefits of the Solar Sail to Exploration

Double the warning time for human and robotic exploration in the earth-moon system via an upstream, **sub-L1** monitor of solar energetic particles and the solar wind (L1 Diamond, Geostorm);

Enhanced capability for solar sentinels in the ecliptic plane that provide continuous warning of solar effects throughout the solar system;

Imaging of the ecliptic plane from above or below the Sun's poles to comprehensively monitor the inner heliosphere;

Provide a continuous telecommunications relay between Earth, the Moon and Mars;

Enable pathfinder exploration beyond the solar system.

Indirect Benefits of the Solar Sail to Exploration

Cost-effectively enable science missions that significantly advance our understanding of the Sun and the ability to monitor and predict its behavior (Solar Polar Imager, Particle Acceleration Solar Orbiter);

Validation of models and processes for gossamer structures that have applicability for sunshades (planet-finding telescopes), large apertures, and space solar power;

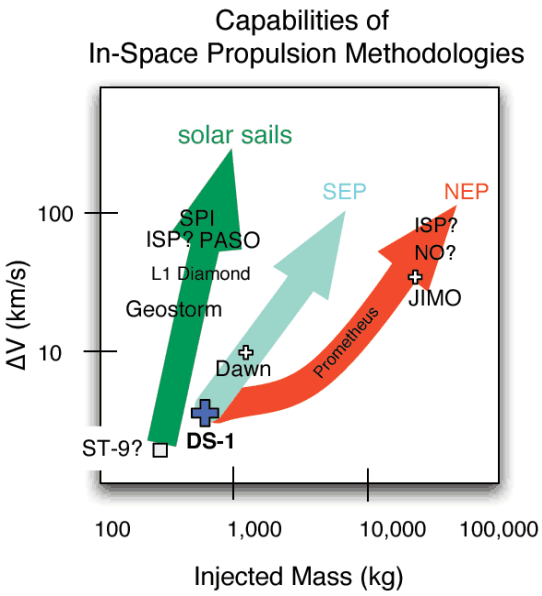
Inspection micro-craft for large space vehicles;

Validation of new measurement techniques based upon a large membrane in space (e.g. high sensitivity dust detectors).

Background

A solar sail flight validation would develop and operate in space, a deployable solar sail that can be steered and that provides measurable acceleration. The approach for the experiment

would be to test and validate the models and processes for solar sail design, fabrication, deployment, and flight. Such models and processes can then be used *with confidence* to design, fabricate, and operate the larger solar sails needed for strategic and future competitive missions. The New Millennium Program has solicited technology providers for a solar sail (and four other concept areas) for the Space Technology Nine (ST9) opportunity: http://nmp.jpl.nasa.gov/

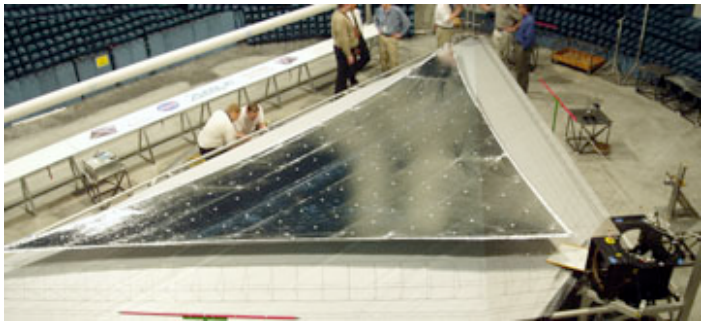


Strategic Niche of the Solar Sail

The solar sail is complementary to other propulsion technologies currently being developed by NASA. Nuclear power and nuclear electric propulsion (NEP) are a necessity for advanced missions to the outer planets (where solar flux is low), for large exploration payloads, and for extended surface operations on the Moon or Mars. A solar sail system can operate efficiently anywhere in the inner solar system and its launch mass is largely independent of the total mission delta-V requirement, making it ideal for long duration missions requiring continuous low-thrust. The niche of the solar sail stems from its high performance in the inner solar system (see chart at left) and the propellantless nature of the propulsion. Unlike conventional propulsion systems, the sail will receive a continual low thrust when facing the Sun, and will need little or no propellant even for attitude control. Since the thrust is continual and limited only by the structural integrity of the sail itself, long-term station-keeping at otherwise inaccessible vantage points is enabled.

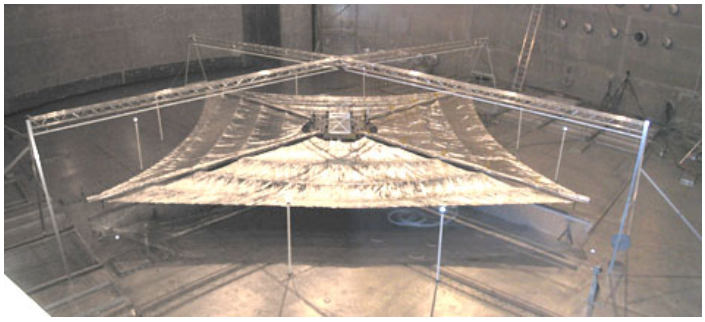
Maturity of Solar Sail Technology

As a result of the investment by the In-Space Propulsion Technologies (ISPT) Program, solar sail technology is rapidly approaching readiness for flight. A 10-m sail quadrant has been deployed and tested in a vacuum chamber at LaRC (see image at right).



10-m sail quadrant, post-deployment in vacuum chamber

A second, 4-quadrant sail concept has been tested at the Space Power Facility at GRC/Plum Brook in July 2004 (see image at right). In the early spring of 2005, vacuum deployment and testing of flight-like, 20-m sails will take place at GRC/Plum Brook.



10-m, 4-quadrant sail, post-deployment in vacuum chamber

ISPT is also funding development of essential components for solar sails such as system tools for mission planning, an optical diagnostic system, advanced structural modeling, and lightweight boom architectures.

The **Solar Sail Technology & Applications Conference** was held on 28-29 September 2004 in Greenbelt, MD. Presentations may be found at: https://www.infonetic.com/tis_conferences/sst/

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