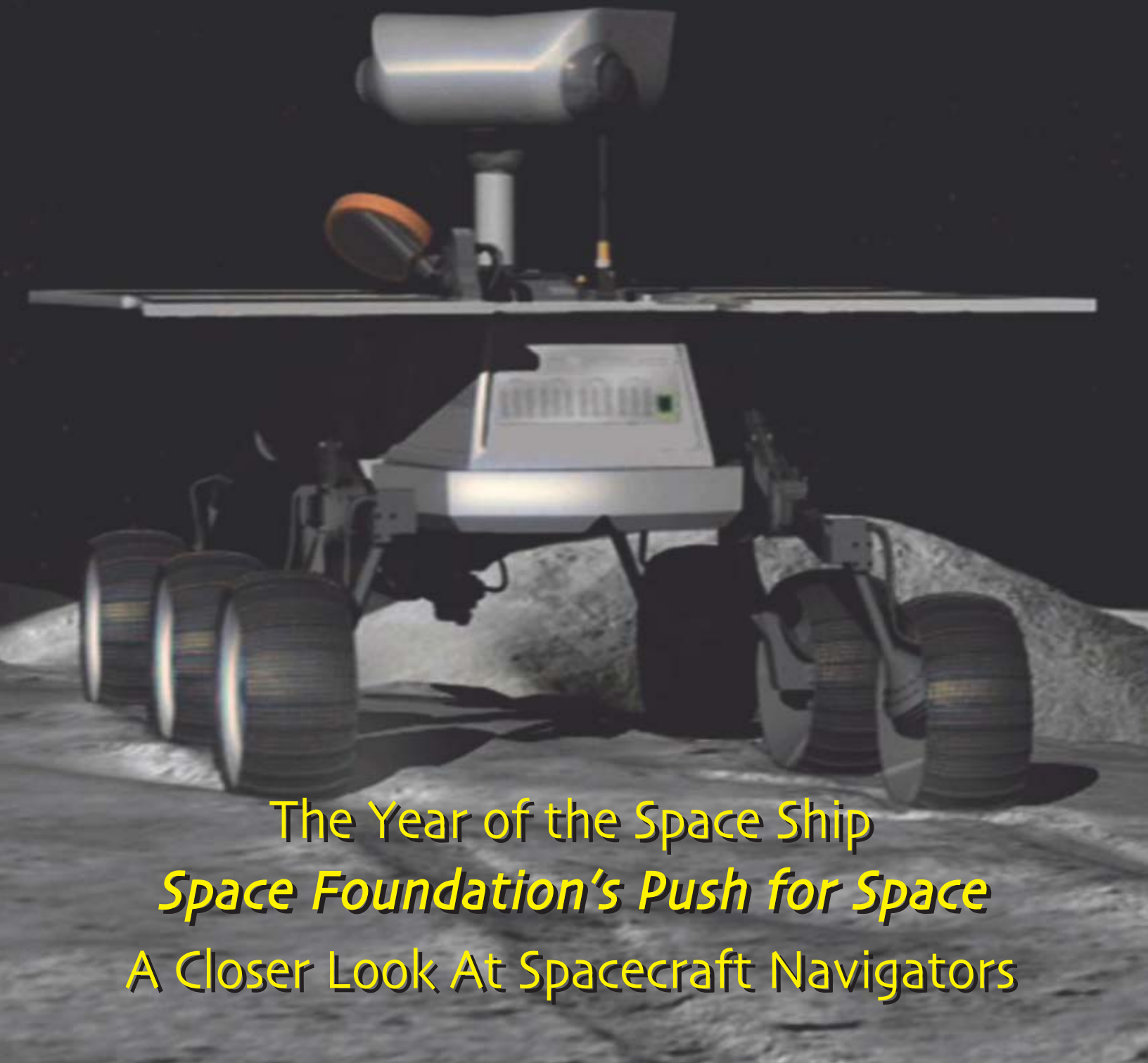


Space Lifestyle

M A G A Z I N E

WINTER/SPRING 2008

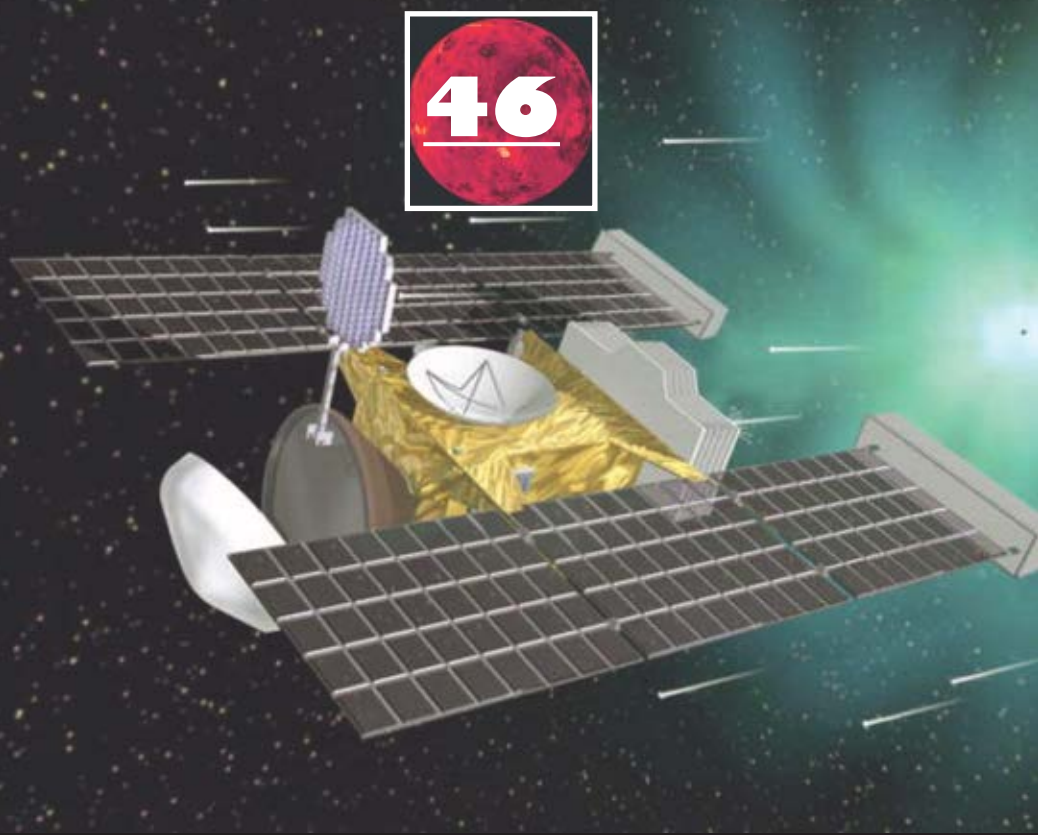
Google Lunar X-PRIZE's 10-Team Start



The Year of the Space Ship
Space Foundation's Push for Space
A Closer Look At Spacecraft Navigators

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Could something dire soon happen to Earth's magnetosphere that might affect life as we know it? Michael Ricciardi takes a look at how the magnetic field may change, debunking a few myths along the way.

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In the drivers seat of every robotic mission, navigators at the Jet Propulsion Laboratory and KinetX guide spacecraft to destinations in our solar system. Using techniques requiring extreme precision, these engineers have an excellent sense of direction.

About the Cover



A promotional illustration for the Google Lunar X-PRIZE. After landing on the moon's surface, a hypothetical team's rover gathers information to send back to Earth, completing one of the requirements needed for a cash prize.

Image Credit: X-Prize Foundation

editor's letter

Hello, and welcome to another issue of Space Lifestyle Magazine

First, I want to thank you for taking the time to read this issue. Your enthusiasm for this publication has been remarkable. Thanks for the criticisms, but mostly thanks for the positive encouragement.

In turn, I want to announce that this will be my last issue as Editor-in-Chief. For the next issue, all editorial responsibilities will be handed over to the current Managing Editor Nancy Atkinson. I am going to be taking over the position of Publisher for *Space Lifestyle Magazine*, and concentrate more on the business of the publication.

Nancy is a strong writer, with an impressive background. She has consistently delivered reliable copy and relevant stories to the publication. Her work as a NASA Solar System Ambassador and as one of the staff writers at *Universe Today* has proven her worth outside of SLM.

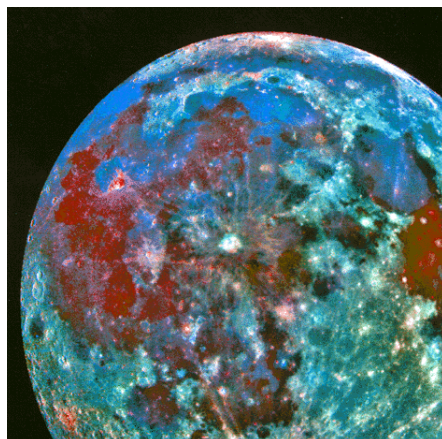
I am sure that *Space Lifestyle Magazine* will only get better under her leadership.

