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HIGH POWER ELECTRIC PROPULSION (HIPER) STUDY NUCLEAR ELECTRIC POWERED MISSIONS

Abstract

As the exploration of the inner solar system becomes more established thoughts are turning to missions to Jupiter, its moons and beyond. The 'High Power Electric Propulsion; a Roadmap for the Future (HiPER)' project has analysed how best electric propulsion could support such missions. Significant benefits in schedule and payload fraction have been identified when compared to chemical propulsion for the inter-planetary transit.

Sufficiently large solar power arrays become increasingly impractical beyond 1.6 AU. Nuclear electric powered missions have been considered for many years but it is difficult to justify the overheads of developing this capability for one or two missions. Although nuclear electric propulsion may be considered mission enabling only for rendezvous with or sample return from the outer planets once developed it could also bring significant benefit to other missions. Of particular interest is the ability of a nuclear space tug to shuttle large payloads quickly and efficiently between destinations in the inner solar system and the asteroid belt. Potential applications include large infrastructure assembly at L2 or on Mars, asteroid mining or even a space-port' and the Earth-Moon first Lagrange point (EML1).

There are practical constraints in designing a nuclear electric powered spacecraft which must be allowed for in future mission design. These include the lift capability and internal faring size of the Ariane 5 ECA launcher and a mass efficient high power electrical configuration and feasibility depends on mass-efficient radiation shielding. Power system configuration and shielding mass efficiency must also be compatible with thruster locations optimised for maximum effective velocity without risk of exhaust plume damage to the spacecraft.

Initial specific mass, lifetime and efficiency targets for a nuclear power generator design to meet nominal mission objectives were selected in the Study to exploit the capabilities of envisaged gridded ion engine, Hall Effect thruster and magneto plasma dynamic thruster electric propulsion systems. The targets were based on the US and Russian fusion nuclear electric space power generator experience and more recent European studies. The ability to deliver the targets has been assessed within the Ariane 5 launch and other constraints through modelling and simulation.

The paper presents the mission benefits identified during the initial analysis based on the design targets. It then reviews the modification to targets arising from practical constraints and nuclear power generator modelling and simulation. The benefits to the potential missions are then updated in the light of these findings.