Horizons

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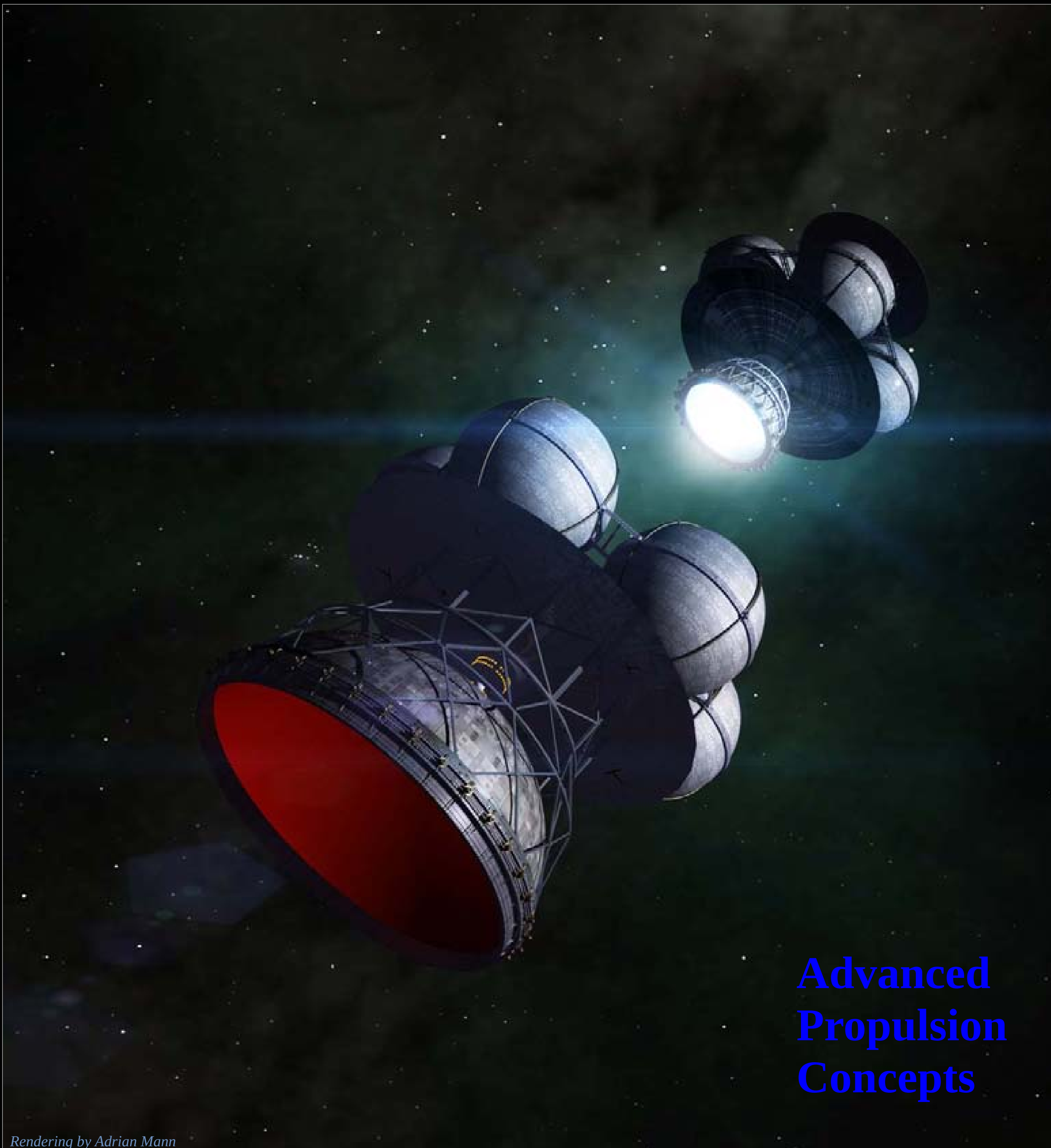

Rendering by Adrian Mann

Advanced Propulsion Concepts

Winter 2006/7

AIAA HOUSTON

American Institute of Aeronautics and Astronautics

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Cover: Project Daedelus concept art by Adrian Mann.

From the Editor From the Earth to the Moon

JON S. BERNDT

"Forty-seven minutes past ten!" murmured the captain.

"Twenty seconds more!" Barbicane quickly put out the gas and lay down by his companions, and the profound silence was only broken by the ticking of the chronometer marking the seconds.

Suddenly a dreadful shock was felt, and the projectile, under the force of six billions of litres of gas, developed by the combustion of pyroxyle, mounted into space."

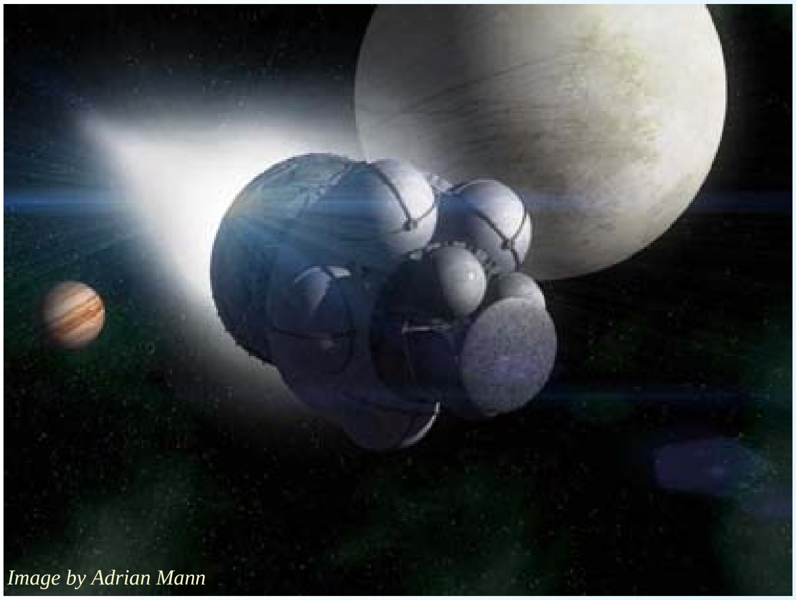


Image by Adrian Mann

And so began the journey toward the moon for three astronauts in French writer Jules Verne's, "From the Earth to the Moon". Written in 1865 - almost a hundred years before the start of the Apollo program and four decades before the Wright brothers flew their aircraft - this early instance of a science fiction story covers the creation of a lunar program and how it progresses. Verne takes a sometimes humorous tone when telling the story, but what amused me the most were the passages that seemed to reach forward a century and across an ocean, from when and where he penned them. The approach that was eventually adopted by the characters in the story involved lofting three astronauts in a 9 foot diameter, 20,000 pound aluminum capsule skyward at 36,000 feet per second, from a Florida launch site, at the start of a 97 hour traversal to the moon. The method of propulsion originally suggested in the story included the use of 1.6 million pounds of "solid fuel" (gunpowder), though a different charge was eventually used. The five segment solid rocket booster selected for launching Orion contains just under 1.4 million pounds of propellant.

The 900 foot long cannon (named "*Columbiad*") used to hurl the capsule to the moon in Verne's story helped to propel a colorful fictional account, but of course it's a completely unworkable form of propulsion for crewed space travel (20,000 g's!).

Move forward 140 years, and humans have traveled to the moon, and are exploring our solar system with robotic spacecraft – several of which are now in or nearing interstellar space. One of those - Voyager 1 - is now about 100 AU from the Sun. The distance to Proxima Centauri (the closest star to us apart from the Sun) is about 268,000 AU from us.

There are some very interesting places in our solar system that we have not yet visited, or have only just begun to explore. Titan, Venus, Io, Europa, are all places that beg for a closer examination. But, as I mentioned in my previous column, our propulsion technology is lacking if we want to explore very distant worlds at a faster pace. What if we had a way to travel at speeds approaching the speed of light (ignore Einstein for a moment)? What would that do for us – what would that bring within reach? One estimate (see http://imagine.gsfc.nasa.gov/docs/ask_astro/answers/980123d.html) suggests that there are about 1,000 stars within 50 light years of the Sun. If each of those has a couple of Earth-size terrestrial planets and large moons, what are the chances that at least a few have an atmosphere and water? It seems safe to assume that there must be - and that right now, as you read this, there is another sun, reflecting over the surface of a sea as it sets over the horizon, on a planet very far away from here. Perhaps there is even intelligent life there – someone looking out over a sea at sunset and wondering about … us?

One estimate suggests that there are about 1,000 stars within 50 light years of the Sun. If each of those has a couple of Earth-size terrestrial planets and large moons, what are the chances that at least a few have an atmosphere and water?

In this issue are two articles describing advanced propulsion concepts (neither of which involves a cannon!). Perhaps one of these concepts will lead to greater accessibility to the outer solar system and beyond.

Incidentally, one hundred forty years after Verne wrote his classic story, the European Space Agency is preparing to launch an automated transfer vehicle (ATV) on its maiden flight to the International Space Station (ISS). The first ATV flight vehicle is named appropriately, *Jules Verne*.

-JSB

Chair's Corner

JAYANT RAMAKRISHNAN, AIAA HOUSTON CHAIR

EXECUTION – The Art of Getting things Done – has been the name of the game for the AIAA-Houston Section. As I look back on the last five months, we have excelled as an organization in coming together and laying out the 2006-2007 chapter year.

Beginning with the "State of the Johnson Space Center" in September 2006 where Col. Robert Cabana presented the vision as we move forward to the recently completed all day workshop on Matlab and Satellite Tool Kit, we have had an exciting year. Along the way we had our bumps when our distinguished speaker Dr. Mark Adler from JPL made it as far as Pasadena before his car stalled in high water in what was the "wettest" Monday in October and we had to forgo the presentation on Mars Rovers. Dr. Adler has agreed to give his talk on his next visit to Houston. The AIAA awards were announced last month and I am proud to inform you that the Houston Section was recognized in the following categories for 2005-2006 (Very Large Section Category):

FIRST PLACE:

- Outstanding Award – Steve King, Chairman
- Communications – Jon Berndt, Section Newsletter Editor
- Membership – Elizabeth Blome, Membership Officer

SECOND PLACE:

- Public Policy – Lynn Nicole Smith, Public Policy Officer

THIRD PLACE:

- Harry Staubs Precollege Outreach Award – Joy Conrad King, Precollege Outreach Officer
- Young Professional Activity Award – Laura Slovey, Young Professional Officer

Additionally the Houston Section also got a third place award for our submission to the AIAA Good Practices Database. Congratulations to our team!

Some of the highlights of the last few months have been:

MATLAB/STK Workshop – This day long workshop at NASA Gilruth Center had a great turnout and several demos showing the capabilities of both these scientific computing packages.

Lunch & Learns – The topics have been diverse and extremely interesting:

- Emerging Software Tools for Satellite Design
- Plug and Play Satellites
- Turning Reality into Fiction which becomes Reality – The challenges in crafting an authentic Space Thriller
- Earth, Moon and Spacecraft – Stars A, B and Planet
- Today's Unfolding Relationships – Earth Space and Life

Videos – We had a showing of the building and testing of the Boeing 737 and other Discovery Channel videos.

As I write this article, the 2nd Space Exploration Conference at George R. Brown Convention Center in Houston is round the corner. The Space Exploration Conference promises to be very exciting with the roadmap for the new space exploration. AIAA-Houston volunteers will be at the conference. Also ahead are the Workshop on Robotics and Automation and a visit to the Aerospace Museum at Hobby Airport. We will start the New Year with more exciting programs for our members.

EXECUTION - This year is a great year to get involved with the local section with all the local and national events that are planned around the strides in space exploration. We are looking for volunteers who want to be a part of the excitement. Join our team and make it a win for you and AIAA-Houston.

All of us here at AIAA-Houston hope you had a great holiday season!

