

Ion Beam Propulsion Study



Spacecraft
Nutation Models

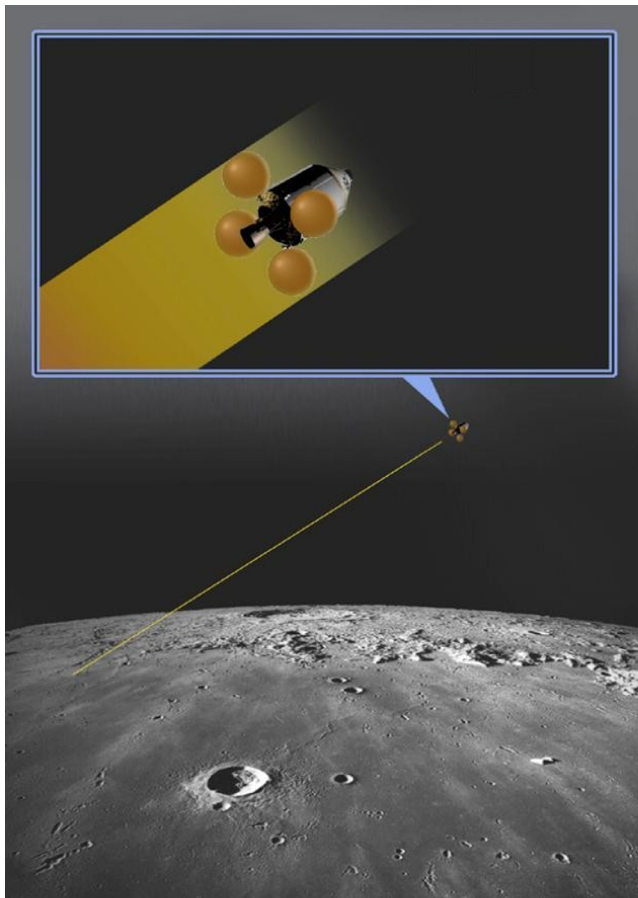
The Ion Beam Propulsion Study was a joint high-level study between the Applied Physics Laboratory operated by NASA and ASRC Aerospace at Kennedy Space Center, Florida, and Berkeley Scientific, Berkeley, California. The results were promising and suggested that work should continue if future funding becomes available.

The application of ion thrusters for spacecraft propulsion is limited to quite modest ion sources with similarly modest ion beam parameters because of the mass penalty associated with the ion source and its power supply system. Also, the ion source technology has not been able to provide very high-power ion beams. Small ion beam propulsion systems were used with considerable success. Ion propulsion systems brought into practice use an onboard ion source to form an energetic ion beam, typically Xe^+ ions, as the propellant. Such systems were used for steering and correction of telecommunication satellites and as the main thruster for the Deep Space 1 demonstration mission. In recent years, “giant” ion sources were developed for the controlled-fusion research effort worldwide, with beam parameters many orders of magnitude greater than the tiny ones of conventional space thruster application. The advent of such huge ion beam sources and the need for advanced propulsion systems for exploration of the solar system suggest a fresh look at ion beam propulsion, now with the giant fusion sources in mind.

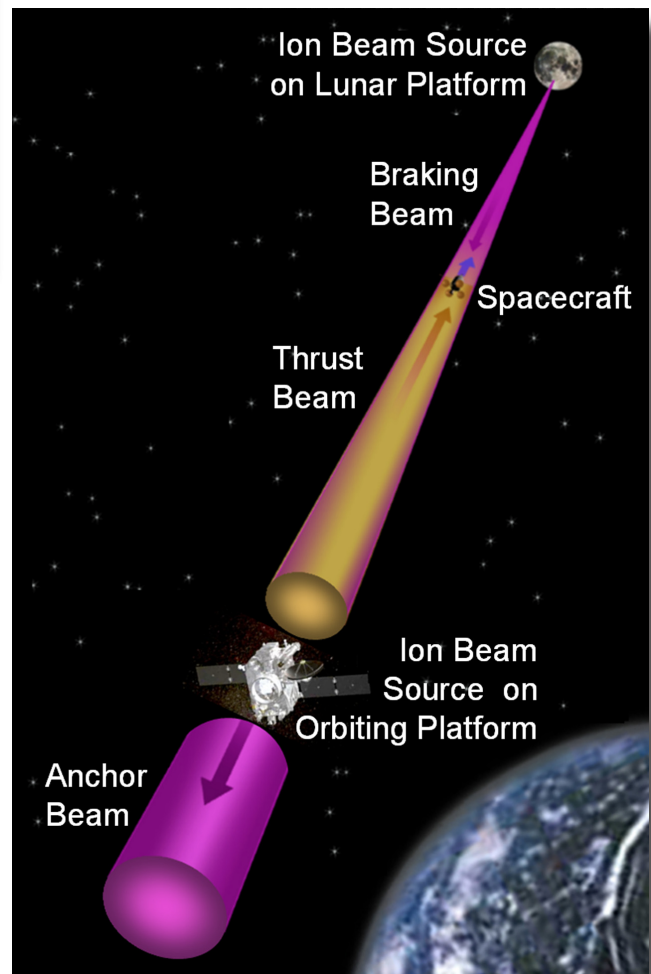
At the same time, the severe mass penalty associated with such huge ion sources and their power supply systems calls for innovative approaches that could avoid this substantial drawback. The giant ion source and its power supply system are located not onboard the spacecraft but at a fixed location, with the powerful ion beam directed toward an “ion beam sail,” which collects the beam and transfers momentum to the spacecraft, thus providing thrust. Several related but different embodiments of this approach are envisioned. The ion source cumulative power supply system could be located on the lunar surface (but not on the Earth’s surface because the ion beam will not propagate through the atmosphere) or in space (e.g., Earth orbit), with the reaction force from the driving ion beam balanced by another identical ion beam that provides equal and opposite reaction force and thus anchors the beam generator system. Further, the ion beam sail might be passive, simply collecting the beam and transferring momentum to the vessel, with the thrust vector aligned with the incident ion beam; or it might be active (electrostatically biased) so as to reflect some of the incident beam in a controllable way, thus providing the possibility of steering the spacecraft. Alternatively, the sail might be a system of a number of sail segments, perhaps spherical appendages that could be independently positioned and electrically biased. In this way, the incident ion beam, rather than being absorbed by a passive collector, could be deflected in a chosen direction, adding a new thrust vector to the system and thereby allowing momentum to be transferred in a direction other than toward the incident ion beam.

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Ion beam generator located on the surface of the Moon.



Dual ion beam generator positioned in Earth orbit.