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A COMPREHENSIVE METHODOLOGY FOR DESIGNING A NUCLEAR ELECTRIC PROPULSION (NEP) CONCEPT

Abstract

A multidisciplinary team is conducting an assessment of Nuclear Electric Propulsion technologies for the European Space Agency (ESA) within the frame of the Future Launcher Preparatory Program (FLPP). One of the key objectives of this project is to identify the more promising NEP concepts that could be developed in Europe. The starting point for this assessment are six Use-Cases (UCs) proposed by ESA, expected to cover demands for medium and long-term missions to earth, Moon, Mars orbits and exploration beyond Mars. This work presents a comprehensive methodology for designing a NEP system, beginning with the selected Use-Cases and provides preliminary results of the study. In the proposed methodology, the selected Use-Cases serve as the starting point for determining approximate mission requirements. These requirements are then refined based on an initial market assessment. The goal of the market analysis is to characterize potential markets for the Use-Case, estimate the potential payload and establish economic objectives to ensure competitiveness compared to other alternatives such as chemical and solar electric propulsion systems. The refined mission requirements derived from the

original Use-Case are used to determine approximate design requirements, including the reactor power and the mission duration. Based on these design requirements, NEP design studies were conducted, considering different thermal powers from a few kilowatts to several hundred of kilowatts to cover various possible scenarios. Furthermore, following a review of existing NEP technologies, two main reference reactor concepts were selected for detailed design studies: a Heat Pipe Reactor (HPR) concept at low power applications and a Molten Salt Reactor (MSR) concept for moderate to high power applications (exceeding approximately 100 kW). The design studies aim to determine the approximate layouts and materials for the reactor, as well as define power conversion, radiator and electric propulsion systems. They also allowed for obtaining approximate estimates of the masses of the NEP system, propellant and payload for each Use-Case. Additionally, a preliminary safety analysis was included in the studies. Results from the design studies were then used to update the market assessment, providing a comprehensive evaluation of whether the proposed concepts are likely to meet the technical, safety and cost requirements necessary for competitiveness against other technologies.