The Future of Space Propulsion: VASIMR

LEONARD CASSADY, AD ASTRA ROCKET COMPANY

Feature Article

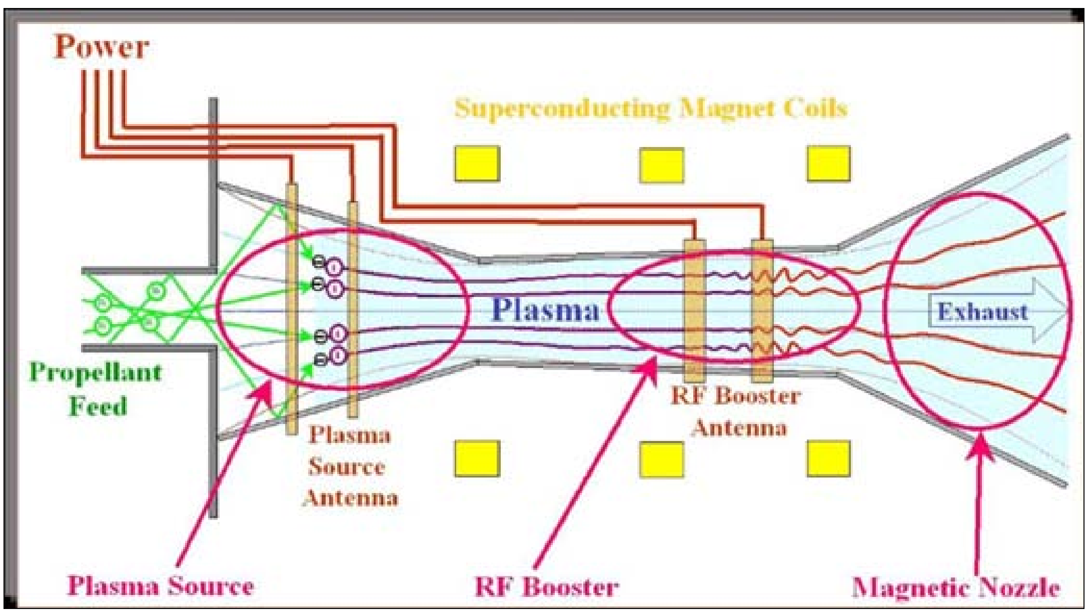
Transporting crew and cargo to the Moon or Mars, or simply maintaining a large satellite in low Earth orbit, is a difficult and expensive proposition solely due to the amount of propellant required to achieve mission goals. Launching propellant into orbit now costs $20,000 per kilogram; the Moon and Mars missions could require multiple heavy lift launch vehicles for propellant alone if chemical rockets were used. Clearly, finding a way to reduce the propellant mass requirement could save millions of dollars. For a given mission, the propellant mass required primarily depends *exponentially* on the inverse of exhaust velocity, i.e., the propellant mass decreases strongly with increasing exhaust velocity. Chemical rockets are limited to approximately 4.5 km/s, but electric propulsion thrusters can operate up to and beyond 100 km/s. Electric propulsion thrusters are capable of such high exhaust velocities because the energy imparted into the propellant is supplied from an external electrical power source rather than the energy released in a chemical reaction of a fuel and oxidizer. Hundreds of low-power (<2 kW) electric propulsion devices (some examples are resistojet, ion, and Hall thrusters) are already in use in orbit for communication satellite station keeping and as primary propulsion on science missions. However, those devices cannot produce the thrust required for the missions to the Moon or Mars without clustering a large number of them. The future of space propulsion is high-power (100 kW to 1 MW) electric propulsion devices like the Variable Specific Impulse Magnetoplasma Rocket (VASIMR), which can accomplish missions beyond Earth orbit in a reasonable time with only one or two engines and easily maintain large satellites in low Earth orbit.

Thrust is produced by the VASIMR by heating gaseous propellant with radio waves to great enough temperatures that an electron is stripped from every atom forming a high density plasma. The plasma is confined within the rocket by a strong magnetic field, rather than physical walls used in a chemical rocket, which allows the gas to be heated to millions of degrees Celsius without melting any components. The VASIMR consists of two heating stages and a magnetic nozzle. The first stage efficiently ionizes the propellant utilizing a helicon antenna to broadcast radio frequency waves into gas. The second stage (or booster stage) supplies the bulk of the energy to the ions by broadcasting at a different frequency than the helicon. That frequency efficiently heats the ions by interacting resonantly with them. By separating the ionization and acceleration processes into different stages the greatest possible efficiency of the rocket is ensured. The magnetic field expands aft of the rocket which acts as a magnetic nozzle that converts the energy of the plasma into directed kinetic energy and thrust - very similar to a conventional nozzle.

The VASIMR has two advantages over other electric propulsion devices: the antennas are located outside of the plasma and the exhaust velocity can vary with constant input power. Most electric propulsion devices have electrodes or antennas that are in direct contact with the plasma or gas; this increases the erosion rate of those components and, therefore, decreases the lifetime of the thruster. Because the VASIMR utilizes a strong magnetic field to confine the plasma, the antennas can be located safely out of harms way, giving the rocket a long lifetime. VASIMR is a unique electric propulsion device because it can operate over a relatively wide range of exhaust velocity while utilizing a constant amount of power. This is similar to the transmission in your car, where the power from the engine is transferred to the wheels at different speeds. The VASIMR can accomplish "constant power throttling" because the two stage design allows for the power to be transferred from the booster to plasma source stage (or vice versa) to match the requirements of the mission.

The VASIMR concept was invented by Dr. Franklin R. Chang Díaz in 1979, while working at

(Continued on page 6)



VASIMR Operation

American Institute of
Aeronautics and Astronautics

Image at right shows an argon discharge inside the helicon section of the VX-50 test engine. Image courtesy of Ad Astra.

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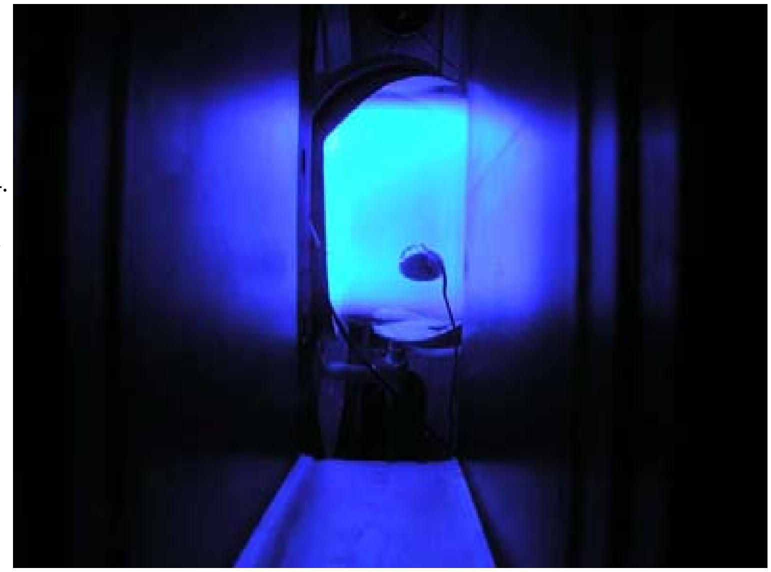
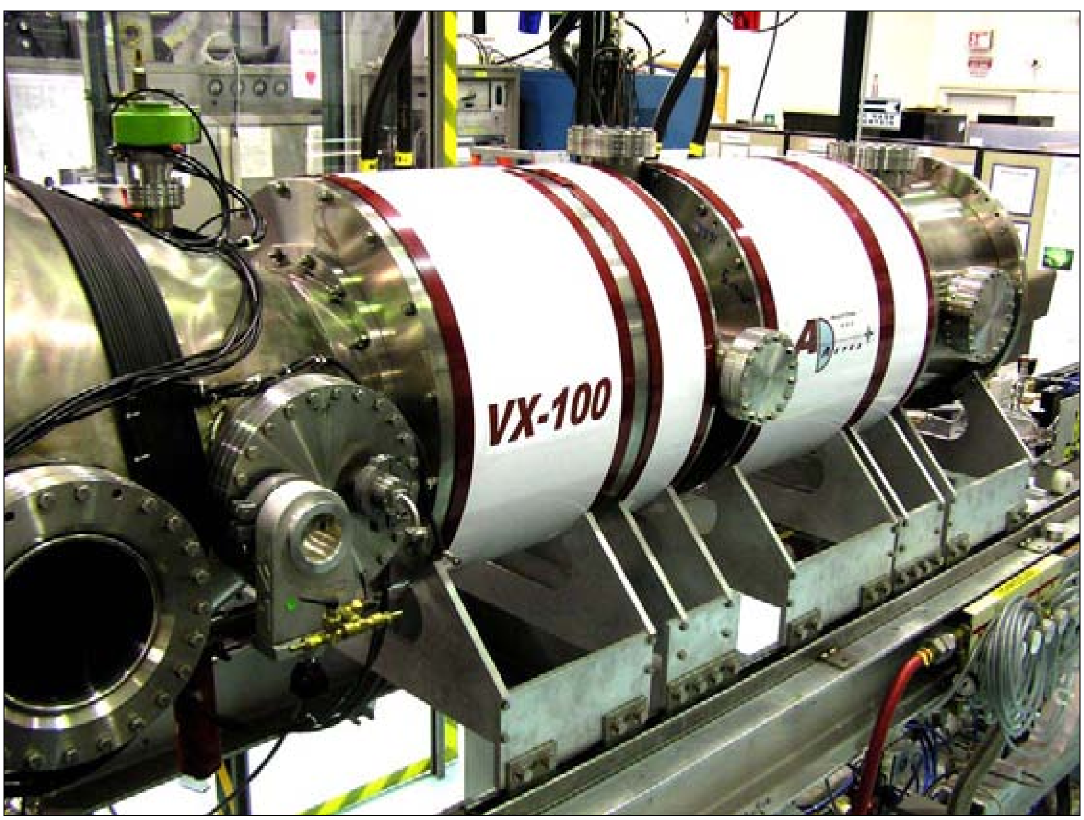


The Charles Stark Draper Laboratory in Cambridge Massachusetts and continued at the MIT Plasma Fusion Center before moving to the Johnson Space Center in 1994. From 1994 until 2005 Dr. Chang Díaz assembled a team of researchers from NASA and Universities around the world to continue development of the VASIMR. Research has been conducted at the Advanced Space Propulsion Laboratory (ASPL), which is located at the Sonny Carter Training Facility. In 2005 the funding for all electric propulsion research from NASA was greatly reduced, terminating many programs. Fortunately Dr. Chang Diaz had already decided to convert his team into a private company in order to stabilize funding and increase the pace of research.

Ad Astra Rocket Company (AARC) was founded through a privatization initiative with NASA to continue research on the VASIMR. Negotiations in early 2005 led to the June 23, 2005 signing of a Space Act Agreement transforming the ASPL into the new private company. Following its transition, the company has operated at a much faster pace exclusively on private investment capital. Major improvements to the original NASA technology have been realized. On July 15, 2006 Ad Astra inaugurated its research facility in Costa Rica. This 700m^2 installation in the province of Guanacaste is designed to carry out reliability and life cycle studies of major VASIMR components, off loading the parent company to focus on the critical design and integration of the system. The AARC facilities at the ASPL will be moved to a larger facility in early 2007 to accommodate the delivery of a large vacuum chamber, which has a 14 foot inner diameter and a length of 33 feet – making it one of the largest vacuum chambers in the nation. This chamber will enable pulsed operation at up to 200 kW of power so that the overall performance of the VASIMR can be accurately determined.

Ad Astra plans to test a full-scale ground prototype called the VX-200 in December of 2007. This test will pave the way for the construction of the first flight unit, the VF-200-1 to be tested in space in late 2010. Beyond these demonstrations, Ad Astra plans to fill a developing high power transportation niche near Earth for orbit maintenance of large space structures for commerce and tourism, satellite repositioning, retrieval and re supply and ultimately the delivery of large payloads to the lunar surface, recovery of space resources from asteroids and comets and support human missions to Mars and beyond.

Below: This is Ad Astra's current test engine, the VX-100. Image courtesy of Ad Astra.



Rockets, Mach Effects, and Mach Lorentz Thrusters

Feature Article

PAUL MARCH (CONDENSED AND ADAPTED BY THE EDITOR)

Why do we need a propulsion system that is better than our best rockets? The answer is illuminated by an interstellar robotic propulsion problem presented several years ago (see "The Starflight Handbook", by Mallove and Matloff), which demonstrates the need for much better power and propulsion techniques for any future explorations of the outer solar system and beyond. This example provides the specific impulse (**I**sp, see sidebar) requirements needed to send a robotic probe to our solar system's nearest neighbor, the Alpha Centauri triple star system, which is 40.61 trillion (10^{12}) kilometers away from Earth. This proposed interstellar mission problem was addressed by determining the propellant mass fraction (PMF) of a <u>conventional rocket</u> powered probe for a one-way Alpha Centauri fly-through mission with the following conditions and comparisons:

- Required mission change in velocity (or delta V): 0.01 **c** (3,000,000 meters/sec)
- Flight time assuming constant velocity from the Sun to Alpha Centauri: 430 years
- Estimated mass in the universe: $1\text{x}10^{80}$ atoms
- Estimated propellant mass for space shuttle external tank (ET): 720,000 kg or ~4 x 10^{32} atoms
- For a local reference, the space shuttle orbiter has a mass of ~100,000 kg
- Shuttle cruise velocity = 9,100 meters/sec or 330 times less than the proposed stellar fly-by.

