From Earth Missions to Deep Space Exploration (05)
Exploration Capabilities (1)

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THIS WAY TO DEEP SPACE: ELECTRIC PROPULSION HUMAN MISSIONS TO ASTEROIDS, THE MOON, AND MARS

Abstract

The Dawn robotic science spacecraft is relying on its high-performance solar electric propulsion (SEP) system to provide a post-launch ΔV of 11 km/s (it has already provided nearly 7 km/s since its launch in 2007). This high-ΔV capability, if scaled up to power levels required for human-scale missions, has the potential to enable an affordable path to human exploration beyond low-Earth orbit. The Dawn spacecraft has a 10-kW solar array (at 1 AU) and a maximum input power to its electric propulsion system of 2.5 kW. The largest commercial communication satellites currently have 24-kW solar arrays (beginning-of-life) and some of these have electric propulsion systems that operate with input powers up to 9 kW. In this paper, we demonstrate that cislunar human missions become possible with SEP systems at power levels of about 30 kW, asteroid missions are possible at power leveles of 80-300 kW, and Mars and Mars moon missions are possible at powere levels of 200-600 kW.

We combine these missions into an exploration campaign in which SEP systems of increasing power are used to support human exploration missions of increasing complexity and distance from Earth. This campaign emphasizes flexibility and sustainability over a focus on any one mission. In this way disruptions from delayed development of any one element or political re-direction are minimized. Early emphasis on in-space propulsion technology reduces the cost impact of mass growth in flight elements. In-space elements from early missions are reused to reduced the launch mass required for later missions. Alternate development paths are presented as contingencies should a planned technology development (such as radiation protection) proves to be more difficult than expect.