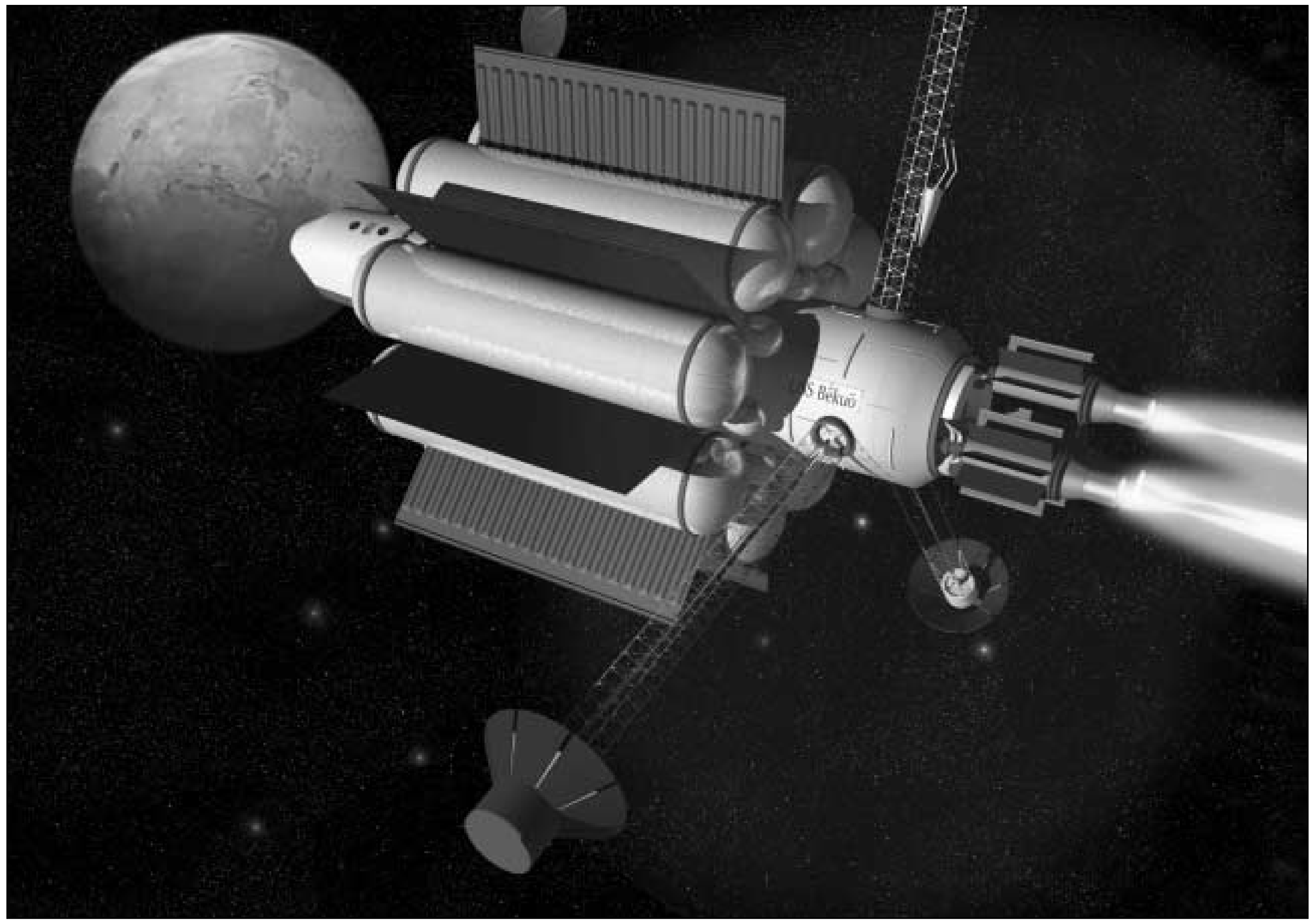
The potential of plasma

By Lisa Tidwell



Artist's concept of plasma-powered space vehicle

Plasma-powered engine could be 'ticket to interplanetary travel'

Tucked away in the Sonny Carter Training Facility, down a long bare hallway and through a nondescript entrance, is a laboratory. Resembling a warehouse, the laboratory has one distinct difference – it is home to some revolutionary research that might just be the ticket to human exploration of Mars and beyond.