For this issue, we may have brought you the standard fare for SLM, but there have been many new developments since the last quarter. Most notably, Virgin Galactic's unveiling of SpaceShipTwo and our cover story on the Google Lunar X-PRIZE.

So, enjoy this issue of *Space Lifestyle Magazine*. I hope to see you back again next quarter.

Starward dreams,

David Bullock
Editor-In-Chief
Space Lifestyle Magazine



Space Lifestyle M A G A Z I N E

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[ISSN 1939-411X] Issue 3, Space Lifestyle magazine is published quarterly by New Forks, LLC 1115 Almonte Ave, Lower Unit, Grand Forks, ND 58201 Digital subscriptions are currently free of charge. Individual issues can be purchased for the Amazon Kindle. Customer service, please contact spacelifestyle@newforks.net

stupid cancer

Wow!

So much progress since 1977.

Death rates are falling.

More people survive.

Sounds great, right?

Sure. If you're 65... or 7.

**For young adults (15-39),
survival rates have not
improved in 30 years.***

This is not ok.

Welcome to the
I'm Too Young For This!
Cancer Foundation.

We are the only national
cancer research and advocacy
organization serving the unique
needs of survivors and their
caregivers under the age of 40.

Stupid cancer. Survivors rule.

Laura Higgins

Singer/Songwriter

LauraHiggins.com

Survivor: Hodgkins Lymphoma

Diagnosed: 1997

Status: Rocking on.



ImTooYoungForThis.org

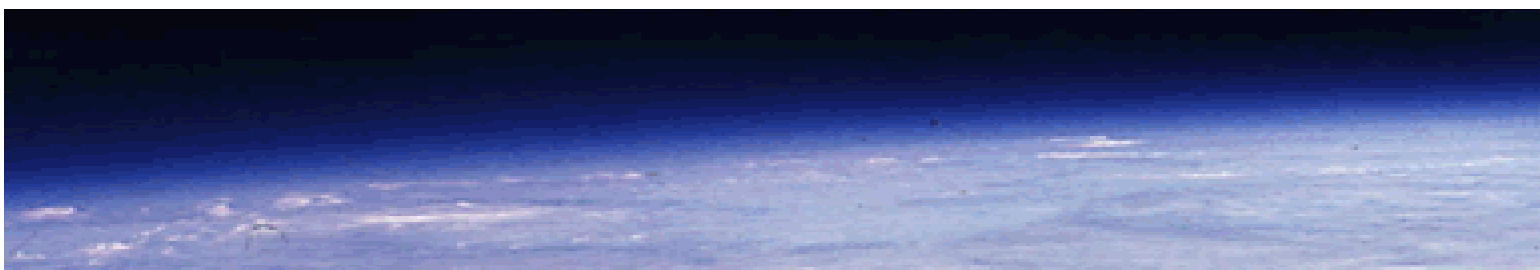
a place for young adults affected by **cancer**

*national cancer institute report, Closing The Gap, 2006

NASA To Better Brand Space Initiative

According to an early February 2008 article in *The Washington Post*, NASA has turned to a New York-based advertising firm to enhance the image of the Vision for Space Exploration, and in particular, the \$230 billion *Constellation* Program, to spur public support. This comes at a time when some scientists and other space experts have questioned the VSE's future plans to colonize the moon and then Mars, instead favoring a more direct mission to Mars for the U.S. program. More information on *Constellation* can be found on its website at:

http://www.nasa.gov/externalflash/constellation_front/.



Scaled Composites Fined for Mojave Desert Explosion

In an 11-page report during February 2008, Cal/OSHA claimed Scaled Composites LLC, the company known for launching the first privately-funded manned rocket into space, failed to train workers on how to handle nitrous oxide properly, and as a result, fined the Northrop Grumman-owned company \$25,870. In July 2007, three workers were killed and three injured during an explosion at a remote testing facility in the Mojave Desert while building the rocket motor for Virgin Galactic's SpaceShipTwo, according to the Associated Press. For the official Personal Spaceflight Federation statement, visit <http://www.personalspaceflight.org/mojave2.htm>



Airplane at Mojave Desert Airport.

Herrington Departs; Metz On Board at Rocketplane

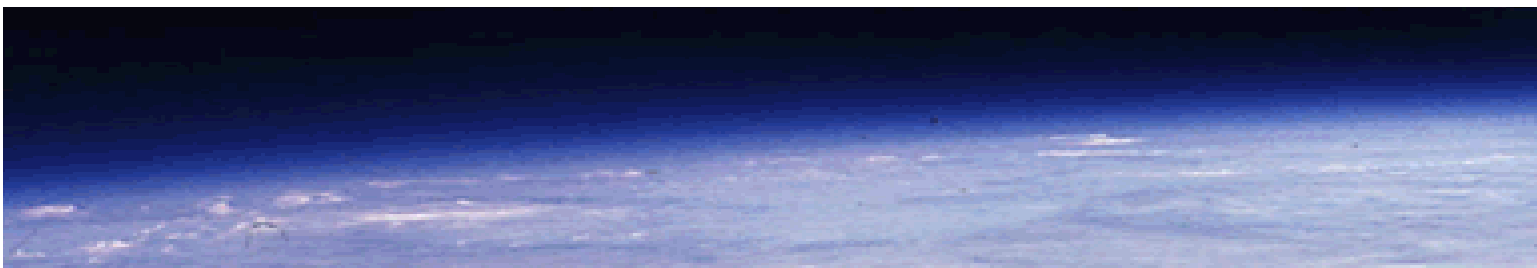


Former NASA astronaut John Herrington resigned from the NewSpace company Rocketplane in December stating that, despite their impressive technological innovations, he was frustrated by the company's difficulty in raising money. Filling Herrington's position, Rocketplane announced that USAF pilot Paul Metz joined the company as Vice President and Chief Test Pilot in March 2008. Metz had once served as vice President for Integrated Test and Evaluation for a Lockheed Martin fighter plane program. Also, David G. Faulkner, who has been with Rocketplane since 2005 was promoted to Chief Technology Officer of the company.

<http://www.rocketplane.com>

NASA States Astronauts Did Not Fly Intoxicated

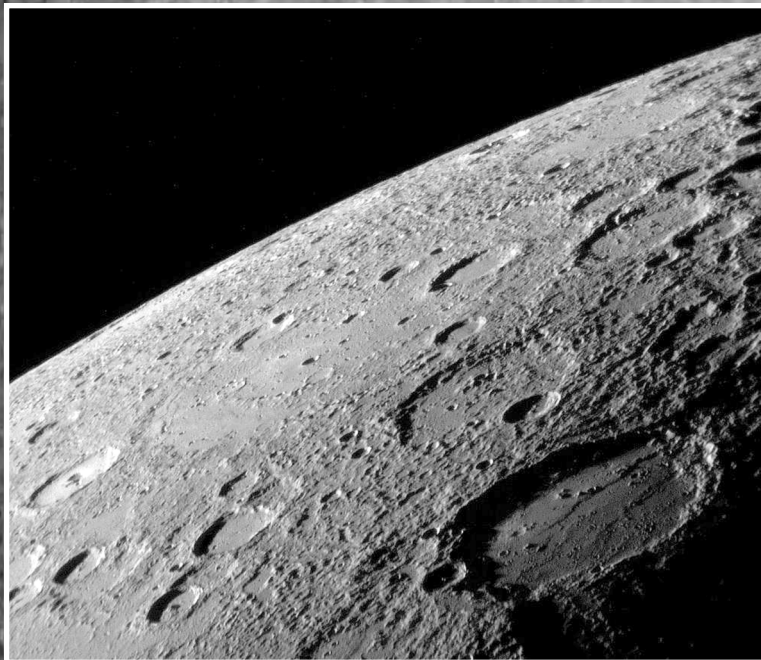
NASA officially stated that they found no evidence to support two alleged cases of pre-flight intoxication of astronauts. The report comes from a NASA committee formed to evaluate medical and psychological screening processes, which were deemed inadequate. For the detailed report, visit <http://www.nasa.gov/audience/formedia/features/astronautreport.html>.





