IAEA Webinar on the Use of Nuclear Energy in Space

March 23 (EIRNS)—Over 500 people from 66 countries attended a two-day webinar, “Atoms for Space: Nuclear Systems for Space Exploration,” Feb. 15 and 16, sponsored by the International Atomic Energy Agency, to hear a panel of experts from the public and private sectors discuss “a new age of space travel to Mars, our solar system, and beyond, as nuclear power and related technologies promise to make interplanetary missions faster, more efficient and economical.” [https://www.iaea.org/newscenter/news/nuclear-technology-set-to-propel-and-power-future-space-missions-iaea-panel-says]

Mikhail Chudakov, Deputy Director General, IAEA; and Head of the Department of Nuclear Energy:

“Nuclear technology has long played a vital role in prominent space missions, but future missions could rely on nuclear powered systems for a much broader spectrum of applications. Our pathway to the stars runs through the atom.”

Propulsion Options

William Emrich, former Lead Project Engineer at NASA, added that a solid candidate to be used for space travel is Nuclear Thermal Propulsion (NTP):

“Crewed interplanetary missions of the future will almost certainly require propulsion systems with performance levels greatly exceeding that of today’s best chemical engines.”

In NTP, a nuclear fission reactor heats up a liquid propellant, for example, hydrogen, until it turns into a gas, which expands through a nozzle to provide thrust and propel a spacecraft. The advantages of NTP are that space flights would need to lift less fuel into space, and NTP engines would reduce trip times—cutting travel time to Mars by up to 25% compared to chemically fueled rockets. Reduced time in space also reduces astronauts’ exposure to cosmic radiation.

Another option is Nuclear Electric Propulsion (NEP), in which the thrust is provided by converting the thermal energy from a nuclear reactor directly into electrical energy, eliminating the associated NTP needs and limitations of storing propellants onboard. In NEP, the thrust is lower but continuous, and the fuel efficiency far greater, resulting in a higher speed and potentially over 60% reduction in transit time to Mars compared to chemically fueled rockets.

Citing a China Academy of Space Technology study from 2015, which found that human Mars missions would not be feasible without space nuclear reactors, Hui Du of the Beijing Institute of Spacecraft System Engineering, reinforced the consensus about fission power in space:

"For space missions that need high electric power output, such as a human Mars mission or space ferries, a fission reactor-based power system can be a very competitive choice."

For its *Chang'e 4* lander on the far side of the Moon, China used a radio isotope thermoelectric generator, with plutonium 238 (half life is 88 years) as the fuel to keep the various subsystems warm during the long lunar nights.

The Ad Astra Rocket Company, meanwhile, is developing an NEP system, the Variable Specific Impulse Magnetoplasma Rocket (VASIMR), a plasma rocket in which electric fields heat and accelerate a propellant, forming a plasma, and magnetic fields direct the plasma in the proper direction as it is ejected from the engine, creating thrust for the spacecraft. Unlike traditional NEP, the VASIMR design enables the processing of large amounts of power while retaining the high fuel efficiency that characterizes electric rockets.

Franklin Chang Díaz, a former NASA Space Shuttle astronaut is now CEO of Ad Astra Rocket Company:

"In the near term, we envision the VASIMR engine supporting a wide array of high-power applications from solar electric in cislunar space, to nuclear-electric in interplanetary space. On a longer term, the VASIMR could be a precursor to future fusion rockets still in the conceptual stage."

(An interview with Franklin Chang Díaz appears in *EIR*, Vol. 14, No. 37, September 18, 1987, pp. 18-23, in which he describes his research into fusion propulsion, and his proposal for an Ibero-American space agency.)

The Princeton Field Reversed Configuration reactor concept under development at the Princeton Plasma Physics Laboratory, on the other hand, would have the advantage of producing a direct fusion drive (DFD), directly converting the energy of the charged particles produced in the fusion reactions into propulsion for the spacecraft.

Stephanie Thomas, Vice President of Princeton Satellite Systems:

“A DFD can produce specific power several orders of magnitude higher than other systems, reducing trip times and increasing payloads, thus enabling us to reach deep space destinations much faster.”

Thomas discussed possible DFD-powered missions into near-interstellar space, human Mars missions and lunar base surface power. She also explained that a DFD could have the advantages of its small size and the need for very little fuel—a few kilograms could power a spacecraft for ten years. To compare, the 100,000-ton, 200,000 horsepower Gerald R. Ford aircraft carrier (CVN 78) will run for 25 years or so on only 4 kilograms (8.8 pounds) of enriched uranium.

Surface Power

Nuclear reactors could also be used to provide astronauts with a reliable source of surface power for extended exploration missions and sustained human presence on other planetary bodies, supplying power for decades before needing to be refuelled. Fission surface power reactor designs are microreactors that could provide power in the range of tens of kWe for one to a few decades. The current focus is on using low enriched uranium fuels or high-assay low enriched uranium fuels.

Anthony Calomino, Space Nuclear Technology Portfolio Manager at NASA:

“NASA’s priority focus remains on designing, building and demonstrating a low enriched uranium fission surface power system that has broad applications for the lunar surface initiative as well as our eventual mission to Mars with humans, scalable to power levels above 100 kWe, and has the potential to advance NEP system needs.”

Vivek Lall, Chief Executive of General Atomics Global Corporation:

“Use of nuclear fission reactors, carrying out continuous chain reactions for many years, is inevitable both for space propulsion and for extraterrestrial surface power.”

Power for Spaceship Systems

Besides thrust, spaceships need electrical power to maintain life support systems, communications, navigation, and other hardware. Radioisotope thermoelectric generators (RTGs), powering for decades the two *Voyager* spacecrafts, now over 22 billion kilometers from the sun, were highlighted for their potential to supply long-term heat and electricity to future spacecraft onboard systems in the extreme cold of deep space, without any maintenance.

Future nuclear-based solutions for thrust, such as the DFD, might also simultaneously be able to provide electricity. “Our studies show that a direct drive fusion-powered rocket engine can produce both power and thrust with the best performance, generating electric power and propulsion from a single engine,” said Thomas.