Development of an European operational capability for the use of Radioisotope Power Source in Space

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Introduction: Radio-isotope heat and power system (RPS) technologies are critical enablers for sustained exploration of the Moon and Mars, as well as science missions to the outer solar system bodies. Radioisotope Heater Units (RHUs) and Radioisotope Thermoelectric Generators (RTGs) have been used extensively on many robotic missions beyond LEO since the 1960's, including for ESA missions. To date, most missions to the Martian surface rely on RHU or RTG units to provide heat and survival power during the Martian nights. Likewise, radioisotope power provides the most efficient solution for surviving the up to 14 Earth-day lunar night. Exploration of the outer solar system beyond Jupiter is very constrained when relying on solar power and certainly only possible with RTGs beyond Saturn.

Despite the critical requirement of radioisotope power for solar system exploration, there is currently no operational capability in Europe.

Development of European capabilities for radioisotope heat and power began over a decade ago and a technical readiness of TRL 4 for both RHUs and RTGs has been achieved through a range of activities conducted through ESA's technology programmes (GSTP), E3P ExPeRT element as well as national and other European activities [1]. The European technology is based on Americium-241 (Am-241) derived from chemical re-processing of waste from nuclear power stations. The basic principles of fuel production and encapsulation have been demonstrated in European technology development activities, including the production of sub-scale Am-241 Oxide fuel pellets. The safety aspects on ground, during launch on the European launcher Ariane, but also potentially on the Moon surface in case of astronaut interaction, have been addressed and a safety process is under definition[2], in line with the recommendations provided by the international safety framework for the use of nuclear power sources in outer space.[3]

Several proposed ESA space Exploration missions and core capabilities have been identified as potential users of an end-to-end RPS capability ([4]). To deliver this end-to-end European operational capability for RPS heat and power systems by the end of this decade, ESA has developed an across-Agency multi-Directorate activity to be started in 2023, including specifically the directorates responsible for exploration, science, technology and space transportation. To achieve this goal, three key objectives will be addressed:

1. Fuel Production and encapsulation capability.
2. RPS Systems Development.
3. Launch Safety Authorisation Process, launch site and launcher adaptations.

The overall objective of the activity initiative, which is proposed within the main ESA technology development programme, is to reach an operational capability of production and certification of RPS units for space before 2030. In this paper the details and the associated technology roadmap will be presented.

References:

[1] R. M. Ambrosi et al. "European Radioisotope Power Systems Programme: Recent Updates", Nuclear and Emerging Technologies for Space, Knoxville, TN, April 6 – April 9, 2020, https://nets2020.ornl.gov.

[2] Barco A., Ambrosi R. M., Williams, H. R., Stephenson, K., 'Radioisotope power systems in space missions: Overview of the safety aspects and recommendations for the European Safety case, Journal of Space Safety Engineering 7 (2020) 137-149.

[3] *Safety Framework for Nuclear Power Source Applications in Outer Space*. United Nations Committee on the Peaceful Uses of Outer Space and IAEA, 2009.

[4] ESA Terrae Novae – Exploration Strategy https://www.esa.int/Science_Exploration/Human_and_Robotic_Exploration/Exploration/Terrae_Novae_Europe_s_exploration_vision