Paper ID: 90149
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IAF SPACE PROPULSION SYMPOSIUM (C4)
Joint Session on Nuclear Power and Propulsion Systems, and Propellantless Propulsion (10-C3.5)

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UNITED KINGDOM'S CONTRIBUTIONS TO ENHANCING NUCLEAR POWER SYSTEMS FOR SPACE EXPLORATION

Abstract

Nuclear power is an increasingly important strategic enabler for commercial and multinational space missions. All space missions require power. With the anticipated increase in commercial missions over the coming decade, there is a growing demand for power for robotic exploration of the Solar System and the return of humans to the Moon. For missions to the outer Solar System, the effectiveness of solar power decreases quadratically with distance from the Sun, making nuclear power sources often the best or only option.

Simultaneously, nuclear propulsion addresses the need for high transfer delta-V in space exploration missions, effectively bridging the gap between high-thrust/low-specific-impulse chemical propulsion and very-low-thrust/high-specific-impulse solar electric propulsion systems. This enables reaching trajectories, pass times, and return windows that are compatible with exploration ambitions.

The UK is uniquely positioned to develop this technology and provide it to space agencies and private companies, owing to its rich industrial heritage and capabilities in both space and nuclear sectors. The strategic approach is based on three distinct pillars of activity, each with significant potential for the UK:

1. Heat and power for robotic spacecraft or rovers: Radioisotope Power Systems offer essential, reliable power, notably for the Moon's extended 'lunar nights' and missions to Mars. The UK's stockpile of nuclear waste can provide fuel for new system developments, meeting global demand. This supports ESA's exploration strategy and may enable new global partnerships..
2. Power for human exploration on the Moon: Fission power is crucial for sustaining future, extended lunar missions, powering habitats, vehicles, and drilling operations. The simplicity and modularity of fission-based microreactors present a promising solution to meet these energy needs.
3. Propulsion for deep-space missions: Nuclear Electric Propulsion (NEP) and Nuclear Thermal Propulsion (NTP) offer advanced propulsion for space exploration; NEP provides durable, low-level electric propulsion, while NTP's fission-based method delivers significantly more power, supporting larger, more frequent Solar System missions.

The UK Space Agency, in cooperation with other UK governmental authorities and sponsors, is delivering this strategy through various national grants, contributions to ESA programmes, and bilateral cooperation. The Agency is also contributing to all aspects related to the international regulation to ensure nuclear systems in space are used sustainably, safely, and peacefully.

This paper presents the technical elements of ongoing activities, provides a view on the challenges, and offers a perspective on the possible path to the full realisation of the UK's nuclear ambitions in space exploration.