As interstellar missions go, these are very modest requirements, so our standard chemical rockets should be able to get the job done, right? We will find out by plotting the rocket's PMF versus specific impulse using the rocket equation to solve for the propellant mass fraction for this problem (see Equation 1). The result of this relationship for the proposed Alpha Centauri fly-by mission is shown in Figure 1 for various values of specific impulse.

$$\text{(1)} \qquad \frac{Mass_{start}}{Mass_{final}} = e^{\left(\frac{\Delta V}{c}\right)}$$

$$\text{(1b)} \qquad \Delta V = c \cdot \ln\left[\frac{Mass_{start}}{Mass_{final}}\right]$$

("c" is exhaust velocity)

Assuming some "reasonable" figure for the desired PMF, as exemplified by an economical jet airliner such as the long-range version of the Boeing-777, which has a fuel to mass ratio of about one to one, i.e., a vehicle with a gross liftoff mass that is one-half fuel and the other half dry structural mass plus payload, yields a target PMF of 2.0. This implies that what's needed is a conventional rocket engine with an Isp of around 440,000 seconds to get these desired results. Even backing off to a PMF of 21, which has never been achieved in practice, still requires an Isp of at least 100,000 seconds, whereas the Space Shuttle Main Engines (SSME) only supply a measly Isp of 455 seconds. And even if we went up to a nuclear thermal rocket with an Isp of ~1,000 seconds, we are still two orders of magnitude off the required performance mark.

No, unless a scoop-ramjet rocket can be developed using interstellar gas as propellant, chemical or even nuclear rockets are next to useless when it comes to interstellar flights. If fast and affordable human space flights to the outer solar system or nearby stars are ever to become a reality, something much better has to be found in the propulsion arena - conventional rockets just won't cut it. Thus the need for a breakthrough in propulsion physics is demonstrated.

Breakthrough Propulsion Physics (BPP)

Marc Millis (1997), who ran the NASA's Glenn Research Center (GRC) sponsored Breakthrough Propulsion Physics (BPP) program, defined which propulsion technologies need to be developed before practicable human-crewed starships can become a reality. They are:

- Traversable Wormhole and Navigable Warp Bubble (TW & NWB) field generators.
- Prompt, near lightspeed travel. Like TW & NWB generators, this technology requires the generation of "Negative" Gravitational / Inertial (G/I) matter that reduces the effective mass of vehicles.
- "Propellantless or Recycled Propulsion (R-P) schemes that involve the production of accelerating forces without the expulsion of propellant mass from the vehicle.

<u>Definitions</u>

I_{sp} — The specific impulse of a propulsion system is the impulse (change in momentum) per unit mass of propellant. Essentially, the higher the specific impulse, the less propellant is needed to gain a given amount of momentum.

PMF — The propellant mass fraction is a measure of a vehicle's performance, determined as the portion of the vehicle's mass which does not reach the destination. A higher mass fraction is desirable (everything else being equal), since it gives a higher delta-V.

(from Wikipedia)

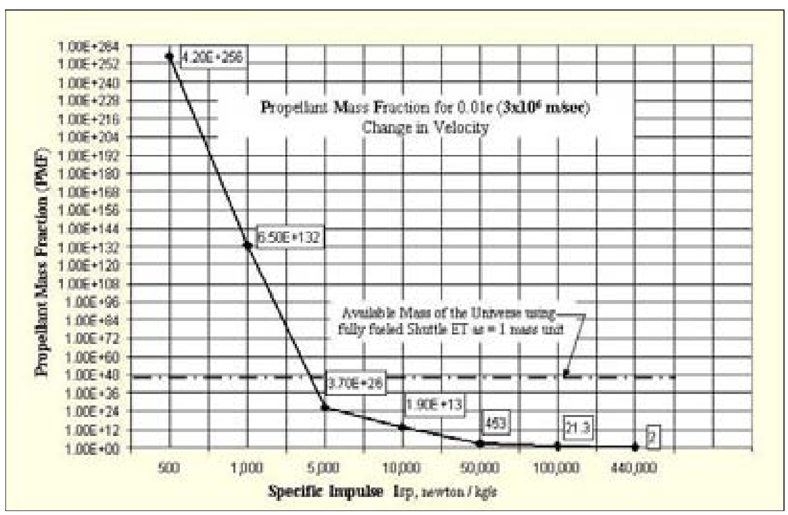


FIGURE 1. Vehicle Propellant Mass Fraction (PMF) in 10^X verses Isp for a Slow Interstellar Mission to Alpha Centauri.

Looking at these three requirements and noting the current sad state of the art in space propulsion based on chemical rockets, one could surmise that the third item on the list, Recycled Propulsion or R-P, might require the least amount of basic research to discover and could be the easiest

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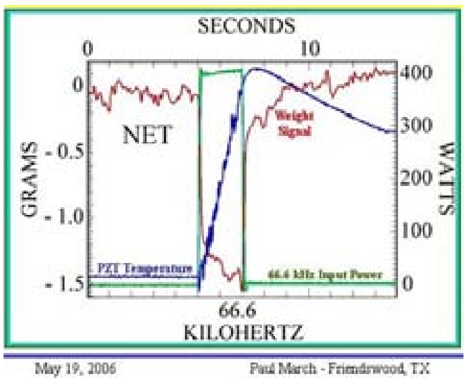
Conservation of energy and momentum must be maintained globally, but nature doesn't say how big the system box has to be, nor when the accounting has to be done.



Notice the immediate weight reduction upon application of power.

technology to implement in the next twenty years. So how does one make an R-P thruster that can accelerate a local mass *without* throwing mass overboard and thus apparently bypassing Newton's third law of motion, or in other words, *how can the rocket propellant be recycled*? In order to better understand the challenges of manifesting this system in practice, two concerns are presented:

- <u>How</u> does the R-P scheme account for coupling to the distant matter in the universe relative to which all accelerations and motions take place per Mach's Principle?
- <u>How</u> is momentum and energy conserved globally?

The answer to these questions - at a minimum - require a minor expansion of Einstein's General Relativity Theory (GRT) that fully integrates the strong form of Mach's Principle and also allows for effectively instantaneous momentum and energy (momenergy) exchanges between an accelerated local mass and all the rest of mass of the universe to occur. A professor at the California State University at Fullerton may have found a way to accomplish this.

The Mach Effect (M-E)

James F. Woodward, joined later by his ex-graduate student Tom Mahood have provided a theoretical explanation for how an R-P scheme could be built in several papers over the last fourteen years. Other researchers such as Funkhouser in 2003 have also come to the tentative conclusion that the relationship between inertial mass and Mach's Principle could be used to integrate macroscopic G/I phenomenon such as the speed of light with the quantum mechanical realm including the derivation of the Plank Length, thus reinforcing the credibility of Woodward's propositions. Woodward's M-E papers, the first of which was published in 1990, explain in detail Woodward's ideas on the origin of inertia, mass fluctuation and his R-P proposals including several STAIF presentations as well, so just a summary of Woodward's theoretical rational will be provided now for reference.

The M-E is based on the idea that when a mass is accelerated through a local potential field gradient, its local rest mass is momentarily perturbed about its at-rest value. These resulting acceleration induced "mass fluctuations" used in conjunction with a secondary force rectification signal can then be used to generate an unbalanced force in a local mass system, which can accelerate a payload or generate energy. Local system energy and momentum conservation is maintained by interactions with all the distant mass in the universe. Therefore to accelerate a spacecraft here, the Machian interpretation of inertial reaction forces means that each star or other distant matter in the universe will move in the opposite direction of the locally accelerated mass in response here – even if only on an extremely small scale. Conservation of energy and momentum must be maintained globally, but nature doesn't say how big the system box has to be, nor when the accounting has to be done.

A derivation from first principles of the M-E's controlling equation was performed by Woodward and then Mahood during the last decade of the twentieth century. Details of that derivation are beyond the scope of this condensed article.

Woodward has also developed and executed a large number of "tabletop" physics experiments that seem to confirm to some degree the existence of these mass fluctuations and their potential for use in a Uni-directional Force Generator (UFG). John Cramer of the University of Washington, Seattle, WA has explored related super-luminal energy transfers in 1997 and also performed a series of vibrating wire experiments on the existence of mass fluctuation under contract with Marc Millis' NASA/Glenn BPP program with published results to date being inconclusive. Hector Brito of the Instituto Universitario Aeronautico, Cordoba, Argentina has published two known papers suggesting a possible R-P effect based on accelerated local mass using Lorentz force rectifications. His latest (2003) paper described using piezoelectric materials, and the production of μ-Newton forces.

How Can the M-E be Used to Implement an R-P Device?

There are two elements in the M-E equation that might be used for building a thruster like device. The first is using the M-E's impulse term to generate an R-P device utilizing external force rectification inputs. The second is using the W-E's negative matter term's always negative-going mass reductions for either increasing the impulse term's total mass fluctuations, or to make a G/I mass reduction system for a rotary force rectified and amplified R-P device using centripetal accelerations to multiply the small negative mass changes. Both approaches have been or are currently being investigated.

Applying the W-E Impulse & Negative Matter Terms

Assuming that mass fluctuations really do exist, in theory an M-E thruster can be built using externally applied forces that can push on the device's "active" mass when it is lighter and then pull on this active mass when it is heaver in a cyclic manner, thus generating a net time-averaged force per Newton's F=ma relationship. This results in Equation 4 for the net force on a per cycle basis:

(4) $\mathbf{F}_{net} = \mathbf{S}(m_1 a - m_2 a)$

If one uses a sinusoidal drive signal to excite the W-E's impulse term, the net force equation then becomes Equation 5 for a M-E "Shuttler" thruster:

(5) $\mathbf{F}_{net} = - 2w^2 dl_o \, dm \cos q$

where w is the angular frequency,

Paul March is a Senior Engineering Specialist working for Barrios Technology supporting the NASA/JSC/EP Electrical Power System Laboratory (EPSL) at JSC as well as other EP projects or administrative needs as needed. He has also been working on the side with Dr. James F. Woodward. (California State University – Fullerton), for the last nine years developing the ideas, performing the experiments, and writing STAIF papers required to bring the Mach-Lorentz thruster concept to fruition. For more information, contact Paul at Paul.March@escg.jacobs.com and/or paulmarch@sbcglobal.net.

(Continued from page 8)

dl_o is the magnitude of the "Push / Pull" displacement produced by the externally applied force, d*m* is the magnitude of the instantaneous mass fluctuation and q is the phase angle or timing delta between the externally applied displacement and the internally generated mass differentials. Note that the net force should scale up with the square of the drive frequency, the magnitude of the delta-mass and applied rectifying forces.

MLT Applications

Could the Mach-Lorentz Thruster usher in a new era in space exploration? If the nascent MLT technology scales as Woodward's theory predicts, then it might. It could allow us to go anywhere interesting in our solar system in less than three weeks; travel times limited only by the specific power of the available power supplies available and the accelerations human physiology can endure. However, there's a large chasm between this vision of what could be and where we are today, for there are several MLT engineering challenges to be overcome first before we can make this vision a reality. We still need to determine experimentally what the MLT's actual specific thrust and thrust to weight ratio scaling rules will be by constructing more powerful MLTs than the tens to hundreds of micro-Newton test articles that have been demonstrated thus far. MLT capacitor aging issues also need to be solved, but given that these engineering tasks are not insurmountable, what new capabilities could these MLTs offer a spaceship designer?

The basic performance parameters of an MLT powered vehicle include the MLT's *specific thrust*, electrical input energy, MLT subsystem mass, operating lifetime, the vehicle's electrical power subsystem's *specific power* ratio, gross-lift-off-weight (GLOW), and obtainable payload mass fraction. All of these parameters interact with each other, but the primary parameters of interest in an MLT powered vehicle are the MLT's specific thrust in N/W and the vehicle's electrical generation subsystem's specific power in watts per kg (W/kg). A quick survey of existing high performance turbofan jets and rockets shows that the current specific thrust values for these engine types runs in the range of ~$2.5x10^{-3}$ N/W for high bypass turbofan jets to ~$2.5x10^{-4}$ N/W for the Space Shuttle Main Engine (SSME) rocket. Electrical power generation subsystems run in the 10-to-200 W/kg range dependent on their run-times, which is driven by their energy source. Due to the fact that the MLT's recycle their onboard propellant, their specific thrust could be much higher than these current engine examples and may be as high as 10 N/W or higher dependent on the desired peak acceleration and other gravinertial issues such as how to define local verse global momentum and energy conservation. For this MLT capabilities study, a variable specific thrust range of 0.5-to-1.0 N/W was chosen to allow peak vehicle accelerations of up to 2.0 Earth-gravities (E-g = 9.81m/sec^2) while allowing economy cruise at ~0.5 E-g when in deep space.

Given the foregoing constraints, what could an MLT vehicle with variable specific thrust MLTs accomplish if we combined them with an electrical power subsystem with a specific power of ~150 Watts/kg? This design study indicates then that we could perform routine missions to the Moon and beyond safely, quickly, conveniently and economically. This MLT powered vehicle could fly from the Earth to the Moon and back carrying a crew of two and two metric tonnes of cargo per round trip, in less than twelve hours, *without refueling* the MLT's fuel cell tanks. Back on Earth, the same variable specific thrust MLT's could provide the means to construct the fabled "flying car" as well as ultimately replacing all internal and external combustion engines in land, sea, and air applications.