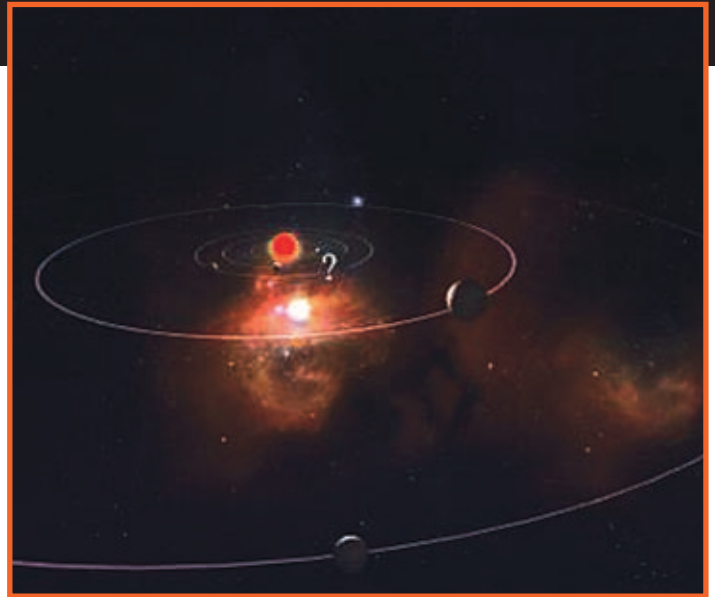
MESSENGER ***Delivering New*** ***Images of Mercury***

The Mercury Surface, Space Environment, Geochemistry and Ranging (MESSENGER) spacecraft recently returned never-before-seen images of the first planet from the sun. One image included a mysterious, spider-like impression. A return fly-by is set for October 6, 2008. More images from Mercury are available on NASA's online photojournal at <http://photojournal.jpl.nasa.gov/targetFamily/Mercury>.



Beatles Song Beamed into Space Celebrates NASA Anniversaries

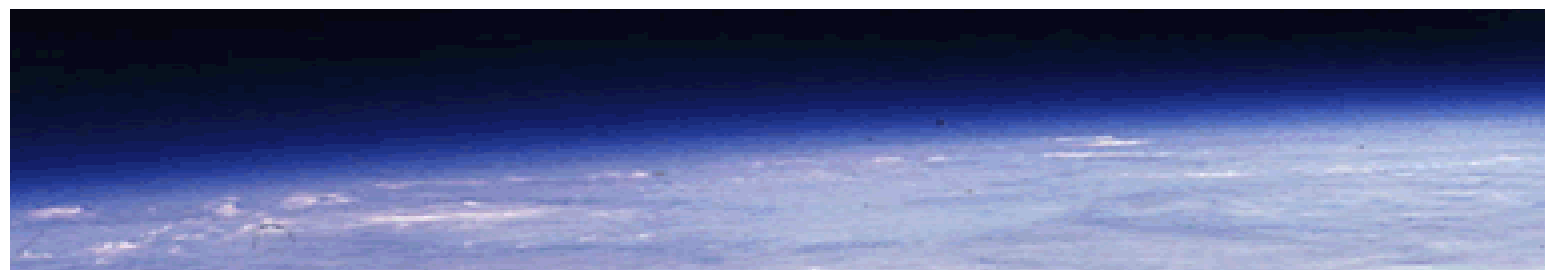
On February 1, NASA celebrated three events: It marked the 45th anniversary of its Deep Space Network, the 50th anniversary of NASA and the 40th anniversary of the Beatles hit 'Across the Universe' by beaming an MP3 of the song to the star, Polaris. At 2.5 quadrillion miles away, this first-ever beamed song will reach its destination in 431 years. For more information, visit http://www.nasa.gov/topics/universe/features/across_universe.html



Newly Discovered Solar System Contains Jupiter and Saturn-like Planets

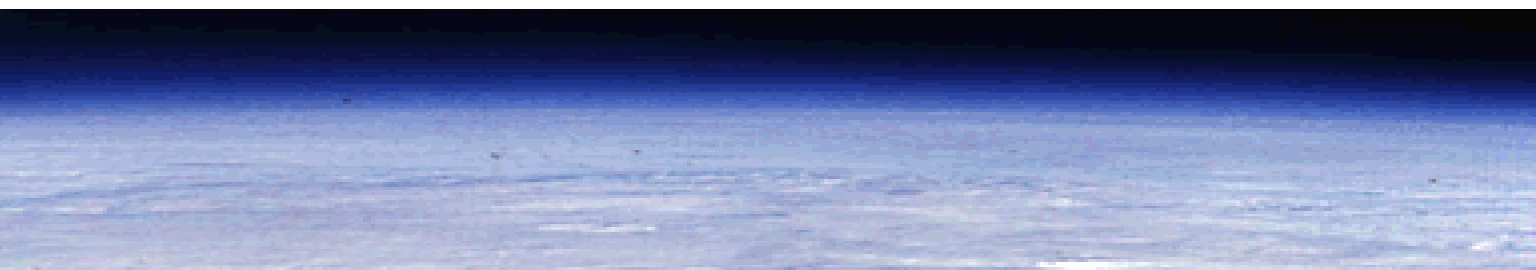
Researchers uncovered a solar system similar to our own some 5,000 light years from Earth using a technique first theorized by Einstein called gravitational lensing, on Valentine's Day 2008. So far, scientists have uncovered a total of six planets. Two planets are comparable to Saturn and Jupiter in density, size and distance from the sun. For the official National Science Foundation release, visit

http://www.nsf.gov/news/news_summ.jsp?cntn_id=111093&org=NSF&from=news

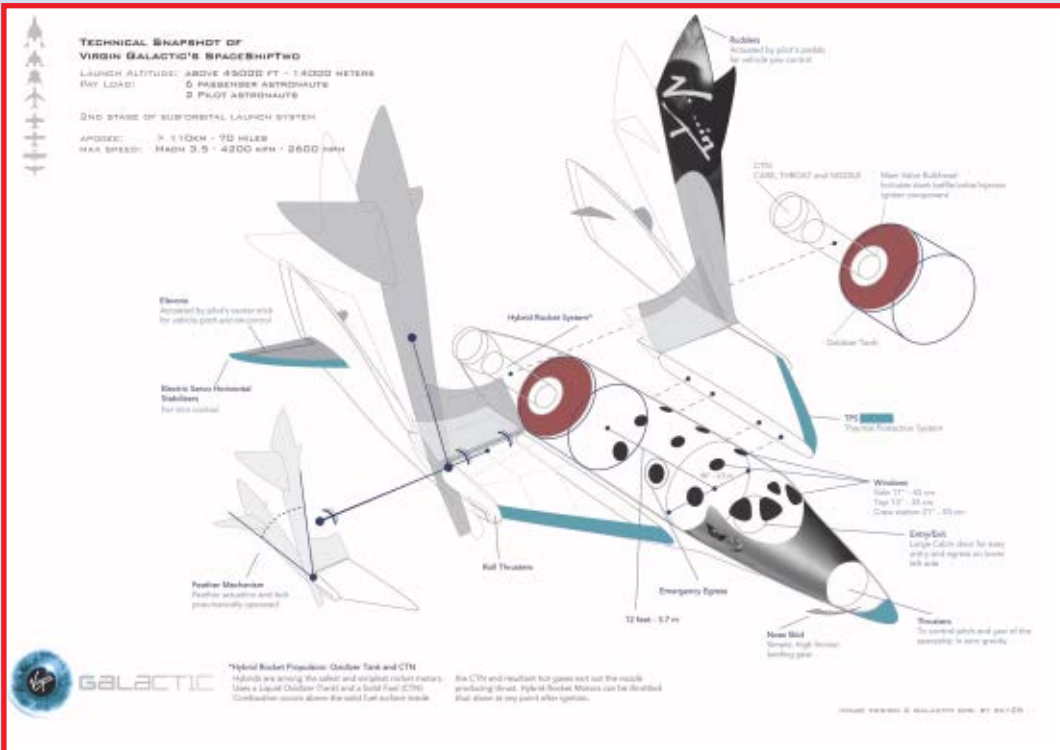


Yuri's Night Only One Month Away

The international party to celebrate the first human to visit space, Russian Cosmonaut Yuri Gagarin, is set to take place on April 12, 2008 in several countries around the world, including Japan, Afghanistan, Chile and the United States. The parties mark the anniversary of Yuri's 1961 venture into space and the first U.S. space shuttle flight in 1981. For more information on the event or to research party locations, visit <http://www.yurisnight.net/>



Branson Reveals SpaceShipTwo



Richard Branson, Virgin Airlines founder, revealed his latest project, Virgin Galactic SpaceShipTwo at NYC's Museum of Natural History and declared 2008, "the Year of the Space Ship." Double the size of its predecessor with a wingspan of 140 feet, the space tourism vehicle can hold six passengers at \$200,000 each. Despite the hefty price tag, SpaceShipTwo boasts a waiting list of 200 customers. To reserve a spot for a 2009 trip, visit <http://www.virgingalactic.com/>.



