Foreword

Selected papers from the 2021 Nuclear and Emerging Technologies for Space Topical Meeting (NETS 2021)

Guest Editor

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Nuclear technologies have played a long and successful role in the exploration of space. Within the United States, there has been a strong legacy of the development of radioisotope, fission, and other advanced technologies (such as non-solid-core fission, fusion, antimatter, hybrid fission–fusion technologies, and many others) for in-space power and propulsion. The United States has had much success in the use of radioisotope thermoelectric generators (RTGs) in space missions since 1961, when the first RTG, the SNAP 3B onboard the U.S. Navy *Transit 4A* spacecraft, successfully deployed in space. The *Voyager* spacecraft are another example of successful RTG-enabled missions, which have surpassed their initial mission objectives and have persisted to operate since their 1977 launch, becoming the first humanmade spacecraft to leave our solar system and enter interstellar space. Solid-core fission technologies also have a rich development history but require additional development. The SNAP 10A reactor remains the only reactor operated in space by the United States. Launched in April 1965, the SNAP 10A reactor provided electrical power in space for 43 days until a nonreactor subsystem failure required the reactor to be shut down.

For current National Aeronautics and Space Administration (NASA) missions, nuclear technologies continue to play a strong role in space exploration. The Mars *Perseverance* rover, which successfully landed and began operations in February 2021, relies upon a multimission radioisotope thermoelectric generator (MMRTG). Future science missions are planned that will continue to leverage RTG technologies, including the Dragonfly mission, which will use an MMRTG to power a rotorcraft to explore Saturn's largest moon, Titan. Fission technologies are also under consideration by NASA. For instance, NASA is developing a fission power system to provide a long-duration power source that would help to enable a sustainable presence on the moon and Mars. Nuclear electric and nuclear thermal propulsion technologies are also being developed to reduce trip times and enable short-duration opposition-class crewed missions to Mars. Other applications of nuclear technologies are under consideration, as well, both within the United States and internationally. Because of this, space nuclear technologies are currently undergoing some of the most significant advancement in the past 20 years.

This special issue of *Nuclear Technology* features a selection of eight technical papers and two technical notes derived from the 2021 Nuclear and Emerging Technologies for Space (NETS) conference, hosted (virtually) by Oak Ridge National Laboratory April 26–30, 2021. Each year, representatives from government, industry, and academia gather at the NETS conference to present the latest progress in the development of space nuclear and other advanced technologies. After a year delayed due to the pandemic, this year we gathered together again, albeit online, to hear the latest research, science, technology, and policy advancements related to the use of nuclear technologies for space applications. The NETS 2021 conference had 285 people in attendance with over 70 full technical presentations and 30 lightning talks spanning four unique technical tracks:

Track 1: Radioisotopes and power conversion systems (chair: Scott Wilson, NASA Glenn Research Center)

Track 2: Nuclear fission power and propulsion (chair: Paolo Venneri, Ultra Safe Nuclear)

Track 3: Mission concepts and policy for nuclear space systems (chairs: Bhavya Lal, NASA; Susannah Howieson, U.S. Department of Energy)

Track 4: Advanced and emerging technologies for nuclear space applications (chairs: Gerald Jackson, HBar Technologies; Steven Howe, Howe Industries).

During NETS 2021, several panels highlighted emerging needs for thermoelectric and dynamic power conversion technologies for radioisotope power systems; the latest findings from the National Academies of Science, Engineering, and Medicine on space nuclear propulsion (fission) technologies under consideration for crewed Mars missions; industry advancement of space reactor technologies; updates to the launch approval process for nuclear technologies; and technology challenges for the implementation of advanced technologies. The conference proceedings spans a wide array of ongoing development efforts, mission planning, and policy advancements. These include the deployment and qualification testing of the MMRTG for use in the Mars *Perseverance* rover, the development of dynamic power conversion systems (i.e., heat engines) to increase the efficiency of radioisotope power systems, design and analysis of high-performance space fission systems for lunar power applications or in-space propulsion to Mars, mission needs and opportunities for the use of nuclear technologies for in-space crewed exploration and robotic science missions, the impact of new U.S. presidential memoranda and space policy on missions using nuclear technologies, as well as advanced in-space fusion or antimatter propulsion technologies. The invited publications in this special issue highlight a subset of the ongoing efforts related to these impactful topics.

On behalf of the NETS 2021 technical committee, I would like to extend a huge thank-you to the authors who contributed to this special issue and their efforts to update their original NETS summaries to meet the standards expected of a *Nuclear Technology* publication. We would also like to thank *Nuclear Technology* staff, specifically Andrew Klein for his continued support in the publication of NETS special issues and Mary Tong for coordinating all publications to ensure this special issue was a success. Last, I extend another thank-you to the track chairs, fellow members of the technical committee Lawrence Heilbronn and Michael Smith, our conference general chair Robert Wham, and conference assistant chair Richard Howard.

If you are excited by any of the publications in this special issue and are interested in learning more, please look up the NETS 2022 conference proceedings (meeting hosted by the NASA Glenn Research Center in Cleveland, Ohio, May 8–12, 2022) at www.ans.org/pubs/proceedings/issue-3201/. We are also looking forward to NETS 2023 in Idaho Falls, Idaho, May 7–11, 2023, and we hope to see you there.

Per aspera ad astra!

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