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

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In-Space Propulsion: Strategies, Choices and Options

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. In securing our ability to travel in deep space safely and sustainably we are also insuring the survival of our species.

We have learned a lot about living and working in space during more than half a century of human space flight. We have also discovered many new things about our solar system and the universe in which we live. Every year we seem to find a handful more planets orbiting nearby stars, some of which may harbor the conditions for life as we know it. Even closer to home, the ocean worlds in our own solar system orbiting Jupiter and Saturn may offer the conditions for life. We have also opened the path for the private sector to usher new business opportunities on a cosmic scale for the United States. We are in the lead today but that leadership is by no means assured; we have to continue to earn it. Fortunately, Americans love competition.

I believe space travel beckons humanity even more today than it did 50 years ago, but we need to secure a safe, robust and fast means of transportation.

On the screen, I would like to offer you a graphic representation of the in-space propulsion challenge before us (display Figure 1).

Despite decades of progress in many areas of space technology, the challenges of deep space transportation remain as clear and present as they were in the 1960s. Our transportation workhorse, the chemical rocket, has reached an exquisite level of refinement. It has also reached its performance limit. That technology will not provide us with a sustainable path to deep space. It does not mean we need to discard it. On the contrary, chemical rockets will continue to provide foundational launch and landing capabilities for the foreseeable future and reducing their cost is a worthy goal.

But, once in space, the path to sustainable transportation lies in high power electric propulsion. By high-power, I mean power levels in the hundreds of kW and up. Each one of us in the NextSTEP Program is due to demonstrate the efficient operation of our respective technologies at a power level of no less than 100 kW for 100 continuous hours. These rockets will first be solar-electric and later, as we move outwards from the Sun they will transition to nuclear-electric power.

Ad Astra Rocket Company is an American corporation, developing a uniquely American technology. We are based in Texas. Our flagship project is the VASIMR® engine, an electric rocket that fits squarely within the high-power niche as previously defined and can scale naturally to multi megawatts. The VASIMR® originated at MIT in the early 1980s. The technology was transferred to NASA in the mid 1990s and privatized in 2005 by Ad Astra Rocket Company. The most advanced VASIMR® engine is the VX-200, which has executed more than 10,000 reliable and efficient firings at power levels of 200 kW. Its performance data has been well vetted by the science community and published in the top peer reviewed journals of our industry. The technology readiness level of the VASIMR® is now between 4-5. The lion share of this development has been achieved at Ad Astra Rocket Company with more than $30M of private investment from US and international investors. In 2015 NASA became a partner and awarded us a 3-year ~$3M/year NextSTEP contract to help bring the technology to TRL-5. We are halfway through this program and moving smartly to its successful completion in mid 2018.

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 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.

