

NASA Astronaut and Rocket Scientist

Dr. Franklin Chang-Diaz Talks to *Cedar Wings*

BY HANIA JURDAK

Seeking to bring you the cutting-edge in science and technology, Cedar Wings caught up with NASA Astronaut and rocket Scientist Dr. Franklin Chang-Diaz following his recent visit to Lebanon to attend the Advisory Board meeting, as new Board member, of IBSAR-AUB (The Center for Nature Conservation and Sustainable Futures, an interfaculty research center at the American University of Beirut).

Dr. Franklin Chang-Diaz is Chairman and CEO of Ad Astra Rocket Company, inventor of the Variable Specific Impulse Magnetoplasma Rocket (VASIMR, U.S. patent 2002) and other advanced propulsion technologies. He founded Ad Astra Rocket Company, after 25 years of service as a NASA astronaut, through a privatization initiative with NASA that led to the June 23, 2005 signing of a Space Act Agreement transforming its Advanced Space Propulsion Laboratory into the new private company. Dr. Chang-Diaz became an astronaut in August 1981. A veteran

of seven space flights, he has logged over 1,601 hours in space, including 19 hours and 31 minutes in three spacewalks, and is the recipient of many high honors.

His company, Ad Astra, is dedicated to the development and commercialization of the VASIMR™ and related technologies. The company's current objective is to bring the VASIMR™ engine to full operational deployment in space by December 2010. The engine could be initially operated in a number of applications in Earth orbit, including drag

compensation of orbiting space stations and satellite delivery, repositioning and general servicing.

Later, the VASIMR™ is expected to provide primary propulsion for cargo and supply missions to the Moon and ultimately to provide ready access to space resources and to support robotic and human missions to Mars and beyond. Dr. Chang-Diaz talked to *Cedar Wings* all about his space experience and about the potential of this new technology for the future of space exploration.

Photo: Space walking against the Earth background, astronaut Franklin R. Chang Diaz is transported atop the Canadian robotic arm of the International Space Station as he conducts maintenance tasks outside the orbital complex on mission STS-111 in June of 2002. Photo courtesy NASA.



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Q: Most people wonder (and will never know) what it is like being in space. In what ways are space missions like most people imagine, and in what ways are they vastly different?

A: Our simulators are increasingly sophisticated and able to come closer and closer to how space really is. But we still know so little. Space remains a place of wonder, awe-inspiring, new and mysterious and, as we well know, quite unforgiving. Yet, it is the key to our future. As time goes on, more and more people will get to fly and work in space. It is our new frontier. By exploring space we are doing nothing less than insuring the survival of our human species.

Q: Can you tell us about any moments you remember while on your space missions, such as your first space flight or moments that evoked fear or exhilaration?

A: Every astronaut must feel some fear when he or she is launched atop a rocket and catapulted into space. Fear is part of our natural human makeup; but the fear must be controlled and can not take over. That would be called panic and it would be a serious problem to have. The first time I reached outer space, my strongest urge was to look out the window. The sight of our planet below was the most beautiful thing I ever saw. A space walk is

another exhilarating experience where you get to feel space in its full intensity. There is a kind of loneliness there where the only thing separating you from the void of the universe, are the thin layers of your space suit.

Q: What is your vision for Ad Astra, and what have been its main achievements?

A: Our vision is to transform space transportation with the deployment of the VASIMR™ engine and its related technologies. We plan to be a major player in the evolving commercial space market. We started this company as a spin off of NASA technology just two years ago. In this short time interval we have demonstrated the performance of the VASIMR™ system and have built major research capabilities in Houston and Costa Rica. We have met all of major milestones, without departing from our cost and schedule predictions. We are on track to deploy VASIMR™ in space on schedule in 2010.

Q: What is the new technology involved in VASIMR™? What space needs was it originally developed to meet?

