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Technology Roadmaps for Space Exploration (09)
Advancing Propulsion Technologies (4)

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ELECTRIC PROPULSION; AN ESSENTIAL TECHNOLOGY FOR SPACE EXPLORATION

Abstract

Many challenging mission scenarios for space propulsion require a high deltaV, such as deep space exploration, interplanetary missions, asteroid rendezvous and sample return missions and human space exploration, notably missions to Mars. Electric propulsion offers a genuine solution to the technical challenges facing each of these mission scenarios and the vast diversity of different EP technologies permits a wide range of applications:

1) Thrusters with high specific impulse (6000s or higher) and moderate thrust (up to a few hundred milli-Newtons) can and have been used for missions inside the solar system. Missions to asteroids such as DEEP SPACE 1, HYABUSA and DAWN were successfully completed using electric propulsion and the upcoming BepiColombo mission to Mercury can only be enabled through the use of EP. A significant advantage of EP over chemical propulsion on these missions is the reduced flight time it can provide but EP also enables greater mission flexibility, permitting wider launch windows and even the possibility of changing target or mission objective, as demonstrated in the case of HAYABUSA.

2) Thrusters with high specific impulse but very small and very precise thrust levels (micro-Newton regime) can be used for deep space observation missions involving spacecraft formation flying. These missions have very strict demands on attitude control but also have strict mass and volume constraints, which can be met by miniature EP technologies.

3) A realistic human interplanetary mission (Mars exploration), with a maximum allowed mission duration of two years, can only currently be achieved with EP. In this case thrusters with very high thrust (up to several hundred Newtons) with very high specific impulse will be necessary. The different EP technologies ranging from simple electrical heating of propellant through to ion and plasma thruters up to superconducting helicon thrusters offer a thrusting solution for each of the named scenarios.

This paper provides an overview of the different EP technologies summarizing their advantages and disadvantages. The application of EP for some representative space exploration mission scenarios, and the benefits that it can provide, will also be discussed.