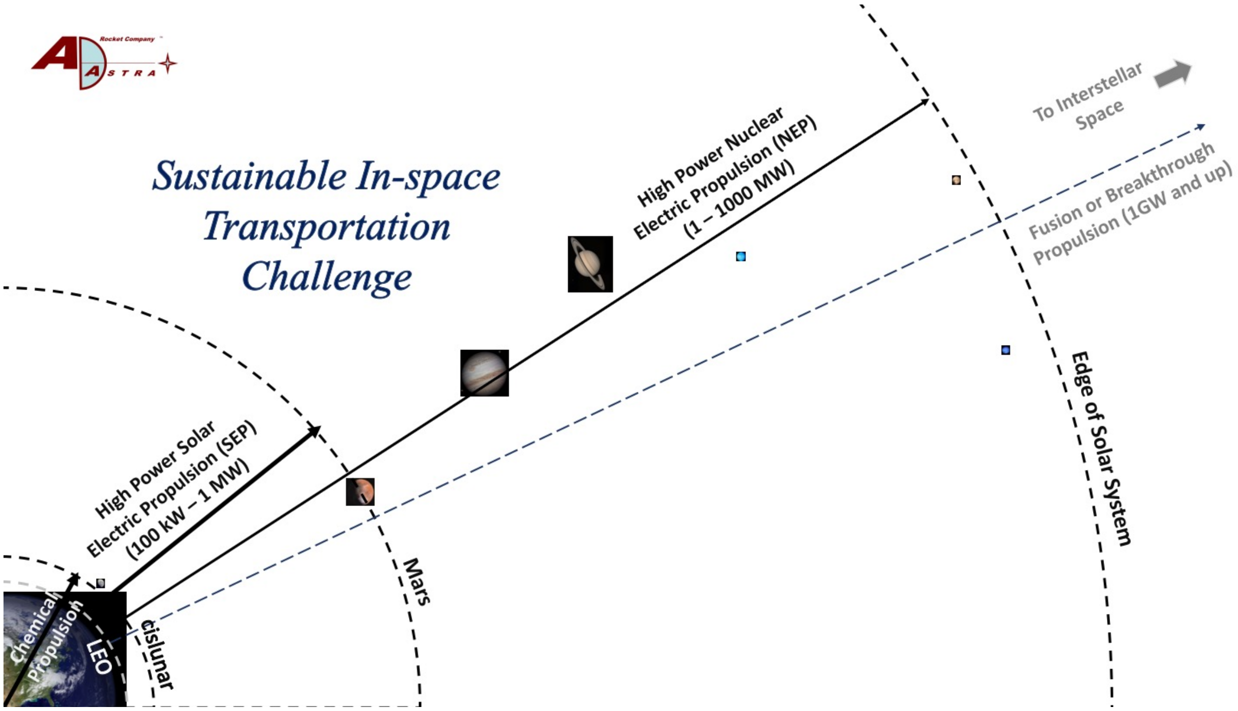


Figure 1

(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.

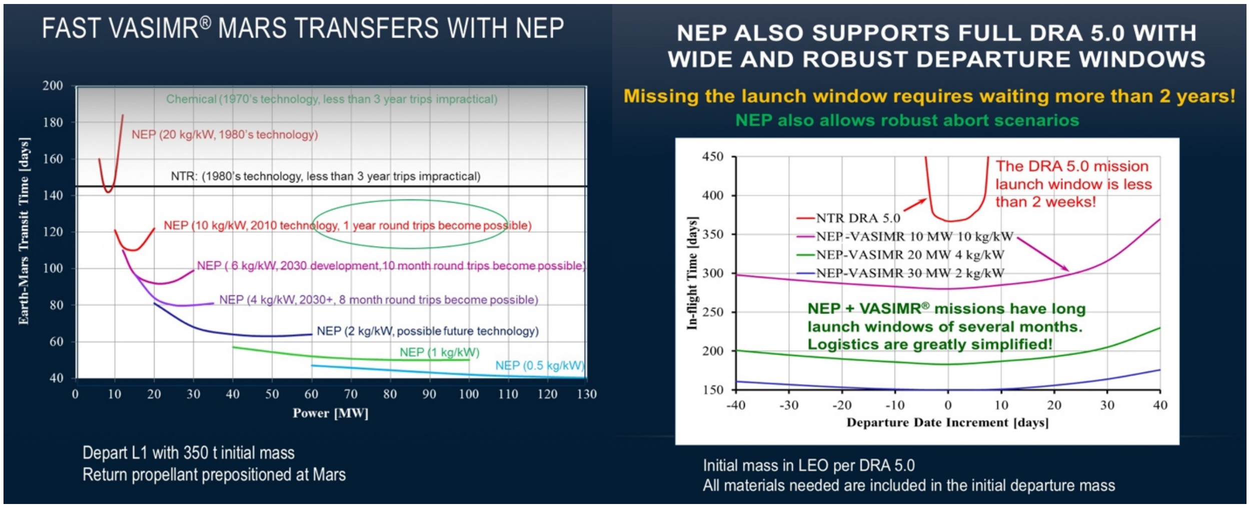
Other important features of the VASIMR® engine include:

- 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) (see Fig 2).



FAST VASIMR® MARS TRANSFERS WITH NEP

Depart L1 with 350 t initial mass
Return propellant prepositioned at Mars

NEP ALSO SUPPORTS FULL DRA 5.0 WITH WIDE AND ROBUST DEPARTURE WINDOWS

Missing the launch window requires waiting more than 2 years!

NEP also allows robust abort scenarios

Initial mass in LEO per DRA 5.0
All materials needed are included in the initial departure mass

Figure 2