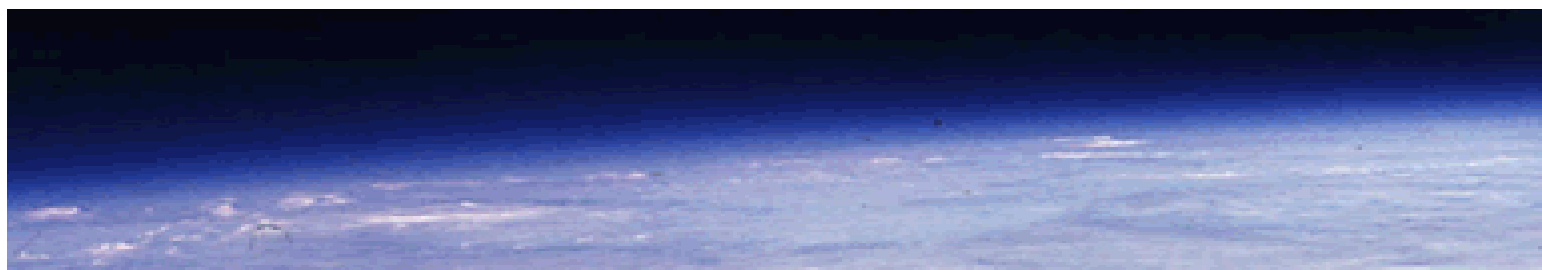


ISDC to Meet in Nation's Capital May 29-June 1

With the theme of "The New Pace for Space," the 2008 International Space Development Conference sponsored by the National Space Society will touch on everything new developing at NASA and the latest coming out of the commercial spaceflight community. Academic papers will be presented and speakers will discuss the latest issues in space technology, science, policy, commerce, exploration and more. The goal of the conference is to engage the public, industry and decision-makers in an open and positive discussion on the future of space exploration and development, especially during this election year. More information can be found at <http://www.isdc2008.org/>

Dazzling, Artful Astronomy on TWAN Website

Professional photographers from around the world have created some of the most unique astronomical photos, which now can be found on one website. On The World At Night (TWAN), one can find photo and video galleries that give a global perspective to our night sky. Find out more and be amazed at: <http://www.twanight.org/>



Arthur C. Clarke Dead at Age 90

Renowned science fiction writer and space enthusiast Arthur C. Clarke died early March 19, 2008 in his Sri Lankan home after a long battle with post-polio syndrome. The prolific writer, most notably known for co-authoring with Stanley Kubrick "2001: A Space Odyssey," devoted his life to exploring the unknown and to contemplating aquatic and celestial complexities. At his December birthday, the Associated Press quoted Clarke as wishing for three things: The end of Sri Lanka's civil war, the worldwide embrace of cleaner sources of energy and the discovery of extraterrestrial life. Visit the Arthur C. Clarke Foundation at <http://www.clarkefoundation.org>.

Space Adventures acquires Zero-G

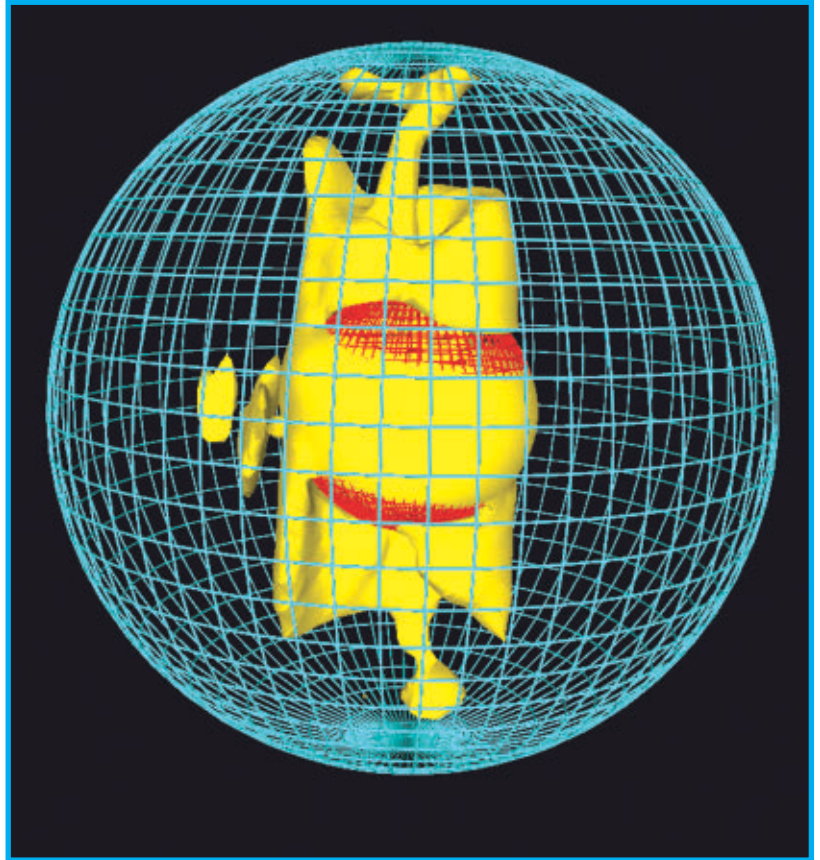


Space Adventures, Ltd., one of the world's leading spaceflight companies, acquired the remaining stock of Zero Gravity Corporation effective January 1, 2008. The ownership comes with little surprise as X-PRIZE Chairman Peter H. Diamandis already serves as CEO of the Zero-G operating unit and is co-founder of Space Adventures. The zero gravity experience is now a part of Space Adventure's offerings along with orbital and suborbital spaceflights and lunar missions.

By Michael Anthony Ricciardi

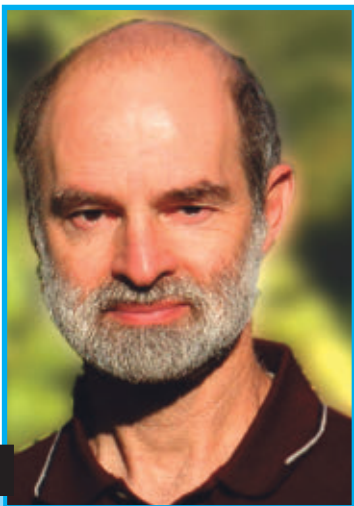
Since the early years of this decade, there has been a sporadic stream of popular science articles reporting evidence that the Earth's electromagnetic field, or magnetosphere, is weakening, and, in fact, is beginning a process of reversing itself. In fact, if a reversal were to occur one day, compass needles will point South, instead of North!

The Earth's electromagnetic field is believed to result from the movement of molten rock in our planet's outer core around



A snapshot of the region where the fluid flow within the Earth is the greatest (yellow). The core-mantle boundary is blue, while the inner core boundary is depicted red.

UC Santa Cruz
Prof. Gary
Glatzmaier.
Photo:
Glatzmaier.



A closer look at the Earth's protective magnetic field, the solar wind, and the latest 'catastrophic' scenario

THE CHANGING

its solid iron-nickel, inner core (a process aided by the Earth's spin). This movement of molten rock around mostly solid iron-nickel produces a massive, convective flow of electrons through and around the planet. This fluid like movement of molten iron constitutes the basis of the 'geodynamo'—the dynamic planetary mechanism that generates our planet's continuously fluctuating, protective, electromagnetic 'field'. However, much about the nature of these 'magnetohydro-dynamics' (MHD) remains a mystery.

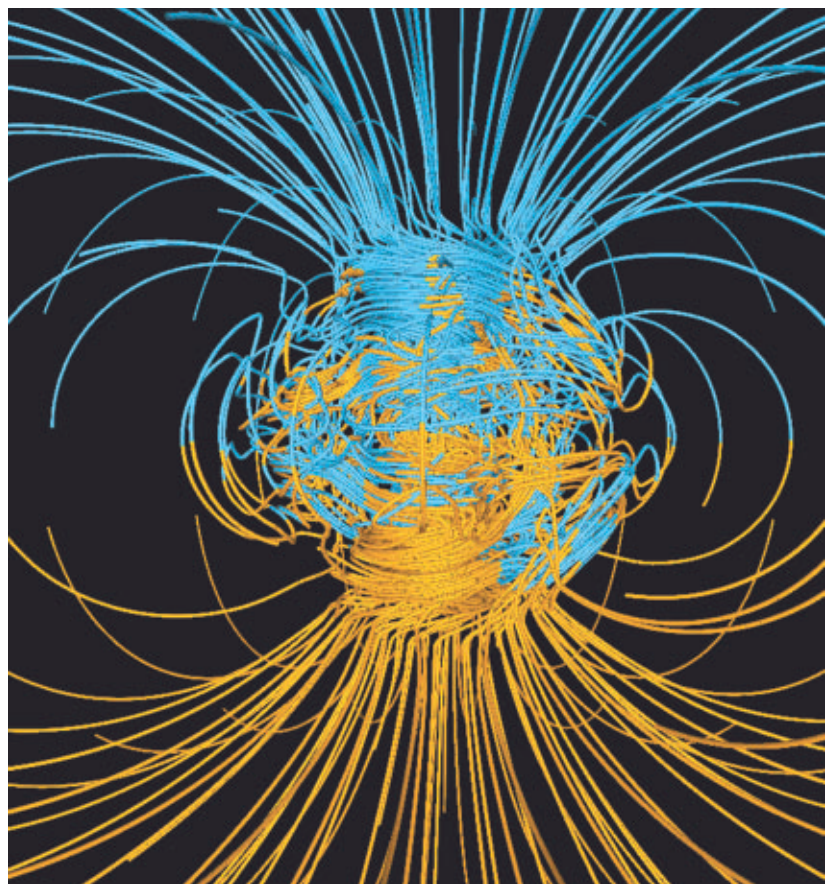
'The full consequences of magnetospheric 'flip', or field reversal, are unknown.' Popular reporting has posited various scenarios—all connected ultimately to intensified solar activity—from damaged/disrupted satellite communications, electronics, and power grids on the Earth, and the behavior of the animals that live here, to more dire effects, like the 'boiling off' of the Earth's atmosphere and even mass extinctions.