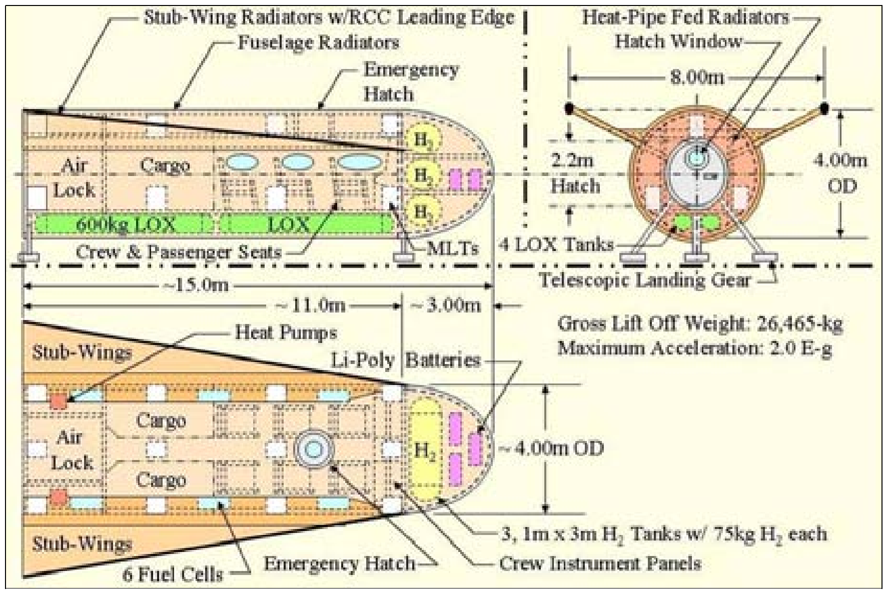


FIGURE 13. 3-View Drawing of the WarpStar-1 MLT Concept Spacecraft.

First Generation MLT Spaceship – The Warpstar-1

Provided we have built an operational MLT, what could this first generation human crewed MLT powered spacecraft look like? MLT's lend themselves quite easily to very large spacecraft designs, but for a first generation vehicle, it would be prudent to keep the vehicle small, providing for a crew of two and a payload in the 2 metric tonne class. MLT's also provide great engine mounting location flexibility due to the fact that their "momentum exhaust" is a gravinertial wave which can be transmitted either directly from the MLT to/from the distant mass in the universe, or by first going through the vehicle's local structures and passengers with no anticipated distress to either. This WarpStar-1 vehicle concept is shown in Figure 13.

Safety concerns indicate that a first generation electric spacecraft should include conventional aero-

(Continued on page 11)

This article is condensed and adapted for Horizons. The full length paper will be presented at the Space Technology and Applications International Forum:

STAIF 2007
February 11 - February 15, 2007
Albuquerque, New Mexico, USA

See:

http://www.aip.org/cal/viewbyuser.jsp?eid=1171

Lunch and Learn Summary Report

Constellation Program Overview and Challenges

DOUGLAS YAZELL, CHAIR-ELECT

Chuck Knarr and Mark Thomas of United Space Alliance described the new vehicles to be used for upcoming NASA missions to the International Space Station (ISS), the Moon, Mars, and beyond. A crowd of about 100 people enjoyed the discussion on Thursday, November 16, 2006, in the NASA/ JSC building 30 auditorium. This event was sponsored by the AIAA Houston Section Guidance, Navigation, and Control Technical Committee. (We hope to have some PowerPoint charts from our speakers on our web site at www. aiaa-houston.org.)

Following the announcement of the President's Vision of Space Exploration (VSE) in 2004, NASA and contractors are on their way to design the next generation of spacecraft and launch vehicles. After the retirement of the Space Shuttle program in 2010, these new vehicles (Orion, Ares I and Ares V) will continue the human space exploration by ferrying our Astronauts to the ISS and Moon under the Constellation Program. Chuck Knarr of United Space Alliance (USA) presented the many challenges facing NASA and its contractors as we enter this new era of space exploration.

"Charles R. (Chuck) Knarr is the Vice President Flight Operations of United Space Alliance, LLC. He is responsible for the day-to-day operations and overall management of the USA Flight Operations element, which provides direct mission planning, training and real time mission support to the NASA Mission Operations Directorate (MOD) and Flight Crew Operations Directorate. Knarr, a former NASA flight director, was named to this position in March 2002.

Mr. Knarr spoke first and shared some his opinions on Constellation (not necessarily those of the Program) as well as Program information. PowerPoint charts from Mark Geyer dated 4/19/06 were used as well as some of the speaker's own. One chart displayed a roadmap from 2005 to 2025 with an ambitious first test launch in 2009. The frequently asked question, "Why the Moon before Mars?" was answered with how much closer the Moon is to home and how the Moon can be a stepping stone to Mars.

The speaker described the importance and excitement related to commercial crew and cargo options for ISS. NASA has recently supported two companies, Rocketplane Kistler and Space X. He asserted that the recent failed launch attempt of the Falcon 1 rocket at Kwajalein by Space X was a success by most measures.

Mr. Knarr explained that the new Crew Exploration Vehicles (CEV), the Apollo-like capsules and related elements, will carry humans twice a year and cargo 3 times per year. Since plans call for an end to space shuttle missions in the year 2010, a gap will exist in American launch capabilities for supporting ISS. As for "Will we really respect that deadline of 2010?" that depends on where we are with space shuttle schedules at the end of 2009. The speaker also noted that different heat shields are required on the CEV capsules depending on whether it is returning from the Moon or Low Earth Orbit.

Another slide described Program Management. Propulsion work is centered at the NASA Marshall Spaceflight Center in Alabama. The government also selected the United Space Alliance (USA) to perform functions for the Constellation Program that are similar to those performed in support of the Shuttle and ISS Programs for the duration of their current contract.

Launch vehicles are heritage-derived. The J-2S Saturn rocket follow on engine was developed in the mid 1960s and used liquid hydrogen and liquid oxygen. It was resurrected in 2005 (modified and updated to reduce risk, etc.) to support the Constellation Program. It provides 274,000 pounds of thrust. These will be used on the Ares I and 5 second stages. The RS 68 engine from Rocketdyne is from the late 1990's. It has high thrust and is already in production. It uses liquid hydrogen and liquid oxygen, has 650,000 pounds of thrust at sea level, and can throttle down to 60%. Those engines will be used for the first stage of the Ares V. ATK Launch Systems has been selected by NASA as the prime contractor for the Ares 1 first stage which is essentially a Shuttle solid rocket booster except that it has 5 segments instead of for. USA is subcontracted to ATK to process the Ares 1 first stage at the Cape in Florida. A request for proposal (RFP) is expected to be released sometime in the spring for the upper stage.

Back to the future with CEV

It will service the ISS and be capable of staying there for six months like a Soyuz capsule, providing rescue capabilities. Components of the Constellation Program include the Heavy-Lift launch Vehicle (HLLV), Earth Departure Stage (EDS), Crew Launch Vehicle (CLV), Crew Exploration Vehicle (CEV), and the Lunar Lander (LL). A typical lunar reference mission includes two launches close together and a rendezvous in Earth orbit. As for landing, the CEV capsule is water capable but will plan for land. When speaking of the lunar lander, Mr. Knarr specified a cargo capacity of 21 metric tons. High priority lunar landing sites will be places where they want to find water, and possibly develop the capability to produce propellant in situ for coming home – a capability that will be very important for a Mars mission. For now, the South Pole on the Moon is preferred as a landing site, and Shackelton Crater is a possible lunar outpost there. Why expansion of the space frontier? "World leadership and national security."

(Continued on page 11)

(Continued from page 10)

This is a different approach to a new program, improving and applying existing technology. This provides less risk and supports an ambitious schedule, but is sometimes unpopular, for example, when canceling or deferring a LOX/methane engine under development for missions to Mars.

A budget profile showed details from fiscal year 2006 to 2020. A list of subjects there includes CEV, launch vehicles, program integration, ground operations, a lander, surface systems, reserves, ECANS, and extra-vehicular activity (EVA).

Mr. Knarr concluded with a few personal opinions and observations. The Constellation Program is wonderful and can be done within schedule and budget. Technology is not the driver. There are so many variables affecting planning that it helps to take the five-year test. What relevant factors could we have used five years ago to predict the environment we are in today? The point being that predicting the future is very difficult to do.

Mark Thomas of USA spoke next and his PowerPoint charts included some from Dale Nash dated 9/18/06. A few notes are included here: The winning Lockheed Martin CEV (Orion) team consists of Hamilton Sundstrand, United Space Alliance, Honeywell, Orbital, and Aerojet. USA tasks include flight software development. Orbital's tasks include the Launch Abort System (LAS) and Safety and Mission Assurance. The CEV pressure vessel is reusable. Plans for CEV work include a light refurbishment and a heavy refurbishment. Currently the Crew Launch Vehicle (CLV), Ares I, has some performance issues that might affect the design of CEV.

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Rockets, Mach Effects, and Mach Lorentz Thrusters

CONTINUED …

(Continued from page 9)

dynamic backup systems. In the event of primary propulsion failure, aerodynamic lift and control surfaces, along with heat resistant ceramic tiles would enable it to make unscheduled hypersonic reentries much like the Space Shuttle. Other safety concerns suggest it should be equipped with a redundant fuel cell and battery electrical power subsystem that drives an array of twelve (12) "Tesseract" MLT propulsion assemblies mounted throughout the spacecraft. If two of the fuel cells and up to five MLT Tesseract assemblies failed, the craft could still fly above the Earth and land normally. It could also fly with four failed fuel cells and eight failed Tesseract assemblies while over the Moon.

Fast transit is a result. This design could provide round-trip service to the Moon in under 12-hours accelerating half way there, then decelerating the rest. If it was driven past the human comfort zone of approximately 1.0 E-g and instead accelerating at the WarpStar-1's maximum of 2.0 E-g acceleration; it could execute a one way trip from the Moon to Earth in as little as 2.5 hours assuming MLTs with 1.0 N/W specific thrust.

Convenience and Utility are intrinsic. The design provides vertical takeoff and landing (VTOL) along with hover capabilities. It could fly continuously in the Earth's atmosphere at subsonic and low supersonic speeds as the need dictates, and land silently with no downwash in any landing area large enough to *park* a business jet. In space, the preferred operating mode for the vehicle would be a near constant acceleration of 1.0 E-g at an angle normal to the cabin deck. The crew and passengers would not be bothered with high-g stress or zero-g adaptation issues and it would allow easy movement about the WarpStar cabin during the trip. While operating on the Moon with 1.0 L-g (1.62 m/sec^2) conditions, it could provide up to 175 lunar metric tonne lift capability, acting as a "Lunar Sky Crane." *Economy* is built in. The WarpStar's VTOL ability removes the need for most of the support infrastructure needed to service conventional spacecraft for both Earth and Moon operations. If it avoids hypersonic reentry during its trip back from the Moon, which would be its standard operational mode, there is every reason to believe it could refuel its fuel cells, refresh its life support subsystem and be headed back to the Moon in less than an hour. A single, small vehicle like the WarpStar-1 could deliver over 1,100 metric tonnes of materials and/or personnel to/from the Moon in a single year if we can build these 0.5 to 1.0N/W MLTs.

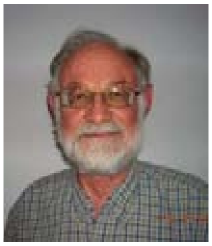
SUMMARY

The advent of the Mach-Lorentz Thruster is in many ways like previous technologies that have transformed society. Domesticating the horse gave humankind vast mobility and with that change came unpredicted growth of all sorts. Harnessing the wind made us able to cross oceans. The Conestoga wagon opened up a continent. Rail transport, steam power, the internal and external combustion engines have all contributed to explosive growth in cultures and societies around the world and throughout human history. Mobility matters. This study shows that the MLT is like these previous technologies in that it offers a revolutionary leap in mobility through safe, quick, convenient and economical transportation. This is something that chemical rockets, because of their energy limitations, have never been and will never be able to provide us.

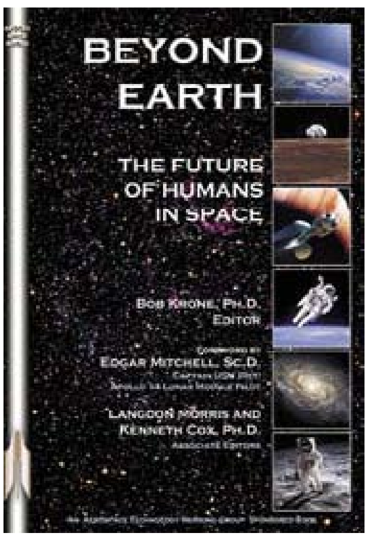
(Continued on page 22)

If it was driven past the human comfort zone of approximately 1.0 E-g and instead accelerating at the WarpStar-1's maximum of 2.0 E-g acceleration; it could execute a one way trip from the Moon to Earth in as little as 2.5 hours assuming MLTs with 1.0 N/W specific thrust.