The Advanced Space Propulsion Laboratory (ASPL) at Johnson Space Center is actively developing a new type of rocket technology: the Variable Specific Impulse Magneto-plasma Rocket (VASIMR).

Unlike conventional rockets, VASIMR does not use chemical reactions to drive the engine but rather ionized gases, or plasma, accelerated by electric and magnetic fields.

Astronaut Franklin Chang-Diaz directs the laboratory and has been working on the plasma rocket since 1979. Chang-Diaz, a veteran of seven Space Shuttle flights, holds a doctorate in applied plasma physics and fusion technology from the Massachusetts Institute of Technology.

"We are severely limited by today's rockets," Chang-Diaz said. "We are building a whole new generation, which will increase the speed of travel by orders of magnitudes."

"There are two fundamental barriers we have to overcome to explore space with humans," he said. "First there is a propulsion challenge: chemical rockets do not have the capability to deliver the propulsion needed for interplanetary travel."

Power is the other major barrier that must be overcome. "Nuclear power has the potential to change the way we power rockets," he said.

Overcoming those barriers is critical. "If we don't get those figured out, we will not be going anywhere," Chang-Diaz said.

While conventional chemical rockets continue to provide excellent surface-to-orbit transportation, they are still considered by some the "covered wagon" of rocket technology. New technologies that overcome the fundamental barriers such as VASIMR are needed to transport humans and cargo in the long journeys to the planets and ultimately the stars.

The next steps in the VASIMR research are both ambitious and exciting. "The next step is to take (VASIMR) to a large-scale vacuum chamber and measure the thrust," said Tim Glover, a post-doctorate research associate from Rice University working at the ASPL, "but the ideal environment for this type of research is space."

The team hopes to test a small-scale VASIMR engine on the International Space Station.

"Station is an ideal platform for developing (electric propulsion) technology," Glover said.

Looking into the future, the research being done in connection with the VASIMR engine could be the key to further human exploration of Mars and beyond. It is important to reduce the crew's exposure to weightlessness and solar radiation; it is therefore important to shorten the trip duration.

Chemical rockets today would take about 10 months to reach Mars; however, with VASIMR the trip time could be reduced dramatically. After being inserted into orbit by a traditional chemical rocket, a spacecraft with a VASIMR engine could deliver an exploration crew to Mars in as little as 39 days.

"We feel this technology is the way, our ticket, to interplanetary travel," Chang-Diaz said. "It will completely revolutionize space travel."

Astronaut Franklin Chang-Diaz, Director of the Advanced Space Propulsion Laboratory, works on the VASIMR engine.

jsc2003e49523 Photo by James Blair

Scott Winter, from Safety, Reliability & Quality Assurance, makes adjustments on the VASIMR.

