Facts About the VASIMR® Engine and its Development

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This article is intended to correct significant inaccuracies and misconceptions about the VASIMR® engine technology and its development, including several that have recently appeared in the electronic press. We offer here factual information about the history of the project, its present status of technological maturity and its intended applications. We encourage the reader to visit our web page: www.adastrarocket.com for additional information.

The VASIMR® engine has its roots in magnetic plasma confinement studies conducted in the late 1970s at the Charles Stark Draper Laboratory and The Massachusetts Institute of Technology (MIT). A small NASA-funded experimental program began in the early 1980s at the MIT Plasma Fusion Center and was transferred to NASA's Johnson Space Center in the early 1990s. These initial studies demonstrated the efficiency of the plasma physics processes at the heart of the engine and led to three US patents. These results were presented in numerous scientific conferences and peer-reviewed publications and are widely available in the scientific literature.

In cooperation with NASA, the project was privatized by Ad Astra Rocket Company in 2005. Since that time, Ad Astra has continued the development of the technology exclusively on private investment. Over the 25 years at NASA preceding privatization, the total direct government funding for the project by the space agency was approximately $6,000,000. Since the company's formation in 2005 – with the exception of a small 2010 contract to support testing of a high-temperature superconducting magnet, totaling $142,000 – Ad Astra has received no direct government funds for VASIMR® development. At present, via a Non-Reimbursable Space Act Agreement, Ad Astra and NASA/Johnson Space Center collaborate on several aspects of mutual interest relevant to technology and systems integration – with no exchange of funds.

In the development of the VASIMR® technology, Ad Astra collaborated with research teams at established, recognized scientific institutions and laboratories in the United States, such as the Oak Ridge and Los Alamos National Laboratories, The Electric Propulsion Laboratory at the University of Michigan, the Departments of Physics at Rice University, the University of Texas at Austin, The University of Houston, as well as recognized research institutions internationally, such as The Australian National University, The Alfvén Laboratory in Sweden, The Irish National University, The University College Dublin and many others. Several Master and award-winning Doctoral theses were successfully completed on the controlling physics of the engine that laid the foundations for the present system.

Within the normal constraints of US export control regulations, Ad Astra publishes the results of its work regularly at professional conferences and peer-reviewed journals. At the upcoming International Electric Propulsion Conference in September 2011, Ad Astra will present recent testing results that demonstrate a system efficiency of 60% (thruster efficiency of 72%) at 210 kW and 4800 seconds specific impulse (I_{sp}) with argon propellant. Recent experiments with krypton, a heavier gas, are exploring the potential to further expand the engine's thrust/I_{sp} envelope. Ad Astra's most advanced engine configuration is the VX-200 (for VASIMR® experiment at 200kW), a 200 kW test engine currently in operation at the company's main laboratory in Houston. Ad Astra also operates a smaller test device, called the VX-CR, at its sister facility in northwestern Costa Rica. This test unit is used primarily for component life-cycle evaluation, materials characterization and thermal management studies. Ad Astra is currently designing the flight version of the VX-200, called the VF-200 (for VASIMR® flight at 200 kW).

The technology of advanced high-temperature superconductors has also matured significantly in the last decade with the development of commercially available high current density BSCCO and YBCO conductors by companies such as Superpower Inc. and American Superconductor. These developments have made lightweight, high-field magnets for VASIMR® applications feasible. Moreover, miniaturized cryocooler technology, such as the Sunpower M series model, has already flown in space and are being considered by Ad Astra as part of the cryogenic system for the flight magnet. Ad Astra's VX-200 test engine features the largest cryogen-free, high-field, low-temperature superconducting magnet in existence today. This magnet was developed to meet Ad Astra's specifications and has operated quite successfully in the VX-200 engine since its integration in May of 2009. The company is currently designing a high-temperature flight version of this system.

As for electrical power, just like all other electric rockets, VASIMR® needs electricity, so questions related to the power source naturally rise to the top. While Ad Astra is not in the business of developing space power sources, the company follows carefully the progress in both of the leading space electric power options: solar and nuclear. What follows is a brief discussion of both.

For its near-term, robotic commercial applications, Ad Astra foresees (within 5-10 years) high delta-v VASIMR® flights maneuvering payloads in the LEO to GEO regions of space, powered by concentrator solar electric arrays. Combined with state-of-the-art support and deployment mechanisms, these arrays should be able to provide power (out as far as Mars) at a specific mass in the range of 2-7 kg/kW (the range depending on radiation shielding requirements) – much lower than the best nuclear space power systems developed to date.

In the near term, using solar-electric power at levels of 100 kW to 1 MW, VASIMR® propulsion could transfer heavy payloads to Mars using only one to four first-generation thrusters in relatively simple engine architectures. By optimizing the ratio of power to total vehicle mass at an appropriate specific impulse, significant cost savings over chemical in-space propulsion can be realized. This application should be attractive for a methodical, cost-effective, long-term plan of Mars exploration in which infrastructure and supplies are pre-positioned at Mars by slow cargo flights in advance of faster human transits. This is a capability that can be demonstrated first at relatively low power levels in support of robotic exploration, and then grow as space electric power generation improves.

But such improvements point squarely to the need for advanced nuclear electric power. In this realm, much remains to be done and development work is a long-term effort that must not be delayed. Ad Astra has explored the scaling of the VASIMR® technology to multi-megawatt engines driven by nuclear-electric power and conducted interplanetary mission studies of very high power architectures. These studies yield a wide range of fast interplanetary mission options with one-way trip times to Mars ranging from four to just over one month, depending on the performance of the nuclear power source (generally specified in kilograms/kilowatt). It is abundantly clear that the nuclear reactor technology required for such missions is not available today and major advances in reactor design and power conversion are needed. However, a number of serious research studies have been conducted that point to reactor and power conversion designs that meet the kg/kW required for such a mission. Again, much remains to be done, and closing the door on these possibilities on the basis of the relatively primitive state of our present nuclear space technology would be highly premature.