Lunch and Learn Summary Report



Dr. Ken Cox



Today's Unfolding Relationships: Earth,Space,Life

DOUGLAS YAZELL, CHAIR-ELECT

Dr. Kenneth Cox delivered a lunch-and-learn talk on Friday, December 1, 2006 at NASA/JSC as the honored guest of the AIAA Houston Section Astrodynamics Technical Committee.

The subject was a new book, "*Beyond Earth: The Future of Humans in Space*", by Bob Krone, Ph. D., editor, Langdon Morris and Kenneth Cox, Ph. D., associate editors. This book provides a foundation for space planners and anyone interested in humankind's next great adventure - the human migration to space. World-class scholars, scientists, engineers, managers, astronauts, artists, authors, and university professors capture the questions that plague our unique circumstance: Why does space matter to us? What can we use it for? How can we get there efficiently? What will ordinary life be like in space? What will our settlements be like on the Moon? On Mars? In orbit? Will we play? Will we love? Will we survive?

The primary reasons for humans to go permanently to space are for the betterment of humankind and the avoidance of threats to humans on earth. Evidence to support those conclusions is provided herein. Research findings over the past decade show huge benefits to humans and to earth of exploiting the resources and capabilities uniquely found in space. Some predictions and projections will produce paradigm shifts unimagined in 1957 when Russians and Americans began departing earth. Space Sciences, technology and experience make the next major breakout from Earth to space not only feasible but also commercially profitable.

Dr. Cox described his talk as a few remarks from experience as opposed to wisdom coming down from the mountain top.

When the Strategic Avionics Technology Working Group (SATWG) was formed in 1990, NASA Code R Centers (Research and Technology based) and Code M centers (Operations and Engineering based) needed better collaboration. In addition it was difficult to convince some groups that digital and informational systems were as important as structural, electrical, and propulsion flight systems.

For outer space, detailed system engineering and integration (SE&I) at both the private and public sector levels are absolutely required for future systems, but always result in some level of embedded bureaucracy that must be tamed. The Lockheed Martin Skunk Works has provided excellent examples of how to tame it. When a project ended, everyone needed to look for a new job - the old team was gone. Even now, the Department of Defense (DoD) has a process that no one can keep a specific job function for more than 3 or 4 years, but that rule still meets resistance. Meeting rooms have often been filled week after week with 38 people, 8 of whom are doing the work while the other 30 report to their bosses on the meetings. These simple examples need improvement as a part of the process of taming bureaucracy.

The world of space commerce is a new world that is influenced but not run by the government. Our country must compete in a more effective manner there. Commercial opportunities can appear like they did at the off ramps when President Eisenhower decided to construct the Interstate freeway system, which led to the development of a new transportation infrastructure. In another example, our government gave rights to the railroads so that private industry could go to work in that sector. Some recommended off ramps for Earth orbit are similar and might include one in high Earth orbit and one in low Earth orbit (not necessarily the ISS orbit). As for activities at these off ramps, they would be analogous to AAA auto services, filling stations, food services etc., with different services provided for departing and returning vehicles.

What we do beyond Earth orbit is still being developed in a scheduling sense and involves choices of exploring and/or creating settlements. This continues to be a big discussion item at present.

Another concern that is listed is that we tend to lowball the unfriendliness associated with living and evolving in the space environment. Learning and applying lessons learned through actual experience is a significant factor associated with the future.

Looking into his crystal ball after the elections in this country a few weeks ago, Dr. Cox made a few observations that apply, no matter who is elected to be our next president in 2008: The ISS role will increase because Earth orbit is not just something to pass through until we get to the real stuff. [Dr. Cox believes the International Space Station (ISS) will continue operations longer than anyone presently is predicting.] Going to the moon now appears underbid, and sticking to an aggressive schedule will quickly drain other NASA activities. The NASA budget will be reasonable but tight in the short term, but several years from now, the schedule for our missions beyond Earth orbit will slip to the right. But, there is a significant need for our country's space program to get beyond Earth orbit.

Dr. Cox also expressed the need to invest in Earth based transportation system technologies that utilize runways coming and going from Earth to orbit and back. Imagine a Boeing 747 leaving New York City with a small plane attached to its back. The small plane separates and lands in Tokyo with 20 passengers while the

(Continued on page 13)

(continued from page 12)
747 continues its flight to land in Los Angeles with 250 passengers. All of the passengers pay fares.

In concluding, Dr. Cox is working hard to support the planning for a International Space Development Conference to take place from May 24 – 28, 2007, in Dallas, Texas (http://isdc.nss.org/). Many of the ideas discussed in this short lunch-n-learn session will be developed in greater scope at this international conference. Dr. Cox would like to initiate a workshop on this topic here with the AIAA Houston Section and incorporate the results into a presentation to be given later at this conference in Dallas.

The Speaker

Dr. Ken Cox is an engineer, technologist, scientist, futurist, and change agent that has worked for NASA for more than 40 years. Previously, he served as the Chief Technologist for the NASA Johnson Space Center in Houston, Texas. Other management assignments in the past have included (1) Technical Manager for the Apollo Primary Control Systems in 1963, (2) Space Shuttle Technical Manager for Guidance, Navigation and Control in 1974, and (3) Chief of the Avionics System Division in 1987.

In 1990, at the direction of the NASA Administrator, he created the Strategic Avionics Technology Working Group (SATWG), a NASA-industry-academia interface and networking organization, which still meets biannually to facilitate an open dialogue between government, industry, and academia concerning space technology issues and futures planning. He received his B.S. and M. S. in Electrical Engineering from the University of Texas in 1953 and 1958, and his Ph.D. from Rice University in 1966. He has originated an oral history project with a Cultural Anthropologist at the University of Texas to collect space stories from the early pioneers of America's space program.

Dr. Cox has served on the AIAA National Board for six years and has been active in the AIAA Distinguished Lecture Series.

His awards include the AIAA Mechanics and Control of Flight Award (1971), the NASA Medal for Exceptional Engineering and Achievement Award (1981), and the AIAA Digital Avionics Award (1986). He has been a keynote speaker at (l) Creative Problem Solving Institute, Buffalo, New York, (2) Science and Consciousness Conference, Albuquerque, New Mexico, and (3) World Future Society, Houston, Texas.

A Final Note

The AIAA Astrodynamics Technical Committee is always looking for qualified student and professional members. Please refer to the web page at www.aiaa-houston.org for details, including a list of current members, a list of past lunch-and-learns (some with PowerPoint charts, and a handout from this event will be added), and contact information.

Ken's Next Speaking Engagement:

Dr. Kenneth Cox,
A Futurist Perspective for Space-Discovering & Shaping Our Intentions

Noon, Thursday, January 25, 2007

Brae Burn Country Club
8100 Bissonnet St
Houston, TX, 77074

Staying Informed

COMPILED BY THE EDITOR

Why the Moon?
http://www.nasa.gov/mission_pages/exploration/mmb/why_moon.html

U.S. House of Representatives Committee on Science and Technology
http://science.house.gov/

Space Exploration and the National Interest
http://www.aia-aerospace.org/library/pubs/space_exploration/index.cfm

Prepared Comments by Michael Griffin before the Space Transportation Association
http://www.comspacewatch.com/news/viewsr.html?pid=23012

2006 Year End Aerospace Industry Review and Forecast Presentation by John Douglass, AIA
http://www.aia-aerospace.org/pdf/yearender06.pps

2nd Space Exploration Conference Presentations at NASA
http://www.nasa.gov/mission_pages/exploration/main/2nd_exploration_conf.html

Critical Issues in the History of SpaceFlight
http://history.nasa.gov/SP-2006-4702/frontmatter.pdf

NASA Podcasting
http://www.nasa.gov/multimedia/podcasting/index.html

Reference Guide to the International Space Station
http://hdl.handle.net/2060/20060056410 (Note: This is a large PDF file, **135 MB**)

"Now, most of us know quite well that scientists and engineers on the government side of the house have an overwhelming urge to specify the design to meet a requirement, and unfortunately we also have the power to gratify this urge. We need to overcome this bad habit, unless we know with certainty that we must have a specific approach, in which case we should then clearly say so, and allow the contractor to move on."

- NASA Administrator Michael Griffin, Speaking to the Space Transportation Association

Lunch and Learn Summary Report

Earth, Moon, and Spacecraft (or, "Stars A, B, & Planet")

DOUGLAS YAZELL, AIAA HOUSTON CHAIR-ELECT

Wes Kelly

Wes Kelly gave this presentation to a crowd of about 35 people in a packed room on November 17, 2006, at NASA/JSC in building 16, room 111. The event was sponsored by the AIAA Houston Section Astrodynamics Technical Committee. Our chair, Dr. Albert Jackson, organized the talk and introduced the speaker. From our publicity flier:

"The Topic: In the '60s and 70s, the last time astronauts prepared to visit the moon, trajectory analysts were encouraged to study the so-called Restricted 3-Body Problem since it characterized the motion of a spacecraft moving from Earth to Moon. Without doubt the subject is under examination again, with guidance and tracking specialists going back to look at work done by pioneers in this field ranging from Lagrange in the 18th century to Americans such as Forrest Moulton and Victor Szebehely (many of whose students work at the Johnson Space Center today). Since the Apollo missions, other applications of 3-body problem analysis have brought new perspectives: studies of stability of bases at Lagrangian equilibrium points, the stability of planets in binary star systems, the consequences of elliptic systems vs. circular…In the last case, should the Earth-Moon system be considered the latter or the former? We will show some implications for lunar flights and returns.

"The Speaker: For most of his engineering career Wes Kelly has been interested in developing models of aircraft, space vehicles and planets in motion covering problems that might otherwise have fallen through the cracks. After serving with the USAF with a flight crew, Wes Kelly received a BS in Aerospace Engineering from the Univ. of Michigan in 1973; later, an MS in Aeronautics and Astronautics from the Univ. of Washington in Seattle in 1978, doing additional graduate studies and staff work in astrophysics and planetary science. Since 1973 he has worked with engineering groups in Seattle, Houston, New Orleans and Denver, principally with development of NASA related spacecraft or launch vehicles: Space Shuttle, Inertial Upper Stage, Solar Electric Propulsion, Orbital Maneuver Vehicle, External Tank and Titan Advanced Programs and the Space Station. In the course of this work Wes Kelly wrote 19 technical papers related to flight mechanics, astrodynamics, optimization, propulsion and performance analysis. As an avocation he has worked as a Russian translator, particularly in support of the International Space Station program. "Wes Kelly is a co-founder of Triton Systems LLC, a Clear Lake engineering consulting firm supporting the JSC Engineering Directorate. This year Triton Systems and its team submitted a proposal to NASA for the Commercial Orbital Transport Service demonstration. The proposal was based on the Stellar-J a partially reusable (first stage horizontal launch and landing) launch vehicle that Kelly and colleagues are developing for commercial space applications."

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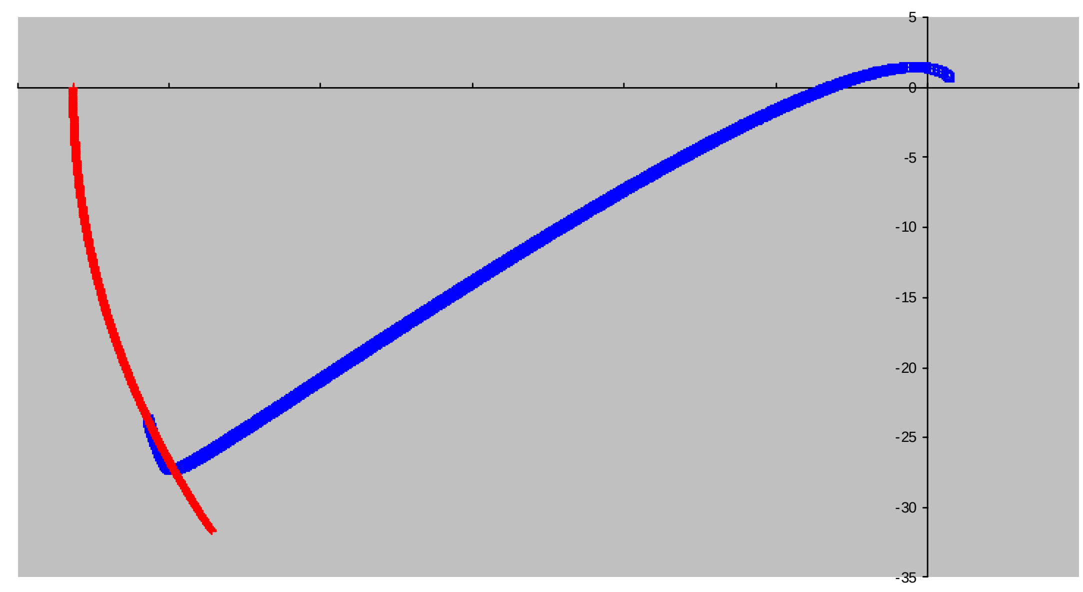


Swing-by trajectory (blue) from Low Earth Orbit crossing in front of the Moon (red).