An apparent weakening tendency of the field is believed to precede a reversal. This tendency has actually been known for almost a hundred years, based upon *paleomagnetic* evidence that has been collected from rocks and hardened volcanic lava layers buried in the earth. Only in recent years has evidence accumulated enough to warrant speculation that a possible magnetosphere reversal is "imminent". But 'imminent' to geologists and geophysicist is not the same as 'imminent' to everyone else. The geologic record indicates, fairly consistently, that these field reversals occur every 250, 000 years or so.

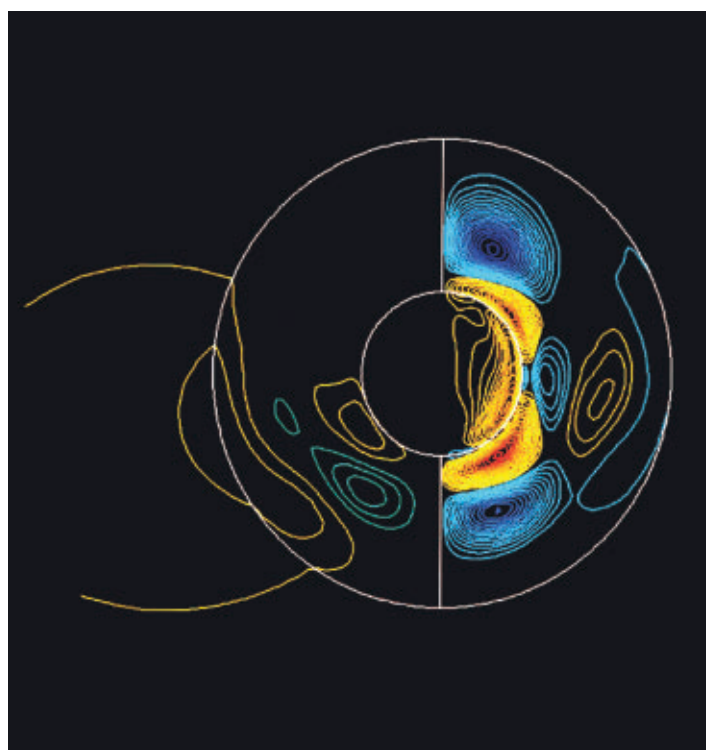
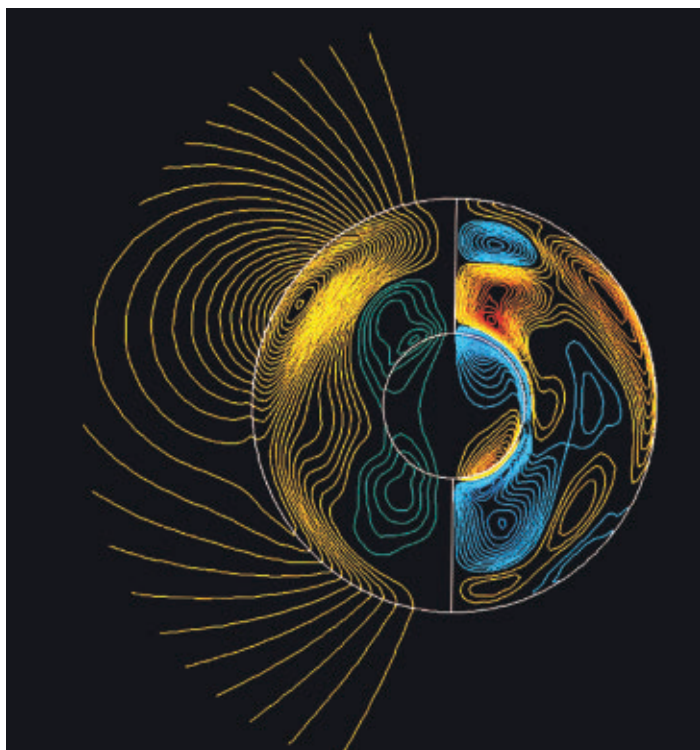
However, the Earth has not experienced a reversal for over 700, 000 years—leading some to assert that we are long over-due for a reversal from the field.

Back in the 1940's and '50's, even Einstein had been preoccupied with the issues of time and length for a electromagnetic reversal. It is a debate that continues to this day. The magnetic field reached its maximum strength around two thousand years ago and has been weakening ever since. A recent study by Gauthier Hulot of the

A 3D magnetic field structure simulated with the Glatzmaier-Roberts geodynamo model. magnetic field lines are blue where the field is directed inward and yellow where directed outward.



OF THE FIELD



Earth's magnetic field evolving for about 9,000 years before, during, and after the simulated reversal. The outer circle indicates the fluid outer core magnetic field contours directed clockwise (green) and counterclockwise (yellow). The right hemisphere shows contours directed westward (blue). Image: Projects in Scientific Computing Archive.

Paris Geophysical Institute, using satellite data of field strength variations over the past 20 years, seeks to find the cause of this weakening.

The study revealed huge 'whorls' of electromagnetic energy near the poles. Hulot believes that these 'eddies' or vortices are compiling and significantly influencing the magnetosphere's polarity. Follow up computer modeling of this chaotic phenomenon supports his hypothesis that an accumulation of these electromagnetic eddies weakens the dominant field, and this weakening, it is believed, precedes a polarity reversal. Despite Hulot's hypothesis, some geo-physicists remain unconvinced by the computer models conclusions.

"Nobody can possibly tell from the available information whether or not the Earth is heading for a polarity reversal," said Paul Roberts of UCLA's Institute of Geophysics and Planetary Physics. "The Earth's fluid core is undoubtedly in a highly turbulent state, and all characteristics of a

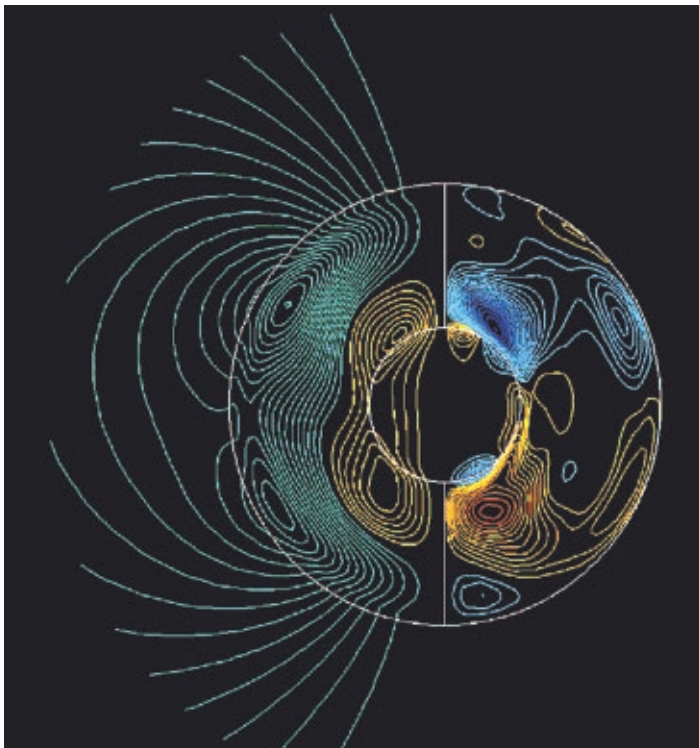
FACTOIDS: During the last 20 million years the fossil record shows 60 reversals, and that the period between reversals seems to be slowly decreasing and getting shorter.

According to the paleomagnetic record, in the Cretaceous period (late Mesozoic Era), a 40 million year stretch occurred in which there were no magnetic field reversals.

turbulent system fluctuate, including (in the case of an MHD -- magneto-hydrodynamic-- system) the magnetic field. Paleomagnetism has shown that the strength of the Earth's field has varied throughout the geologic past, by a factor of up to 4, and that it is a *little above average strength* [author's emphasis] at present. What is more natural then that it happens to be decreasing right now? It's decreased very many times in the past without reversing, why should this time be any different?"

