SPACE PROPULSION SYMPOSIUM (C4)
Special Session on "Missions Enabled by New Propulsion Technologies and Systems" (6)

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PROPULSION TECHNOLOGIES FOR THE FLEXIBLE PATH EXPLORATION STRATEGY

Abstract

In 2009, the new U.S. Presidential Administration convened a special committee, led by former aerospace executive Norman Augustine, to recommend options for the future direction of human space flight. One of the two preferred options – the so-called "Flexible Path" strategy – differs substantially from the Moon and Mars-oriented paradigm that has driven U.S. investment in the past. It refrains from placing humans on planetary surfaces at the bottom of large gravity wells, and instead concentrates on sending piloted spacecraft to in-space locations and to the surfaces of small planetary bodies. The main advantage of Flexible Path is that it avoids the need to develop man-rated spacecraft and propulsion systems for descent and ascent in large gravity wells, and eliminates the need for large man-rated systems on the surface. The evolution in propulsion capability for Flexible Path will feature in-space propulsion systems capable of transporting human crews to Mars, NEAs and possibly Venus orbit. In the far-term it will require advanced technologies to enable missions beyond Mars to the Asteroid Belt and perhaps the Jovian system.

This paper describes the in-space transportation challenges associated with Flexible Path and the best propulsion technologies to meet these in the future. A key strength is that near-term missions can be performed with systems currently under development or upgrades to existing ones. For near-term missions to Lagrange Points, lunar orbit and near-vicinity NEAs, propulsion work will center on incorporating man-rated standards into existing systems, including the man-rating of current upper stage engines, completing development of the J-2X, and enhancing propulsive capability to the Orion spacecraft. Electric propulsion will likely be required as a high-performance stage for in-space orbital servicing and cargo transport.

Propulsion technology needs become more demanding with missions to Mars orbit, Phobos, Deimos, more remote NEAs and Venus orbit. New propulsion technologies will be required. These include cryogenic fluid management for long-duration storage of liquid hydrogen, other propellants and life support fluids; nuclear thermal propulsion; high power electric; and plasma propulsion, along with advancements in very high specific power solar energy systems.

The long-term culmination of Flexible Path favors the development of several advanced propulsion technologies and active research into their demonstration in the near-term. These include In-situ Resource Utilization (ISRU) to support large robotic and eventually crew systems on planetary surfaces; advanced nuclear propulsion (e.g., bimodal nuclear thermal rockets, gas-core nuclear rockets, fusion, antimatter); advanced plasma propulsion; aerocapture; and tethers.