New Members

ALBERT MEZA, MEMBERSHIP CHAIR

We had a great month! If you see one of the folks at the next section event, please make them feel welcome.

September
Stanley Allen
Charles E. Bautsch
Dan A. Bland
Lyndon B. Bridgwater
Dr John B. Charles
Hicham A. Chibli
Barry B. Copeland
David J. Debrestian
Dr Edna Fiedler
Abraham Gutierrez
Bradley J. Knouse
Brian D. Krolczyk
Ravnish Luthra
John R. McCann
Vernon McDonald
Hubert C. McLeod
Stephen Nelson
Zane A. Ney
Kenneth E. Peek
Dr Peter A. Popov
Ralph Rohloff
Prerit P. Shah
Robert T Swanson
Wendy Wilkinson
Jean L. Zophy
Daniel F. Antinone
Dr Matthew R. Barry
Hicham A. Chibli
Thomas P. Davis
Dr Jesse Follet
John R. McCann
Anoop A. Mullur
Jeffrey S Osterlund
Jack W Thrift
Samuel W Ximenes

October
Eleuterio De La Garza
S. Michael Goza
Richard W Guidry
Donald L Henninger
Dr Greg N Holt
Robert M Kelso
Kriss J Kennedy
Rob R Landis
David C Leestma
Alan J Lindermoyer
Dr Ozden O Ochoa
Suzanne C Oliason
Neal Pellis
Dr. Subramanian Sankaran
Dennis A Stone
Valin B Thorn
Heidi M Anderson
Randi B Florey
Michael I Gamble
Rafael E Munoz
Miguel A Pereira
Dr Ashok Prabhakar
Rayelle Thomas

November
Thomas C Evatt
Charles Keierleber
Gopal Salvady
Dr. Shyang-wen M. Tseng
Rick Watkins
Rachel Z. Jones
Dr. Kjell N. Lindgren
Angela D. Anderson
George E. Aulenbacher
Shanna C. Barnstone
Dr. Adetunji B. Bello
Stephanie H. Montez

Important notes:

- *Not a member? See the end page.*

Update Your Membership Records

Please verify your AIAA member record is up to date. Knowing where our members are working is vital to the Houston Section in obtaining corporate support for local AIAA activities (such as our monthly dinner meeting, workshops, etc.). Please take a few minutes and visit the AIAA website at http://www.aiaa.org/ to update your member information or call customer service at 1-800-NEW-AIAA (639-2422).

We do not have current contact information for the following members, which means that either their email or mail addresses are no longer valid. If you know where they are, please either ask them to update their information on www.aiaa.org or send their new information to albert.f.meza@nasa.gov

Sarah L Bibeau
James Boyd
Yuanyuan Ding
Frieda Y Wiley
Ryan Sager
Frank L Culbertson

AIAA Membership Notes

Please say "Thank You" to Liz Blome, Membership Chair

Elizabeth C. Blome has been AIAA Houston Section's Membership Chair for 3 years now and has done such a fantastic job that she was named the Section Winner for the 2005-2006 Membership Award. All good things must come to an end and she has asked Albert Meza to take over her position as Membership Chair. Thanks Liz, for your service!

New Senior Member

Congratulations to AIAA Houston Section's newest Senior Member: Jeffrey E. Carr

To request membership upgrade information or nomination forms, visit our Website at:

www.aiaa.org/upgrade
or contact Customer Service at 800/639-AIAA or 703/264-7500 (outside US).

CALENDAR

Dates, events, and times are subject to change. See the AIAA Houston web site for more information at: www.aiaa-houston.org

Contact chair@aiaa-houston.org or events@aiaa-houston.org for further details.

January

18 Film & Speaker Event: Christa McAuliffe: Reach for the Stars, A Documentary, 5:30 - 8:00 PM, UHCL Bayou Theater, free for members, else $5 at door
20 EC Social at 1940 Air Terminal Museum at Hobby Airport, 11:00 AM - 1:00 PM

February

12 Executive Council Meeting (ARES Corp)
17 Engineer's Day Social at 1940 Air Terminal Museum at Hobby Airport
22 Dinner Meeting, John Connolly (NASA JSC-ZX)
TBD Workshop by Dr. Ken Cox

May

TBD Dinner Meeting (Tentative: Elon Musk, SpaceX), Gilruth

June

TBD Dinner and Awards Meeting, Speaker: John McMasters, "Perspectives on Airplane Design – Past, Present and Future"

Cranium Cruncher

NORM CHAFFEE

Here's the Cruncher from last month:

> Five retired NASA astronauts had a reunion dinner at their favorite restaurant recently, and all sat around a round table. Each ordered something to drink; an entree; and a dessert.
>
> John and Mr. Jackson had martinis. James and Mr. Jones ordered scotch. Mr. Jenkins had cola since he was driving. John and Mr. Jennings ordered steak. Joe and Mr. Jenkins had roast beef. For dessert Joe and Mr. Jordan ate chocolate cake. Jerry and Mr. Jenkins had pie. The other man had ice cream. No one was served an item in common with the two people on either side of him.
>
> Who had the pheasant? And what did Jack eat?

Answer: Jerry Jones had the pheasant. Jack had a coke, roast beef, and pie.

The following individuals had the correct answer:

Frank L. Baiamonte (NASA)
Glenn Jenkinson (Boeing)
Ronnie Newman (NASA)

Current Issue Puzzles (TWO!)

Puzzle #1

Frank Anderson is participating with a team of colleagues in a survival course in the far north of Alaska in the winter. The team's requirement is for Frank to be able to make a six day trek from Base Camp to Remote Camp across the ice and snow. Only Frank needs to arrive at Remote Camp, but other members of his team can participate in the endeavor, but all participants must be able to reach safety back at Base Camp. One person can carry only enough food and water for four days. As you can see, therefore, Frank cannot go alone - his supplies would run out. How many team members, including Frank, need to participate in this trek, in order for Frank to safely arrive at Remote Camp and any other team member to also reach safety at Base Camp?

What is the successful strategy to accomplish this task?

Puzzle #2

InTelCo Engineering has had a budget cut and is required to reduce staffing. The Director of Human Resources decides to use a logic test to identify the staff he will retain. He calls in each candidate for retention and offers the individual three envelopes, and gives the following instructions:
Here are three envelopes. One envelope has an employment contract. The other two envelopes have dismissal "pink slips". Each envelope has a statement written on it, but only one of the written statements is true.
Envelope A says "This envelope has a pink slip"
Envelope B says "This envelope has a contract"
Envelope C says "Envelope B has a pink slip"

Which envelope do you select in order to be retained?

Email your answers to Norm Chaffee at: norman.h.chaffee@nasa.gov

Odds and Ends Imagining the Future

SPECIAL EVENTS, PICTORIALS, ETC.

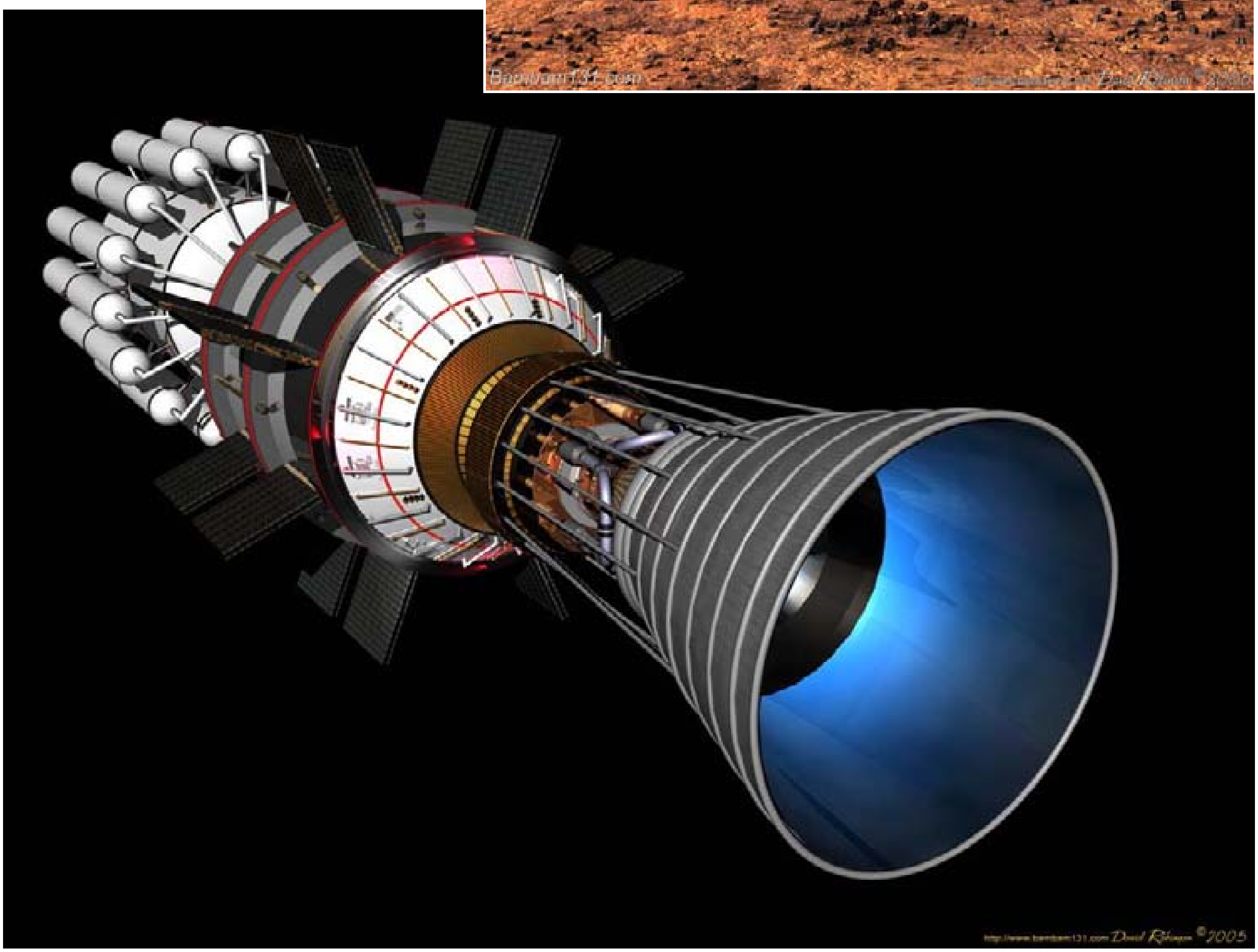
On this page are fictional scenes from the imagination of David Robinson, an Astronautical & Space Artist from Portsmouth, VA (Contact: drobinson@cox.net). Regarding his choice of tools, David explains, "I use Bryce as my main modeling tool but also use Hexagon and Carrara. All post work is done with both Universe and Photoshop." David describes his images presented here as follows,

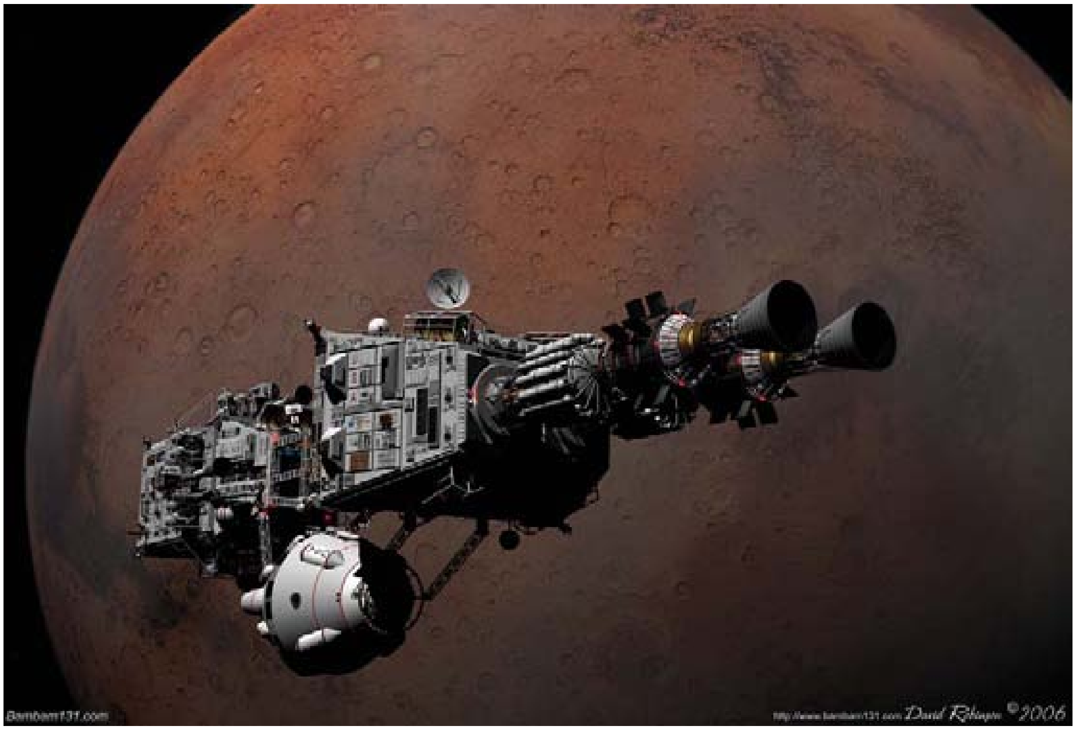
At right: The crew of a Mars Lander checking out the first of 3 autonomous utilities ships that preceded the crew by 6 months to the red planet. This will be the beginning of the first permanent settlement on Mars, this one being a Nuclear power station.