jsc2003e49525 Photo by James Blair

AT A GLANCE

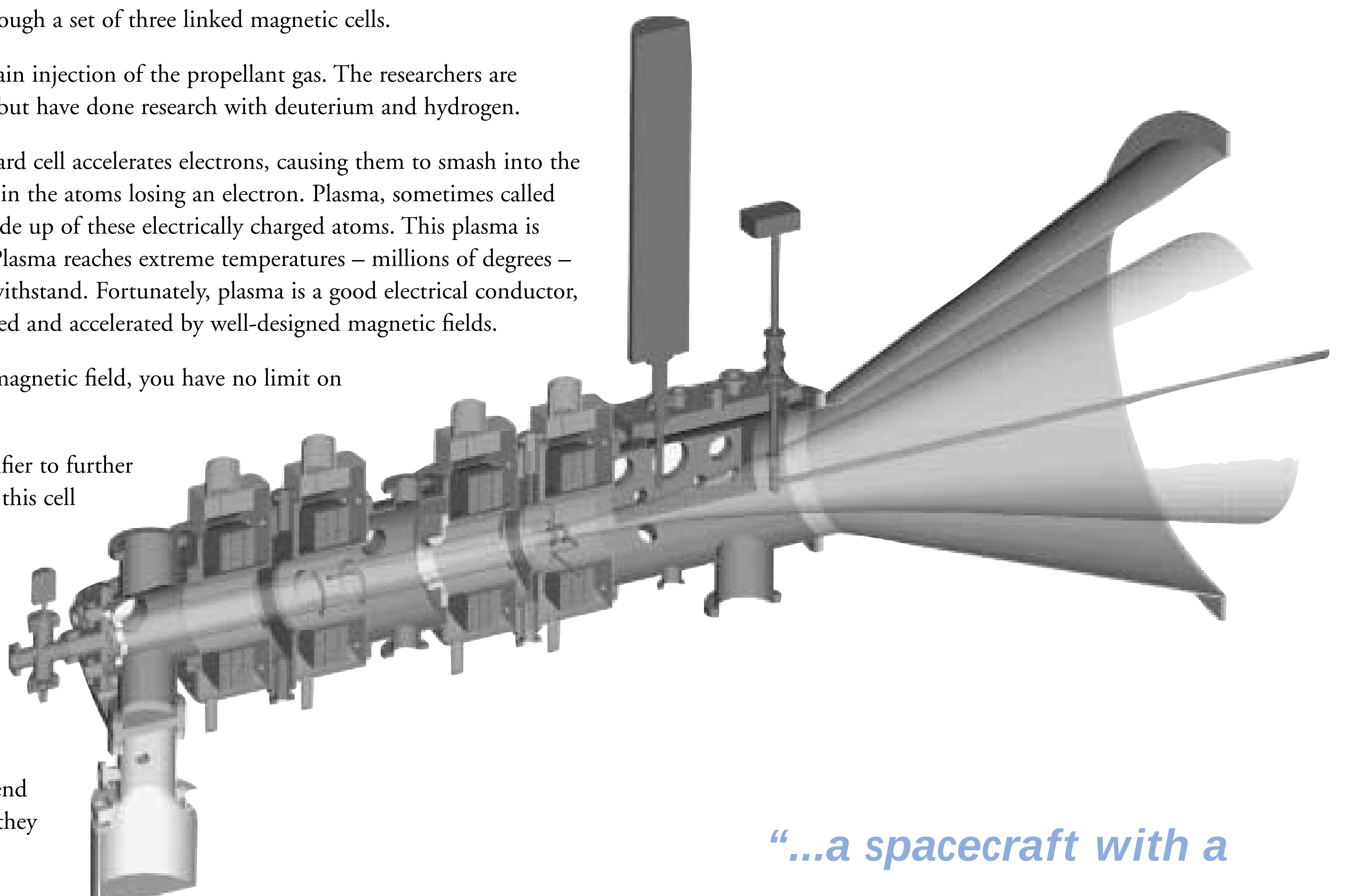
HOW THE VASIMR ENGINE WORKS

The VASIMR engine works through a set of three linked magnetic cells.

The forward cell handles the main injection of the propellant gas. The researchers are currently working with helium but have done research with deuterium and hydrogen.

A Helicon Antenna in the forward cell accelerates electrons, causing them to smash into the propellant atoms, which results in the atoms losing an electron. Plasma, sometimes called the fourth state of matter, is made up of these electrically charged atoms. This plasma is what drives the rocket engine. Plasma reaches extreme temperatures – millions of degrees – which no known material can withstand. Fortunately, plasma is a good electrical conductor, which allows it to be held, guided and accelerated by well-designed magnetic fields.

"By holding the plasma in the magnetic field, you have no limit on temperature," Glover said.



The central cell acts as an amplifier to further heat the plasma. An antenna in this cell creates an electric field that adds energy to the plasma. The energy accelerates the ions, causing their velocity and orbit to increase, which creates a path resembling a chocolate swirl from the base to the top of an ice cream cone. When the ions reach the open end of their "ice cream cone path," they transition into the third cell.

The third cell is a magnetic nozzle, which converts the gyro-spinning motion around the "ice cream cone" into a linear motion through the magnetic nozzle. The magnetic field that has guided the plasma through the engine and protected the stainless steel structure from the extreme temperatures of the plasma now is formed into a shape equivalent to the bell-shaped nozzle used in standard chemical rockets. This final portion of the engine, with its magnetic nozzle, ensures maximum thrust by making certain that the plasma efficiently detaches from the magnetic field.

Several universities and organizations contribute to the VASIMR engine, including the Massachusetts Institute of Technology, the University of Texas, the Los Alamos National Lab, Marshall Space Flight Center, Rice University, the University of Houston, the University of Michigan and the Oak Ridge National Lab.

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