The 'mechanics' of electromagnetic field variation are highly dynamic and variable, but these properties have lead a few geo-physicists to speculate that a complete field reversal's duration could be as little as a few weeks.

Robert Coe, a paleomagnetist at UCSC, investigating Miocene basalt flows at Steens Mountain, Oregon, has discovered *some* anomalous rock evidence that supports this scenario, but even Prof. Coe is skeptical



boundary; the inner circle, the solid inner core. the left hemisphere shows (blue) and eastward (red), out of and into the plane of the paper.

about the 'rapid reversal' theory. "Episodes of very rapid change in field direction [a few degrees per day] may occur during some polarity transitions," said Coe, "The evidence suggesting this possibility is two instances of large variation of direction of magnetization in a series [of] samples from bottom to top of a single lava flow. Each of these two [instances] is part of a long sequence of superposed flows ...that recorded a reversal that happened 16.6 million years ago. The length of time for each flow to become magnetized during cooling of these relatively thin flows is only a week or two. Thus, if the paleomagnetic directions we now observe were produced during cooling in the ancient field, they would imply episodes of extraordinarily rapid change in field direction during the several thousand years that the [global] field took to reverse polarity."

While Coe's data does indicate rapid variation in field direction in one of the lava flows, in the other flow, the changes detected suggest some newer phenomena effecting the magnetization. "Our recent work revisiting this question", continued Coe, "indicates (indirectly) that the magnetization of one of these flows must have been affected by later processes, whereas the magnetization in the other flow still appears compatible with the

What is *paleomagnetism*?

Magnetite (a magnetic ore of iron) crystals in volcanic strata preserve a record of the earth's polarity at the time the crystal substrate (molten lava) was extruded onto the earth's surface. There, the crystals quickly orient themselves along the earth's current polarity (the direction or flow of electrons around the Earth; currently towards the north pole), and, as the lava cools, the crystals become "fixed" into that orientation. By analysis of deeper (older) layers of volcanic rock, scientists can determine the polarity state, and strength, of the magnetic field in the remote geologic past.

This 'geological memory' has been known for nearly 100 years, but not until the late 1950's did scientists learn of magnetite crystals in the brains and cells of animals. Evidence exists supporting the notion that these brain-based crystals' polarity are sensed by certain animals (like whales, turtles, birds, wildebeests, and even bacteria) and help to guide their migratory patterns.

Humans also have magnetite in their brains, and it is still not clear to what extent this impacts human behavior. However, in a recent experiment by Dr. Valerie Hunt, a room was constructed in which the magnetic field intensity could be modified.

Dr. Hunt wrote in her book, *Infinite Mind*, "When the magnetism was decreased, gross in-coordination occurred. The entire neurological integrating mechanism was thrown off. Subjects could not balance their bodies; they had difficulty touching finger to nose or performing simple coordinated movements. They lost kinaesthetic awareness."

hypothesis of rapid-field-change episodes.”

This new data is causing a bit of excitement in the geophysics community. But it would seem to be the kind caused every time new/unexpected data emerges in a highly specialized research field.

Unfortunately it can sound provocative, even alarming. Coe’s data has even been used to ‘prove’ a widely-discredited viewpoint that the Earth is only a few thousand years old.

Until more convincing evidence arises, most geo-physicists espouse a much longer time frame for this reversal to complete itself. Although still relatively ‘short’ in terms of *geologic* time, most scientists estimate that a reversal would take many thousands of years to complete itself. And despite the news stories, many are not even sure that any field reversal is nigh. The problem may stem in part from different scientists conducting independent studies that are not yet integrated into the larger body of geo-physical knowledge that would support it—thus leading some to make generalized claims that lead to sensational headlines and the inevitable misreporting of science facts.

So, it appears that there is a good amount of doubt in the scientific community—but is there *any* evidence for a coming reversal?

“Perhaps the strongest argument for a coming reversal is that, in the recent geologic past, reversals have occurred on average every 250,000 years, but the last reversal was about 720,000 years ago. In this sense, maybe a reversal is ‘overdue,’” explained Paul Roberts. “But implicit in such an argument is that there is some kind of periodicity in this turbulent system, and *there is no evidence for that.* [author’s emphasis] So I tend to think that that argument is not very strong. However journalists [who have to produce something to grab the readers’ attentions] and



Paleomagnetist Rob Coe and assistant using a portable magnetometer to test the polarity of a basalt sample. Photo. Coe

some scientists (who should know better, but want to grab a bit of free publicity) tend to overstate the case for a coming reversal.”

Up until mid 2004, there was some disagreement over the duration of any given ‘magnetic flip’; none of the scientific experts had hard data describ-

ing the temporal limitations to these reversals. Then, in April of that year, Brad Clement of Florida International University published the results of his review of the last four such reversals. His findings indicate that the average duration was 7,000 years. But that the differences are not random—the duration varies with latitude (duration is a few thousand years at low latitudes and every 10,000 years at high latitudes). It is becoming rather clear that use of the term ‘flip’ is misleading and inappropriate.

So, this science would seem to support the contention that any polarity reversal will take several thousand years or more to complete itself (assuming that the field *is* reversing, and not merely fluctuating). But, whether the reversal will be long or a rapid, is not clear if any major or lasting impact will be felt here on the ground.

Some argue that it is a *weakening* of the electro-magnetic field that should give us cause for concern. Some computer model data shows the field strength decrease can be as great as 90%. There have been claims the field could also ‘collapse’ and then, it may take the Earth many thousands of years to rebound. If this weakening period were to coincide with a thinned atmosphere and an increase in solar activity—or perhaps an intensifying solar wind, and, [highly energetic, particles, or *solar plasma*, flung out into space by our sun that continuously bombards the Earth]—then planet Earth could be in for a scorching, or so goes the theory.

There is a more sober take on the weak field

hypothesis. It depends, a bit, on how you define the weakening period of the reversal.

"A polarity reversal does not mean that the geomagnetic field disappears," said Roberts, "Even when the dipole moment is zero, in the 'middle' of a reversal, simulations suggest that the field strength will be on the order of 20% of what it was before and after reversal. It is hard to define precisely what one means by saying that the Earth's field is in a weakened state. Does one mean the time during which the dipole is 50% of its pre- and post-reversal strength, or 30% [say]? The time you seek is obviously affected by your choice of percentage! Also, simulations suggest that the duration of the weakened state may be rather different for different reversals.

"Paleomagnetic records show that the magnetic field strength has decreased much lower than today's value many times in the past without reversing," 'adding to the understanding of field dynamics.' "Moreover, today's field strength is 20 to 40 percent greater than our best estimate of the *average* field strength for the past several tens of millions of years [*Italics ours*]. Yes, the field intensity has decreased at the unusually high rate of about 8% per century..., and archeomagnetic studies show that it was about 40% stronger 1500 to 2000 years ago, but I know of no compelling reason to believe that this time the falling intensity is leading toward a polarity reversal."

Gary Glatzmaier, a leading geophysicist at UCSC and collaborator with Paul Roberts (whose computer models of the Earth's field are helping scientists understand the complexities of the geodynamo), expressed some additional doubt that Coe's discoveries with lava flow records have any major bearing on the issue of a global polarity switch. Glatzmaier stated, "There have been indications of very rapid changes in the direction of the field at a given location on the Earth, recorded in lava flows. However, these changes probably do not represent changes in the global dipolar field." Still, Glatzmaier is cautious about even this assertion. "But we certainly do not understand everything about the geodynamo and so we can't



Geophysicist Paul Roberts of UCLA
Photo: Roberts

say a reversal couldn't take much less time than 5000 years."

Some planetary physicists have suggested that one way to surmise the consequences of the magnetospheric weakening and reversal is to look at other planets and their magnetic fields. Mars, our most earth-like neighbor, experienced a 'permanent failure' of its magnetic field, which may have resulted in the 'boiling off' of Mars's atmosphere. The effect on planet Earth of a prolonged weak-

ening coupled with a massive 'solar storm' could be chaotic and catastrophic. However, as with previous cosmic catastrophe scenarios, Professor Roberts tends to dismiss this possibility. "One can ask, if the solar wind is so well able to blow away an atmosphere, why has it not blown away the Venusian atmosphere," asked Roberts. "Venus is much nearer the Sun and the solar wind is much stronger there. [Of course it is a lot hotter there too, so the lighter gases evaporate from its surface more easily].

Also one can ask, if the solar wind is so capable to blow away the Earth's atmosphere, why do we have an atmosphere at all, considering the very many times that the geomagnetic field has reversed in the past?

Glatzmaier offers a somewhat more optimistic, long-term view, "A significant reduction in the magnetic field intensity and the breakdown of the dipolar structure probably will allow a considerable increase in cosmic radiation hitting the Earth's surface at low latitude. The Earth's atmosphere protects us from much of the cosmic radiation. However, by the time the next reversal occurs (probably no sooner than 2000 years from now) I would imagine people living on Earth will have figured out a way to protect themselves."

