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For the Committee on Science Space and Technology, Subcommittee on Space and Aeronautics
U.S. House of Representatives

October 20, 2021

Accelerating Deep Space Travel with Space Nuclear Propulsion

Mr. Chairman and distinguished members of the subcommittee, I am honored to be called to testify before you on this important topic for our nation and for our civilization.

Space travel beckons humanity even more today than it did in the 60s, not to abandon our planet but to care for it, preserve, and protect it by providing an opportunity for all humans to thrive and prosper in a universe of possibilities. But to do that, we must secure a safe, robust, and fast means of transportation. Nuclear power provides us with that opportunity – but there is homework to be done.

In rocket propulsion, the faster the exhaust the better the rocket. To make the exhaust fast, we must make it hot. The best chemical rocket runs at thousands of degrees and has an exhaust velocity of ~4500 m/sec.

Nuclear rockets come in two flavors: nuclear thermal and nuclear electric. The goal is the same for both, however, to heat the propellant to high temperature and expel it.

In nuclear thermal, the reactor is a contact heater to heat hydrogen and expel it. Nuclear thermal rockets could increase the exhaust velocity to ~9000 m/sec. Higher temperatures are constrained by materials limitations.

In the nuclear electric rocket, temperatures of millions of degrees as accessible, because at those temperatures the exhaust is an electrically conducting plasma, a soup of charged particles which responds to electric and magnetic fields.

In the VASIMR engine, for example, we take advantage of that feature by using a magnetic field to hold and guide the plasma, keeping it away from any material surface as we heat it. The heating is done with electromagnetic waves so nothing physical touches the plasma. In these devices, exhaust velocities in the 30000 to 50000 m/sec are measured (an order of magnitude) and higher velocities are technologically feasible.

The nuclear reactor here is not a heater but an electrical power plant and the big challenge is to develop a powerful, compact, and efficient nuclear electric power source and an electric rocket capable of handling a lot of power.

This is the homework we must do if we want to lead. The potential payoff is extraordinary. For example, with a power and propulsion package weighing 3-4 kg/kW and operating at 20-30 MW human Mars transits of less than 3 months could be possible. Nuclear electric also opens the departure and return windows for Mars from days to weeks and provides a variety of in-flight abort options (if needed) while enroute.

In space, power is life and with nuclear electric the reactor also provides an abundant supply of electrical power for the ship.

The nation has made investments in nuclear thermal. We need to invigorate the nuclear electric option as well.

It is the right time. Our own VASIMR® engine recently achieved a major milestone with an 88-h high-power continuous endurance test last July, a project supported by private investors and NASA. Other high-power technologies are also poised for development.

It is also the right time as nuclear electric draws on advances in fusion energy innovation (now also with private sector investment), and advances in power electronics for electric vehicles. To lead in space propulsion, we must invest in disruptive innovation.

Mr. Chairman and members of the subcommittee, as our nation moves to explore deep space with humans we must be able to travel fast, to reduce the debilitating effects of space on the human body, to reduce the burden of consumables, life support, to be less constrained by planetary alignments and tight launch windows and to expand our capability to recover from unforeseen contingencies enroute. In short, this is the problem punch-list we still need to solve to give our astronauts a fighting chance in deep space. The development of high power nuclear electric propulsion is critical to checking these boxes and to meeting our nation's goals in space.

Thank you and I am happy to take your questions.

(end of opening statement)

Additional material submitted for the record

The VASIMR® engine works with plasma, an electrically charged gas that can be heated with electrical power to extreme temperatures (2-3 million degrees) by radio waves and controlled and guided by strong magnetic fields. The magnetic field also insulates the rocket casing from the hot plasma. In rocket propulsion, high exhaust temperature leads to high exhaust velocity and hence high fuel efficiency. Plasma rockets have exhaust velocities 10x greater than conventional rockets, so their propellant consumption is extremely low. The high efficiency allows a range of missions that are not possible with conventional chemical rockets.

Other important features of the VASIMR® engine include:

- Scalable from ~50 kW to multi-MW in a single engine
- Electrodeless design, implies long component life
- Multiple, low cost, abundant propellants, such as argon (~$5/kg) and krypton (~$300/kg), as compared with other electric thrusters, which operate with rare and expensive xenon (~$1000/kg).
- Variable thrust and specific impulse, can "shift gears" to better adapt to the gravity "hills and flats" of the mission.

Potential applications

The VASIMR® engine could provide primary propulsion for robotic SEP and eventually NEP spacecraft in many venues, with more capability and economy than chemical rockets. Examples:

1. A commercial multiuse solar-electric space tug for orbital debris mitigation, satellite support and cislunar cargo transport.
2. Drag compensation or reboost of orbital space stations in low Earth Orbit (LEO)
3. The VASIMR® engine could propel a re-usable high-power solar electric propulsion (SEP) deep-space catapult to deploy robotic missions to the Jupiter and Saturn systems faster than conventional rockets.
4. With advanced nuclear electric power, the VASIMR® engine provides nuclear electric propulsion (NEP), enabling fast (less than 90 days) human Mars transfers. These reduce radiation exposure and other space-induced debilitating effects on humans. It also relaxes the departure windows on NASA’s Design Reference Architecture 5.0 (DRA-5.0).