Below: One of 2 hypothetical Nuclear engines that will power the spaceship USS Shenandoah to Mars.

To see more space art by David Robinson, see:

http://www.bambam131.com
http://www.spaceartbydavid.com



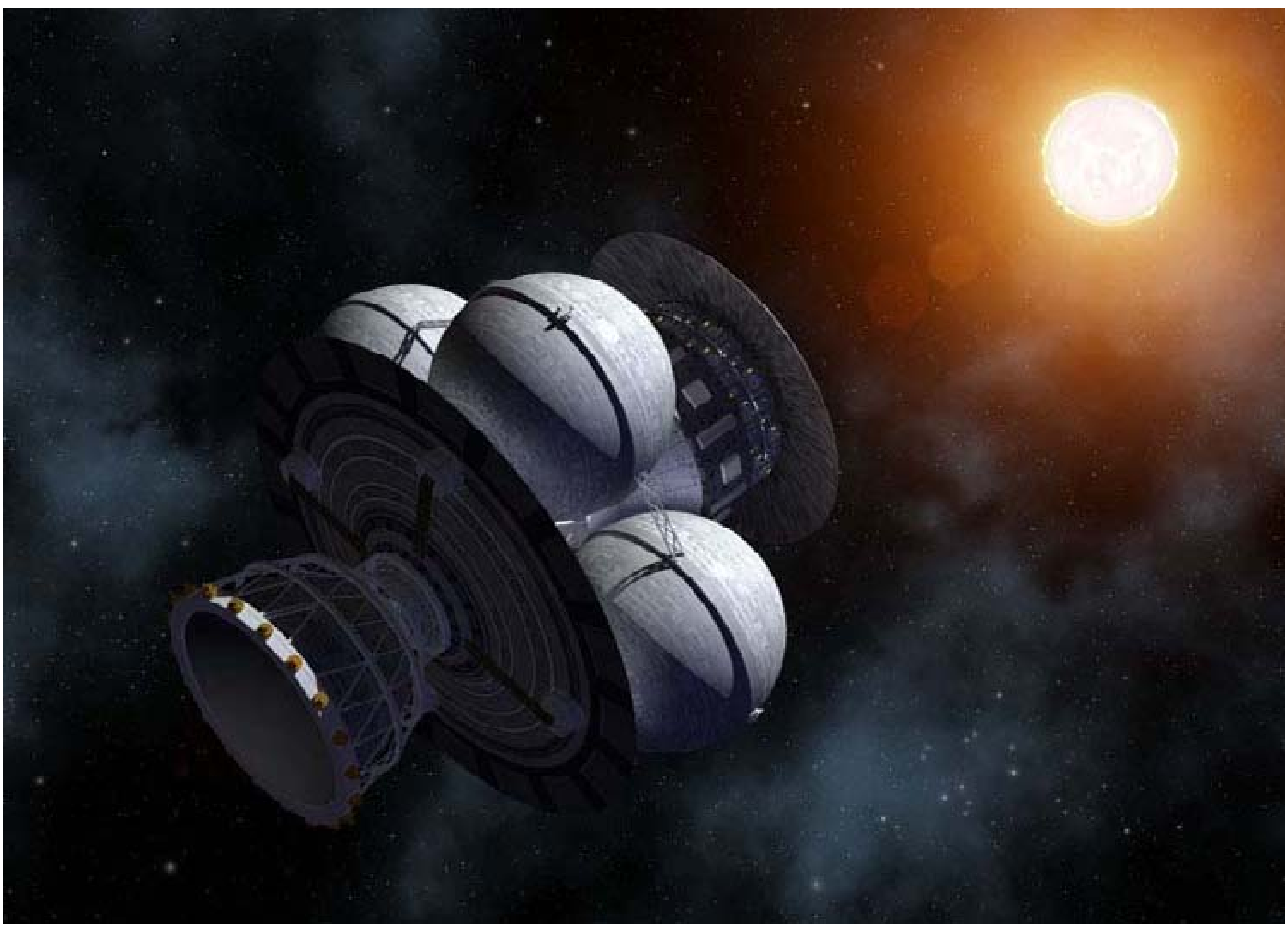


At left: Another creation by David Robinson, the *USS Shenandoah* is shown preparing for insertion into orbit around Mars. This picture shows a possible manned mission to Mars in the not too distant future.

Below: A rendering by Adrian Mann of the starship Daedelus. From his website:

"*The world's first engineering study of an unmanned spaceship to explore one of the nearer stars was made by a technical group of the British Interplanetary Society between 1973-77. The target selected for the exercise was Barnard's Star, nearly 6 light years distant from Earth. The contributors recognized that the work, based on the technology extrapolated to the beginning of the 21st Century, could represent only a first approximation to the solution of starflight.*"

For more information, see: http://www.bisbos.com/rocketscience/spacecraft/daedalus/daedalus.html



Conference Presentations/Articles by Houston Section Members

COMPILED BY THE EDITOR FROM AIAA AGENDAS, SUBMISSIONS, ETC.

Some information here is taken from preliminary AIAA conference agendas. As such, it is subject to change.

45th AIAA Aerospace Sciences Meeting and Exhibit
8 - 11 Jan 2007
Grand Sierra Resort Hotel (Formerly Reno Hilton)
Reno, Nevada

Assessment of Turbulent Shock- Boundary Layer Interaction Computations Using the OVERFLOW Code
A. Oliver, Purdue University, West Lafayette, IN; R. Lillard, NASA Johnson Space Center, Houston, TX; A. Schwing, G. Blaisdell, and A. Lyrintzis, Purdue University, West Lafayette, IN

The Human Research Program
D. Tomko, NASA Headquarters, Washington, DC; K. Laurini, NASA Johnson Space Center, Houston, TX; and M. Nall, NASA Glenn Research Center, Cleveland, OH

NASA Utilization of the International Space Station and the Vision for Space Exploration
J. Robinson, NASA Johnson Space Center, Houston, TX

Space- Based Antenna Morphing Using Reinforcement Learning
H. Feldman, Texas A&M University, Magnolia, TX

The Effect of Material Conductivity, Pressure and Interstitial Material on Thermal Joint Resistance: Analytical and Experimental Study
A. Vistamehr and E. Marotta, Texas A&M University, College Station, TX

A Parallel Multigrid Algorithm for Aeroelasticity Simulations
J. Gargoloff, P. Cizmas, and T. Strganac, Texas A&M University, College Station, TX; and P. Beran, U.S. Air Force Research Laboratory, Wright-Patterson AFB, OH

Exploration Life Support Technology Development Challenges
J. Chambliss, D. Barta, M. Lawson and S. Rulis, NASA Johnson Space Center, Houston, TX

In-Situ Resource Utilization for Lunar and Mars Exploration
K. Sacksteder, NASA Glenn Research Center, Cleveland, OH; G. Sanders, NASA Johnson Space Center, Houston, TX

Human Systems Interaction, Surface Handling and Surface Mobility
C. Culbert, NASA Johnson Space Center, Houston, TX; and J. Caruso, NASA Glenn Research Center, Cleveland, OH

Thermal Control System Development for Exploration
D. Westheimer, NASA Johnson Space Center, Houston, TX; G. Birur, Jet Propulsion Laboratory, Pasadena, CA

Acoustic Source Localization and the Echo Problem
S. Beaver and J. Hurtado, Texas A&M University, College Station, TX

Orbiter Gap Filler Bending Model for Re- Entry
C. Campbell, NASA Johnson Space Center, Houston, TX

Precise Distributed Control for Multi- Body Satellittes and Satellite Formations (Graduate Award)
J. Fisher, Texas A&M University, College Station, TX

Micromechanics Analyses of Complex Microstructures (Graduate Award)
D. Goyal, Texas A&M University, College Station, TX

Exercise Countermeasures and a New Ground- Based Partial- g Analog for Exploration
G. Perusek and K. Gilkey, NASA Glenn Research Center, Cleveland, OH; M. Just, Zin Technologies, Cleveland, OH; B. Lewandowski, NASA Glenn Research Center, Cleveland, OH; J. DeWitt and D. Bolster, NASA Johnson Space Center, Houston, TX

Synergies Between Space Research and Space Operations—Examples from the International Space Station
J. Bartlett, C. Maender and L. Putcha, NASA Johnson Space Center, Houston, TX; J. Tate, Engineering & Science Contract Group, Houston, TX; J. Robinson, NASA Johnson Space Center, Houston, TX; A. Sargsyan, Wyle Laboratories, Houston, TX

Shuttle Debris Impact Tool Assessment Using the Modern Design of Experiments
R. DeLoach, NASA Langley Research Center, Hampton, VA; E. Rayos, C. Campbell, S. Rickman and C. Larsen, NASA

Mesh Generation and Deformation Algorithm for Aeroelasticity Simulations
P. Cizmas and J. Gargoloff, Texas A&M University, College Station, TX

High Power Ion Cyclotron Heating in the Vasimr Engine
E. Bering, University of Houston, Houston, TX; F. Chang-Diaz, J. Squire, V. Jacobson and L. Cassady, Ad Astra Rocket Company, Houston, TX; M. Brukardt, University of Houston, Houston, TX

CEV Crew Module Shape Selection Analysis and CEV Aeroscience Project Overview
R. Lillard, T. Truong, C. Cerimele and J. Greathouse, NASA Johnson Space Center, Houston, TX

Flow Loop Experiments using Graphite Nanofluids for Thermal Management Applications
I. Nelson and D. Banerjee, Texas A&M University, College Station, TX; R. Ponnappan, AFRL, Wright-Patterson AFB, OH

An Acceleration Approach for Reduced- Order Models Based on Proper Orthogonal Decomposition
P. Cizmas, Texas A&M University, College Station, TX

Image Base CFD for Blood Flow Analysis
M. Garbey and B. Hadri, University of Houston, Houston, TX

Numerical and Experimental Investigation of a Serpentine Inlet Duct
P. Cizmas, A. Kirk, A. Kumar, J. Gargoloff and O. Rediniotis, Texas A&M University, College Station, TX

CFD Simulation of Multi- Cycle Nanotube Laser- Ablation with Reduced Kinetics Model
R. Greendyke, Air Force Institute of Technology, Kirtland AFB, NM; J. Creel and B. Payne, University of Texas, Tyler, TX; and C. Scott, NASA

(Continued on page 22)

DoD Experiments Launch Aboard Space Shuttle Discovery

ALBERT F. MEZA, CAPT., USAF, SMC SPACE DEVELOPMENT AND TEST WING

The Space Shuttle Discovery lifted off Dec 9 from launch pad 39B at the Kennedy Space Center, FL carrying aboard 1350 lbs of Department of Defense payloads. The DoD Space Test Program (STP) sponsored experiments will test a number of new technologies to enhance US space capabilities, ultimately giving the edge to tomorrow's warfighters.

At 8:47 pm, Cape Canaveral's dark sky turned to daylight when Discovery's solid rocket boosters and main engines ignited for the first shuttle night launch since November, 2002. Three million pounds of thrust accelerated the shuttle and its cargo to 17,500 mph towards the orbiting outpost, the International Space Station, 180 nautical miles above earth's surface. The Space Shuttle mission STS-116 and crew of 7 was led by former USAF test pilot, Astronaut Mark Polansky.

Once docked to the ISS, Astronaut Joan E. Higgenbotham transferred two DoD experiments from the shuttle to the ISS to conduct science in the one-of-a-kind, zero-G lab. After Discovery undocked from the ISS, Ms. Higgenbotham deployed three DoD experiments into space from the shuttle cargo bay. STS-116 also hosted two additional DoD experiments that utilize ground and space based sensors to collect data from the shuttle throughout the course of the shuttle mission.

The two DoD payloads that STS-116 brought to the ISS are the Elastic Memory Composite Hinge (EMCH) experiment, sponsored by the Air Force Research Lab and the Synchronized Position Hold, Engage, Reorient Experimental Satellites (SPHERES), sponsored by the Defense Advanced Research Projects Agency.