Lastly, looking at the most dire pole switch scenario, there is one major 'sunny' spot to be noted: the fossil record—Going back billions years, shows no correlation between periods of magnetic reversals (or declining field strength) and any 'mass extinctions' of life forms.

Not such a bad day in the universe after all.



Living Off the Land in Space: Green roads to the Cosmos

By Gregory L. Matloff, Les Johnson, C. Bangs

Published by Springer Science and Business Media

Reviewed by Katie Kline

The opening epigraphs in the nonfiction space resource *Living Off the Land in Space* not only sets the theme for each chapter, but can remind the reader of the fantasy and awe that once accompanied the celestial musings of poets and scholars. The stanzas, many of which were scribed by Romantic poets, reflect the elegant lure of distant worlds that has captivated the human race throughout its existence.

This intrinsic interest is the premise of Gregory Matloff, Les Johnson and C. Bangs' book. They put forth that humans began as a migratory species destined to wander the Earth and colonize distant lands, and as a result are tied innately to venturing into entirely new worlds, regardless of the seeming impossibility of the task.

The full title *Living Off the Land in Space: Green Roads to the Cosmos* may be misleading, especially during this time of global climate change and environmentally-friendly marketing. However, as the authors explain not-too-quickly, the dream of humans living on other planets, actually, is limited by their ability to develop sustainable technology.

Through this notion, the authors explore the current theories and innovations in space exploration, travel and colonization, and perhaps in too technical

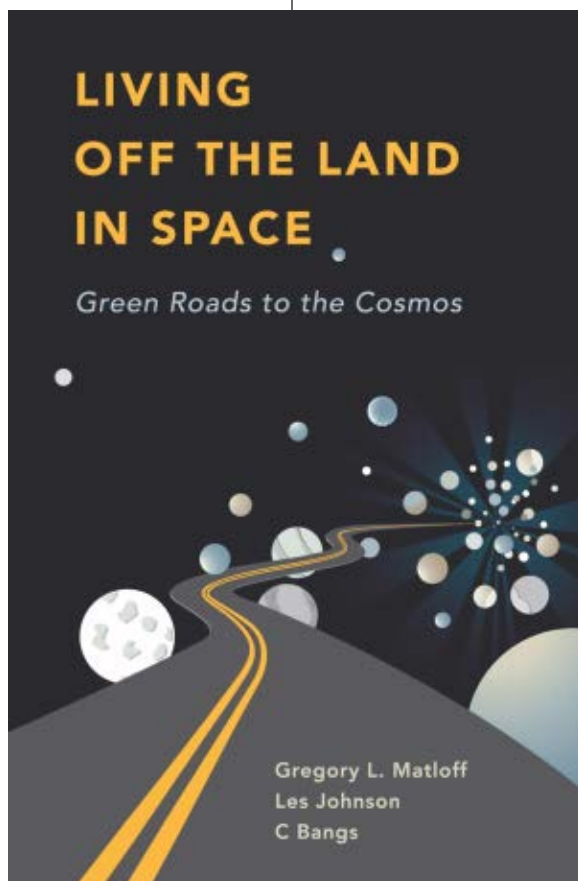
a manner, explain the economic, political and instrumental shortcomings of each option. They candidly propose several historical experiments and revolu-

tionary theories and also give nod to the majority of modern and dynamic spacecraft technologies. These include: aero-assisted atmospheric reentry, atmospheric H-Bombs and electrodynamic tethers.

Matloff, a physicist at New York City College of Technology and a NASA Marshall Space Flight Center consultant, and Johnson, a NASA Space Science Programs and Projects Office manager, together provide detailed descriptions of complex technology complete with diagrams and mathematical equations. Additionally, Bangs, a considerably well-known artist in the NASA and NewSpace communities, graces each chapter with a collage of astronomical and planetary illustrations.

While the book appears to lack a strong and definite coherence when merging the scientific with the fantastic, it still manages to capture the intrigue and vastness of the Universe, and the comparable imagination of humans.

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Book Review

Sex in Space

By Laura Woodmansee

Reviewed by Talia Page

Sex in Space is a short 136 pages, which, if read in one sitting, will leave readers feeling like they've been up all night talking to curious, unexperienced pubescents who are giggling over a sneaky issue of soft porn at a slumber party.

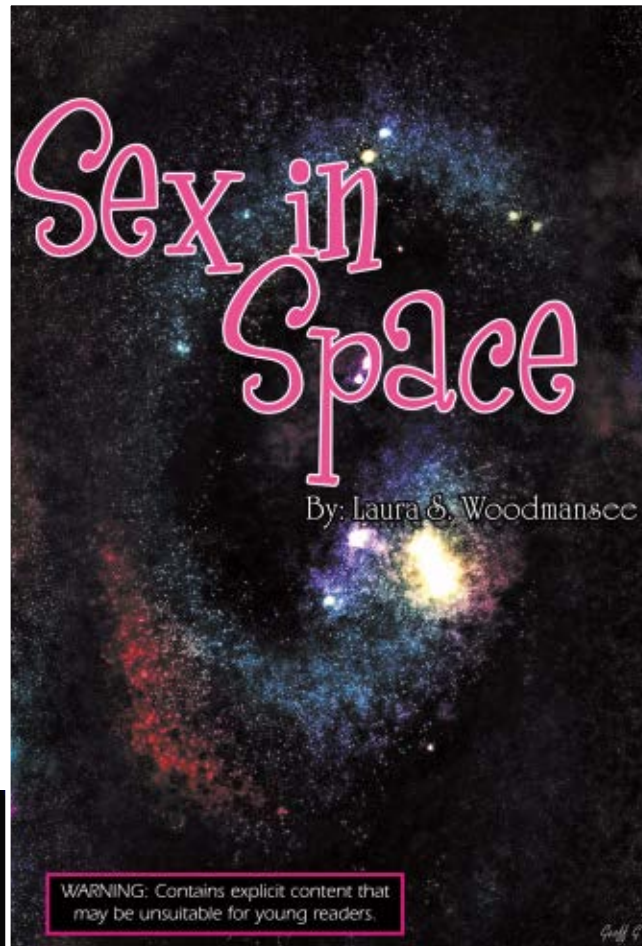
That said, author Laura Woodmansee manages to pack an impressive amount of information in-between all the immature commentary. She delves into a thorough history of sex in space (including sex among fruit flies), logistics, speculation on sex and space tourism, pregnancy, physical risks, suggested positions and toys (diagrams included), psychological issues, and even porn.

This book is full of simple puns, imaginative "what if's," creative propositions, plenty

of facts (she clearly did her research), and too many exclamations for anyone who is not a teenager. Nearly every informative nugget is followed with an enthusiastic "*Hot! That's crazy! Let's get this party started!*"

In sum, the book is informative, but an utterly embarrassing read for anyone who no longer can refer to sex as *hanky panky*. The book will also be irritating for those who have difficulty tolerating a large dose of feminist bitterness.

It is unfortunate that there are very few other books about sex in space, although this one does provide all the up-to-date and necessary information.



By Lois Elfman



Illustration by Michael Delia

MAKING ROOM FOR SPACE

“Our mission: *To advance space-related endeavors to inspire, enable, and propel humanity.*” Lofty goals for any organization, but over the past quarter-century the Space Foundation (www.spacefoundation.org) has unquestionably, as their tagline states, been able to “take up space.” They’ve networked businesses in the industry, inspired teachers, created opportunities and helped foster space awareness. Now, as they prepare to mark the significant milestone of their 25th anniversary, the organization is poised to have a bird’s eye view on what will define the space industry over the next two and a half decades.

The Space Foundation was founded on March 21, 1983 in the wake of the creation of a military space command in Colorado Springs. There was a feeling that a non-partisan, non-profit organization should exist that could communicate why space was in the national interest. The three founders remain involved: attorney William J. Hybl, now chairman and CEO of the El Pomar Foundation; former Congressman Kenneth B. Kramer, now Chief Judge of the U.S. Court of Appeals for Veterans Claims; and accountant J. Braxton Carter.

The founding three can attest to the foundation’s tremendous growth and evolution—from a tiny staff working in a donated office with used furniture, to 45 in full-time staff divided between headquarters in Colorado Springs, a Washington, DC office and a small office near Cape Canaveral in Florida. The Space Foundation has daily interactions with NASA and the National Oceanic and Atmospheric Administration, and individuals affiliated with the Space Foundation comprise one-third of the U.S. delegation to the United Nations Committee on Peaceful Uses of Outer Space on which they serve with representatives of the State Department and NASA.

One of the decisive milestones in the life of the Space Foundation was its participation in a 1986 study conducted by the Annenberg School for Communications at the University of Southern California about the impact of space exploration on students. Were students really more inclined to study if they felt a connection to space exploration?