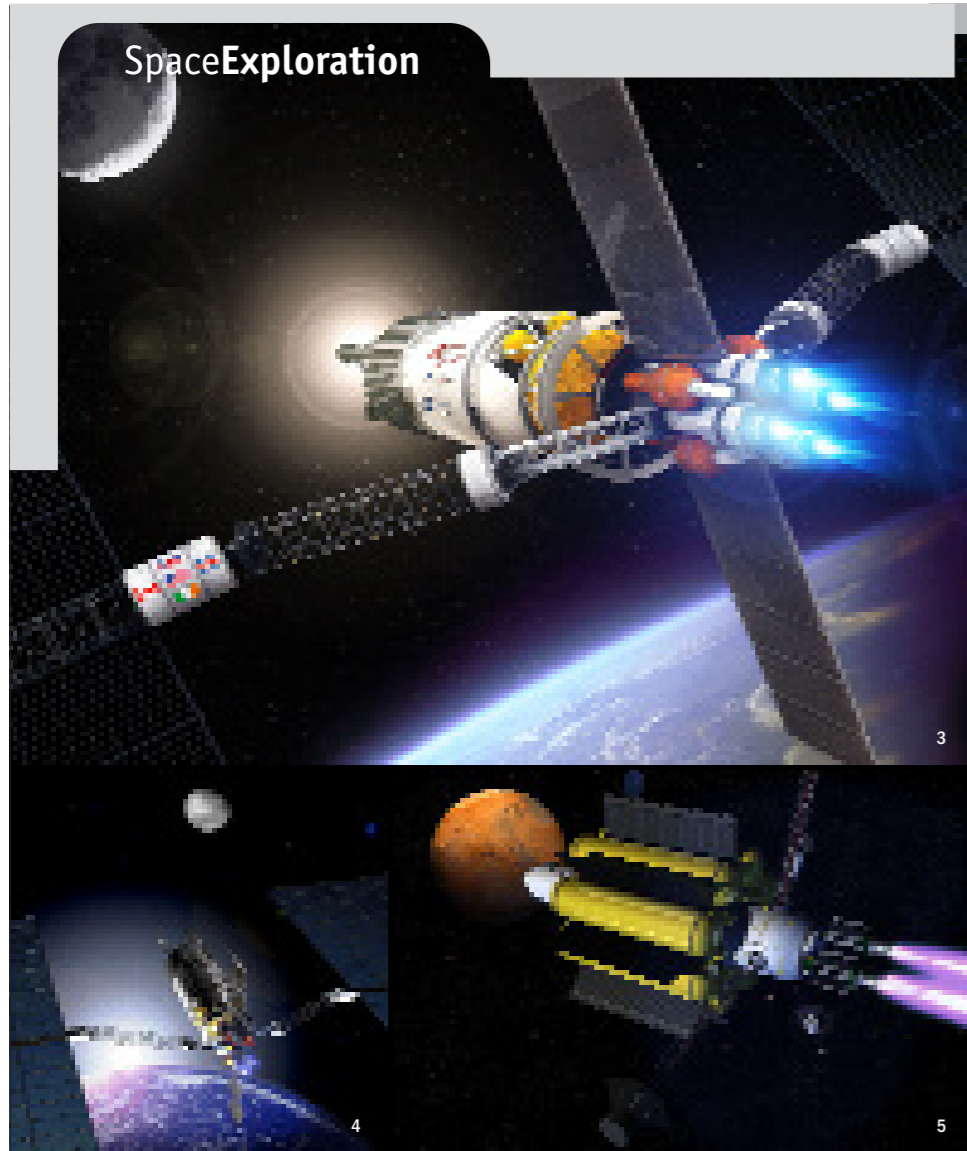
A: The VASIMR™ is full of new technologies, including light weight and compact superconducting magnets, very advanced radio frequency power generators, which are also compact and

light weight. Within the rocket, the very high temperature associated with plasma, coupled with the very low temperature of nearby superconductors, pose major engineering challenges in thermal control and materials science that we have also developed. To design VASIMR™ we have also had to create advanced computer models that can predict the behavior of its components before we actually build them. These, by themselves, also represent major technological advances.

The VASIMR™ fills a growing niche in space operations, requiring rockets that are both powerful and fuel efficient. Conventional chemical rockets are very powerful but their fuel efficiency is extremely low. On the other hand, more traditional plasma rockets, while very fuel efficient, tend to be very low power devices. The VASIMR™ is capable of processing large quantities of power in a small package, while retaining the high fuel efficiency characteristic of plasma rocket propulsion.

1- Franklin Chang-Diaz, former NASA astronaut and Chairman and CEO of Ad Astra Rocket Company.

2- The VASIMR™ team of investigators gathers once a year to discuss progress on the project. This photo was taken outside the USA facility located at the NASA Johnson Space Center in Houston. The team includes company investigators, as well as collaborators from several universities, national laboratories and research centers throughout the world. Photo courtesy Ad Astra Rocket Company.



Q: How can this new technology impact the future of space exploration? How does it differ from previous approaches in terms of performance, cost, or viability?

A: For operations near the Earth and Moon, the VASIMR™ could provide a means to access and service orbiting assets that are now economically unreachable. Communications satellites are sent to their orbits on a "one way trip" and become space junk when their fuel runs out. By having an economically viable refueling and servicing capability one could greatly extend the useful life of these spacecraft and regularly improve them in place as technology advances. On another front, NASA's future operations on the Moon surface must be economically sustainable. Chemical rockets will not enable this. The VASIMR™ will be poised to supply the human lunar colonies at half the cost of present day rockets. In deep space missions, such as Mars and beyond, the

VASIMR™ is capable of reaching speeds unattainable by other rockets. Thus, coupled with nuclear power for electricity, a flight to Mars using VASIMR™ could be done in 39 days, as compared to the seven to eight months that would be required using chemical propulsion. The VASIMR™ is the precursor to the fusion rocket, a plasma rocket capable of generating its own power through thermonuclear fusion. These fusion engines are still far in the future, but some day, they will provide humans ready and quick access to all points in the solar system.