EMCH will test a revolutionary composite material to replace bulky, heavy-weight materials and systems currently in use. EMCH can reduce the mass of conventional mechanisms by 90% and provide a low-shock method to deploy antennas and solar arrays. With launch costs at $10,000 per pound, EMCH intends to drive down the weight of space vehicles to save DoD costs and increase payload capacity.

The SPHERES experiment consists of three bowling-ball sized satellites that will free-fly inside the ISS. They're equipped with a cold gas propulsion system for maneuverability and they communicate with each other using radio and ultrasonic frequencies. The satellites will test autonomous formation flying, rendezvous and docking techniques.

The three deployments from the shuttle cargo bay were the Atmospheric Neutral Density Experiment (ANDE), the Micro-ElectroMechanical Systems (MEMS) based PicoSat Inspector (MEPSI) and the Radar Fence Transponder (RAFT).

ANDE is sponsored by the Naval Research Lab and consists of two near-perfect spheres measuring 19" and 17-1/2" in diameters. The spheres will measure the drag at low earth orbit, as current atmospheric models possess a 15-20% error in drag. Reducing this error will improve orbit predictions for satellites which constantly consume propellant to counter the effects of drag. Understanding drag better will improve space operations and will provide a dramatic increase in fidelity to current atmospheric models.

MEPSI is sponsored by the Space and Missile Systems Center developmental planning directorate. MEPSI consists of 2 cubes, measuring 4x4x5" each and are tethered together with a 15' lanyard. These tiny spacecraft are called picosatellites. MEPSI contains propulsion systems and cameras and the 2 picosats will maneuver around and photograph each other. The purpose is to demonstrate a low-cost, self-inspection capability. As a future application, one of these picosats could be mounted on a host satellite as an onboard inspection capability. In the event of an anomaly, the host satellite will activate the picosat inspector which will downlink images of the troubled host satellite to aid space operators in troubleshooting. These tiny low-cost picosats could potentially save the life of a high dollar satellite like MILSTAR.

RAFT is sponsored by the US Naval Academy and consists of 2 cubes measuring 5x5x5". These are also called picosats but they serve a different purpose than MEPSI. RAFT will calibrate the US Space Surveillance Network's (SSN) radar fence. As one RAFT picosat flies through the radar fence, it will transmit its location. When the second picosat flies through the radar fence, it exercises the radar fence's locating capability. This effort will improve the SSN's ability to track small Resident Space Objects. RAFT also contains an amateur radio onboard and the midshipmen at the Naval Academy will communicate with the space borne picosats from the Yard Patrol ships in Annapolis, Maryland. Exposing military members to space operations early in their careers is an invaluable investment in the DoD's future space professionals.

"The success of the three deploys, and seemingly endless hurdles overcome, reflects over two years of hard work, dedication, and ingenuity by a small team at Johnson Space Center and closes the book on the most complex DoD shuttle mission in well over a decade," stated Maj Matt Budde, Chief of Integration and Operations for the DoD Human Spaceflight Payloads Office.

The additional experiments hosted by STS-116 are called MAUI and RAMBO. Sponsored by AFRL, Maui Analysis of Upper-atmospheric Injections (MAUI) observes shuttle engine firings using the telescopes and all-sky imagers at the AF Maui Optical and Supercomputing Site, located atop the 12,000 ft summit of Mt Haleakala, Hawaii. The purpose of MAUI is to improve space situational awareness by exploiting spacecraft maneuvering systems. Eventually MAUI will develop software that models orbit changes of small spacecraft for a better "eye in the sky." Ram Burn Observation (RAMBO) is sponsored by the Missile Defense Agency and also views shuttle engine firings using a DoD satellite. The purpose of RAMBO is to add to the DoD's gallery of space vehicle engine plume imagery. These data increase the capability to distinguish between lethal and non-lethal reentry vehicles for missile defense and early warning. These and other DoD experiments aboard the shuttle and ISS are further enhancing the United States' space capabilities.

STP is the spaceflight benefactor for the host of experiments from the various Department of Defense agencies. The DoD Space Test Program is managed by SMC Space Development and Test Wing. With the launch of STS-116, the Air Force, along with NASA, is furthering STP's mission to be the primary provider of spaceflight to the entire DoD research and development community. The success of this flight continues a legacy since 1965 when the DEPSECDEF established the program's charter.

Since the inception of the space shuttle program, STP has been imagin-

(Continued on page 22)

(“DoD Experiments ...”, Continued from page 21)

ing ways to incorporate new technologies onto the unique vehicle. The STS-4 launch in June 1982 carried the first STP shuttle payloads to space and since then, has carried over 200 STP payloads including 11 primary DoD payloads. STP conducted experiments aboard the Russian Mir space station and boasts the first ISS internal experiment and the first ISS external experiment. These experiments provide the technologies for the future of military space. A grand example is STP’s launch of an atomic clock in the 1960s and that experiment evolved into today’s DoD Global Positioning System. ▲

(Rockets, the Mach Effect, and Mach Lorentz Thrusters, continued from page 11)

We are therefore looking at the dawning of the true golden age in human space flight if the MLTs can be developed to these foreseen performance levels.

We explored the possibilities of what a first generation 0.5-to-1.0 N/W MLT propelled spacecraft, powered with fuel cells & batteries, could provide in the way of payload and range of operation. It was found that it could carry a crew of two people with a payload of 2-metric tonnes from the surface of the Earth to the surface of the Moon, accelerating at 1.0 E-g during the first half of the course segment and decelerating the last half, and back again; all in under 12-hours *without refueling* the WarpStar-1’s fuel cells. While on the Moon, the WarpStar-1 could provide heavy lift crane services to Moon-based astronauts that could lift up to 175 lunar metric tonnes. This ~26,500 kg MLT propelled spacecraft would be a major advancement over any known spacecraft design to date, and should be an inducement to push the development of these devices towards the 1.0 N/W specific power class Mach-Lorentz Thrusters needed to make it happen.

With this 1.0 N/W MLT technology in hand, we could send our planetary scientists to walk on distant worlds. We could send groups of explorers to the Moon in less than 3 hours, to Mars in under 5 days, to the asteroid belt in 6 days, to Jupiter’s moons Io, Europa, Ganymede and Callisto in 7 days, or to Titan and Saturn’s rings in 9 days. In fact, this 1.0 E-g constant acceleration transport technology could easily prove to be so inexpensive to operate that we find ourselves compelled to build permanent outposts on all these worlds in our solar system. And when we finally find ourselves at the solar system’s boundary with interstellar space, Woodward’s “Wormhole term” may provide the keys to viable interstellar travel as well. ▲

Conference Presentations/Articles by Houston Section Members

(Cont’d.)

(Upcoming Conference Presentations, Continued from page 20)
Johnson Space Center, Houston, TX

Impact to Space Shuttle Trajectory from Temporal Changes in Low Frequency Winds
R. Decker, NASA Marshall Space Flight Center, Huntsville, AL; D. Puperi, United Space Alliance, Houston, TX; and R. Leach, Morgan Research, Huntsville, AL

Toward a General Solution Verification Method for Complex PDE Problem with Hands Off Coding
M. Garbey and C. Picard, University of Houston, Houston, TX

Planar Measurements of Supersonic Boundary Layers with Curvature Driven Favorable Pressure Gradients
I. Ekoto and R. Bowersox, Texas A&M University, College Station, TX

Experimental Analysis of Supersonic Boundary Layers with Large Scale Periodic Surface Roughness
I. Ekoto and R. Bowersox, Texas A&M University, College Station, TX; T. Beutner, DARPA, Arlington, VA

Microgravity Phase Separation Near the Critical Point in Attractive Colloids
P. Lu, Harvard University, Cambridge, MA; M. Foale, E. Fincke, L. Chiao, W. McArthur, and J. Williams, NASA Johnson Space Center, Houston, TX; M. Hoffmann, NASA Glenn Research Center, Cleveland, OH; W. Meyer, National Center for Space Exploration Research, Cleveland, OH; C. Frey and A. Krauss, ZIN Technologies, Brook Park, OH; J. Owens, National Center for Space Exploration Research, Cleveland, OH; M. Havenhill, Science Applications International Corporation, ; R. Rogers, NASA Glenn Research Center, Cleveland, OH; S. Anzalone, Science Applications International Corporation, ; G. Funk, ZIN Technologies, Brook Park, OH; and D. Weitz, Harvard University, Cambridge, MA

Numerical Study of Massively Separated Flows
M. Olsen, NASA Ames Research Center, Moffett Field, CA; R. Lillard, NASA Johnson Space Center, Houston, TX; N. Chaderjian and T. Coakley, NASA Ames Research Center, Moffett Field, CA; and J. Greathouse, NASA Johnson Space Center, Houston, TX

Journal of Spacecraft and Rockets
Boundary Layer/Streamline Surface Catalytic Heating Predictions on Space Shuttle Orbiter, Vol. 43, No. 6 issue of *JSR* (Nov/Dec, 2006)
Jeremiah Marichalar, William Rochelle, Benjamin Kirk, and Charles Campbell

Harper's Magazine, November 2006
Starship Trooper, Mars, the Ultimate Suicide Mission
James C. McLane III

The Space Review
Will Mars challenge the "prime directive"?
http://www.thespacereview.com/article/771/1
James C. McLane III

International Conference on Bond Graph Modeling (Co Sponsored by AIAA)
International Space Station Centrifuge Rotor Models: A Comparison of the Euler-Lagrange and the Bond Graph Modeling Approach
Louis H. Nguyen (NASA Johnson Space Center), Jayant Ramakrishnan (ARES Corporation), Jose J. Granda (Department of Mechanical Engineering California State University Sacramento)

AIAA Section News

AIAA Monthly Meetings are Open

New faces are welcome at our monthly AIAA Houston section executive council meetings. Please review our web site and the org chart at www.aiaa-houston.org before attending, if possible. AIAA membership is not required, though we will be working with you to find a role in our volunteer work. To ensure proper room size and no late changes in time and location, please contact someone from the list below before attending.

Location:
ARES Corporation
1331 Gemini, Suite 120
Houston, TX 77058

Contact List:
Douglas Yazell 281-244-3925
Jayant Ramakrishnan 281-461-9797
Steve King 281-283-4283
Tim Propp 281-226-4692

Seeking Volunteers

The Houston Section is seeking volunteers interested in participating in the following areas:

Pre-College Outreach (K-12)
Professional Development
Programs
Publicity

Opportunity for community service, personal & leadership development, networking, etc.

Contact chair@aiaa-houston.org

Elon Musk Tentatively Scheduled to Speak Here

SpaceX Founder and CEO, Elon Musk, is tentatively scheduled to speak at the May Dinner Meeting at Gilruth in May. Stay tuned for more information!

AIAA Announces New National Public Radio Program on Aeronautics and Space Exploration

January 18, 2007 – Reston, VA – The American Institute of Aeronautics and Astronautics (AIAA), in partnership with the National Institute of Aerospace (NIA), has launched a National Public Radio program called *Discovery Now* to explore the newest advances from NASA and the aerospace community. The 90-second radio segments will air starting January 22, 2007, on National Public Radio's WHRV 89.5 FM, during its prime-time weekday news and public affairs program, *All Things Considered*.

Accessible to everyone, *Discovery Now* will feature highlights in aeronautics and astronautics technology, science, history, innovations, research and inventions from the aerospace industry, worldwide.

Produced by Michael Bibbo and Kevin Krigsvold, NIA's award-winning team of producers, *Discovery Now* will feature 240 interstitials annually, along with a Web component that allows the public to download the radio programs. Each segment will explain how scientific and technological developments are changing our world. The goal is to increase public awareness, understanding and appreciation of science and technology, including NASA's aerospace technology, research and exploration missions.

"The positive impact of aeronautics and astronautics technologies is felt by each of us everyday," says AIAA President Roger Simpson. "We believe *Discovery Now* will highlight those benefits and provide the public with a glimpse of exciting future advancements. We commend NIA's leadership in developing and producing these thought-provoking segments that are both educational and entertaining. They are certain to raise awareness of the aerospace community and will help capture the imagination of future engineers and scientists that may be listening."

Discovery Now is written and produced by NIA and is funded by a grant from AIAA. Additional public radio stations, college and community stations, commercial stations, satellite radio, Public Radio International and Voice of America are targeted to carry the program.

For more information about the National Institute of Aerospace, visit http://www.nianet.org.

AIAA advances the state of aerospace science, engineering, and technological leadership. Headquartered in suburban Washington, D.C., the Institute serves over 35,000 members in 65 regional sections and 79 countries. AIAA membership is drawn from all levels of industry, academia, private research organizations, and government. For more information, visit www.aiaa.org.

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Advance the arts, sciences, and technology of aerospace, and nurture and promote the professionalism of those engaged in these pursuits. AIAA seeks to meet the professional needs and interests of its members, as well as to improve the public understanding of the profession and its contributions.

American Institute of Aeronautics and Astronautics

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www.aiaa.org

Select the AIAA membership option.