Paper ID: 45052
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IAF SPACE PROPULSION SYMPOSIUM (C4)
Joint Session on Advanced and Nuclear Power and Propulsion Systems (7-C3.5)

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CONCEPTUAL DESIGN AND ECONOMIC STUDY FOR A COMPACT NUCLEAR REACTOR TO ENABLE FUTURE HUMAN SPACE EXPLORATION

Abstract

Human exploration in space is at its dawn, with the Lunar Orbital Platform-Gateway (LOP-G) project and the human return to the Moon being considered as the next steps towards space exploration.

Building first the cislunar space station and then bringing human presence to the Moon is perceived by many as the upcoming international space endeavors that will be undertaken, and providing sufficient and sustainable power production to feed such settlements will be pivotal for the success of these missions. As science keeps improving, compact nuclear fission reactors could emerge as a solution to produce the needed electrical power to fully ensure the establishment of a long-term human presence in space. The goal sought through this study is also to guarantee complete mission autonomy and dissociate from constraints such as sun exposure, working in shadowed areas, very long-distance travels, etc., that hinder current power generation methods (i.e. solar panels, fuel cells).

This work presents a conceptual design and an economic feasibility study for a standard and compact nuclear fission reactor using molten salts as a coolant material and Thorium as fuel to produce electricity. This arrangement is easier to control than classical uranium and, in addition, the structure would be coupled with the latest heavy deflector technology that is starting to be used today, in order to protect the habitats from radiations. The proposed concept is built by bringing together the latest nuclear science advancements by focusing on matching their respective natural advantages and by complying to the current launchers volume capacities and restrictions, to ease its access to space. The ultimate objective of this new design would be to rend the reactors as standard power plant units available off-the-shelf for direct integration in future spacecraft.

This technical proposal will be built based on the future needs of the LOP-G and a potential lunar settlement (i.e. ideal quantity of power desired) and will also be subject of an economical study that will provide the necessary input to adapt the reactor's design to the capabilities available today. These include; launcher capacity, international budgets, habitat and life support architectures, scientific and mission objectives, as well as low-cost components available and suitable for the reactor.

This innovative standard compact powerplant conceptual design would greatly enhance the return of manned exploration missions in deep space and establish its presence in a permanent manner by providing a novel electrical production technology using concepts already developed today.