"I did travel back from Lebanon to Paris on MEA just once. In that occasion I found the service outstanding and thoroughly enjoyed the flight."

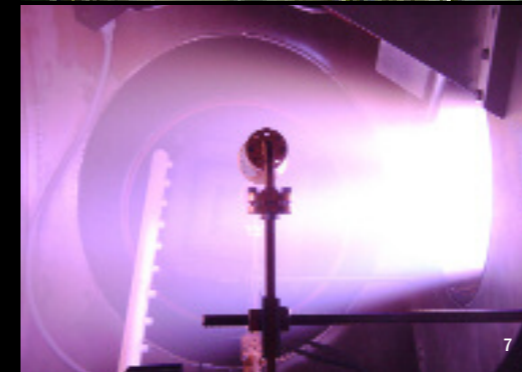
Q: What new space transport/tourism opportunities does this technology make possible? What are its commercial uses?

A: The VASIMR™ will not be used to lift off from Earth but rather to provide primary propulsion between points in space. The chemical engine will continue to provide the short lift off and landing capability for the foreseeable future. Another major use of the VASIMR™ is for re-boosting space stations to their desired orbits. These large structures gradually and continuously fall back to Earth due to the tiny but persistent amounts of friction that the Earth atmosphere still has at those altitudes. From time to time, these stations must be "pushed back up" by on board rockets, which, of course uses fuel. The VASIMR™ can provide this re-boost service at roughly 1/20th of the cost due to its very low fuel consumption.

Q: What is the expected preliminary timeline for the completion, use, or adoption of plasma rocket propulsion technology?

A: We are on a fast track to complete the first flight-like VASIMR™ prototype, the VX-200 by early 2008. This device will be in all ways identical to the flight engine but will not fly. We plan to complete the characterization of this prototype by mid 2008 and begin the design of the VF-200-1 and the VF-200-2, the first flight engines, which will be ready for flight in late 2010 and 2011 respectively. By 2012 we expect to have both engines operating in space in two different venues. By the middle of the next decade we plan to fly more powerful engines in a lunar cargo vehicle, which is presently in our drawing boards. This vehicle could enable economically sustainable re-supply services to the Moon colonies and also be used to access space resources such as water and metals on comets and near Earth asteroids. By the end of the next decade, Ad Astra plans to begin construction of a lunar rocket test facility that will enable us to fully test the very powerful VASIMR™ rockets needed for missions to Mars and beyond. These rockets require a vacuum and a suitable facility large enough is not practical to build on Earth.

3 & 4- Lunar Tug. Photo courtesy Ad Astra Rocket Company.
5- The ship going to Mars is a concept developed by Ad Astra Rocket Company for a human mission to the Red Planet using three 5MW VASIMR™ engines operating on electrical power from nuclear reactors. The large tanks contain liquid hydrogen that serves three purposes: 1) the propellant that makes the plasma 2) the coolant that keeps the superconducting magnets of VASIMR™ operating at the required temperature and 3) the hydrogen is also a shield that protects the astronauts from the radiation of space. The word "Bekuo" on the Mars ship means "shooting star" in the language of the Bri-Bri indigenous people of Costa Rica, descendants of the Maya and Inca civilizations. They were the first astronomers of the Americas. Photo courtesy NASA.



Q: Given the pressing environmental and population problems on Earth, some people view ventures into space as wasteful while others see such ventures as a potential and alternative solution of such problems. What is your view on that?

A: I subscribe to the latter. The ultimate answer to human survival lies in space. Our species must and will continue to grow and sooner or later our planetary resources will run out. We can not wait for that to happen and we must not ruin this world to the point of a human emergency, which forces us to leave it. I dream of a day when humans will have populated space and the Earth will be a protected human patrimony, humanity's national park, a beautiful place where our descendants will come back to know their roots and their history. For this to happen, we must care for our planet now and give ourselves the time to learn to fly beyond it safely.

Q: How have your many years of experience as an astronaut and rocket scientist impacted your vision of our planet, and of human potential?

A: We are all astronauts and this world is our spacecraft, the only one we have.

Q: Would you like to add anything else?

A: Space exploration has brought us together and it will continue to do so as we move away from our cradle into the space frontier. We should think less as citizens of a given country and more as citizens of a planet.

Q: Incidentally, have you ever traveled on board MEA?

A: I did travel back from Lebanon to Paris on MEA just once. In that occasion I found the service outstanding and thoroughly enjoyed the flight.

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6- The VASIMR™ works with plasma, a very hot gas at temperatures close to the interior of the sun. Photo courtesy Ad Astra Rocket Company.
7- VASIMR™ plasma exhaust is viewed through an observation window in the VX-100 VASIMR™ experimental test bed at the Ad Astra Houston laboratory. The plasma, Argon gas heated to ultra high temperatures, is controlled by strong magnetic forces that insulate it from nearby structures. Photo courtesy Ad Astra Rocket Company.