“We found overwhelming evidence that if you get students—grade school through college—involved in space their interest level, their engagement and



The General James E. Hill Lifetime Space Achievement Award. This award is the highest honor presented by the Space Foundation. The Space Foundation annually presents the Hill award in honor of its late, long-time chairman, General James E. Hill, USAF (Retired). It recognizes outstanding individuals who have distinguished themselves through lifetime contributions to the welfare or betterment of humankind through the exploration, development, and use of space, or the use of space technology, information, themes, or resources in academic, cultural, industrial, or other pursuits of broad benefit to humanity. Nominations are solicited from throughout the space industry worldwide, and the board of directors of the Space Foundation selects the honoree. 2008 marks the seventh annual presentation of the General James E. Hill Lifetime Space Achievement Award. Previous award recipients are Norman R. Augustine, Capt. James Lovell, Jr., USN (Retired), Gen. Bernard A. Schriever, USAF (Retired), Edward C. "Pete" Aldridge, Jr., Buzz Aldrin, Ph.D., Col. USAF (Retired), and Simon Ramo, Ph.D. The 2008 recipient is Hans Mark, Ph.D. This award is permanently housed at the Space Foundation headquarters. Each year the recipient's name is permanently etched on the large award and the recipient is presented with a smaller, individual award to keep.

Picture from the opening ceremony of the 23rd National Space Symposium in April 2007



their academic performance goes right through the roof," says Space Foundation president and CEO Elliot G. Pulham. "Their math lesson isn't some boring math drill, it's about how to launch a rocket. Their biology lesson isn't just about cellular growth, it's how would you do that in space. That was a big 'Aha!' moment, because that told us as a foundation that education had to become a primary mission."

So in addition to doing trade association work, government affairs and policy work, and international and economic work, education for both students and teachers comprises a significant component of Space Foundation activity.

Each summer the Space Foundation conducts five weeks of space discovery institutes in Colorado Springs, weeklong programs where teachers learn how to bring space into their classrooms. In 2007, they also did two weeks in Maryland, which they expect to replicate in 2008. Subjects include earth science, rocketry, the biology of living in space, astronomy, space technologies, space history and space law. Some scholarship money is available to defray costs.

"We would like to take these summer institutes into areas such as Chicago, Los Angeles and Seattle, so it opens up more opportunities for these educators, particularly educators in inner city areas," says Iain Probert, vice president of education enterprise. "We also have outreaches such as Space in the Classroom, where we bring space professionals into communities. This is how we excite

young people and get more diverse people into space and science."

Presentation of these programs is dependent on funding. In the past year, they brought a program for teachers to a remote community in Hawaii and a program for students that brought astronauts to visit an equally remote community in Alaska.

"We let them know that space is not limited in regards to career paths," Probert says. "In fact, in space we need the same folks we need down here on planet Earth. We need chemical engineers to develop rocket propellant. We need pilots to fly the space ships. We also need folks in the medical field. And we need people in the culinary field, as well as electricians and plumbers—all levels of expertise."

The Space Foundation is not an individual member organization. There are, of course, numerous activities in which individuals can participate, but the membership is corporate. With the mission of promoting space and space exploration, the foundation creates opportunities where members can collaborate and connect.

"It's an interesting dichotomy in our business that companies that are operators and partners on one project will be vicious competitors on another project," says Pulham. "It's part of the way of life in the space indus-



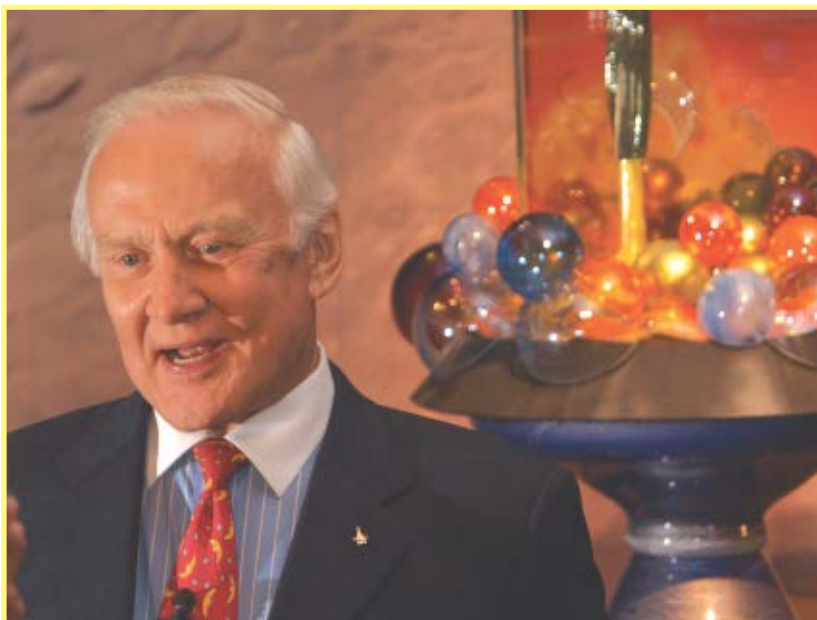
try. We put on the largest trade show conference in the industry (the 24th National Space Symposium will take place April 7-10 in Colorado Springs), and we bring the individuals together several times a year to share ideas, have discussions on topics of interest, review what government is doing, review what's going on in the private sector and have meetings and dialogue. We're a very key part of the glue that holds the industry together.

"We facilitate discussions—not only among U.S. companies, but also among our international partners," he adds. "We work quite extensively in the Pacific and in Europe." Partners include the International Space University and the Japanese Aerospace Exploration Agency. Pulham compares the symposium to the Paris Air Show. Companies actually negotiate contracts with one another while there. There is also significant intellectual content presented, both government and commercial.

The National Space Symposium includes a career fair for college students (undergraduate, graduate and transitioning military personnel), where they can mingle with industry leaders from around the world and gain a greater understanding into career options. There are specific education events, including an entire day of programs for members of the foundation's Teacher Liaison program, who attend the symposium free of charge. Members of the Teacher Liaison program go through a special selection process. "If they get selected, they commit to the Space Foundation that they are going to promote as much as they can and incorporate space activities into their classrooms and also among their colleagues and fellow faculty," says Probert. They receive weekly communiqués on space and science. Over the past five years, approximately 200 teachers from all over the U.S. have participated.



Two pictures from the exhibit center at the 23rd National Space Symposium



2006 Hill Award recipient, Buzz Aldrin, Ph.D., looking at the Hill Award

about the new J.J. Abrams *Star Trek* movie in production,” he says. “As soon as that HD trailer hit the Web, that thing was going everywhere. I am so excited the franchise is kicking back up again. People have been hugely influenced by things like *Star Trek*, and we embrace that. We think there’s a place for everybody in space—whether you’re a storyteller, an artist, a historian, a moviemaker, a scientist, or an astronomer. Space is common to all of us.”

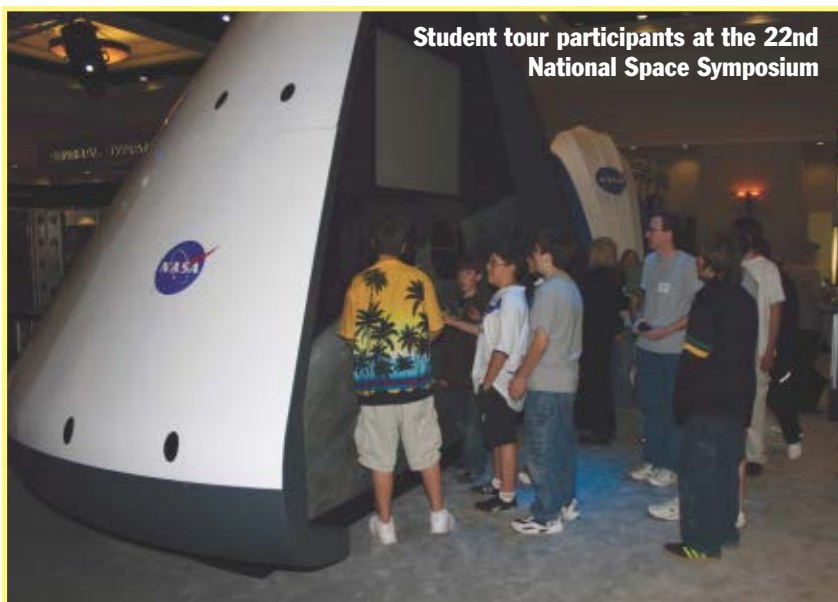
Probert says space enthusiasts can participate in the Space Foundation’s virtual lab. A new one is coming online this spring. “The

In Washington, DC, the Space Foundation government affairs team lobbies on Capitol Hill, keeping members of Congress and their staffs informed on space issues. “Providing a non-partisan evaluation and assessment of things that are going on in space so that members of Congress can make informed decisions,” says Pulham.

The Space Foundation reached out to all the presidential candidates and offered to provide information and serve as a resource on the space-related issues and decisions they may face if elected. Senator Barack Obama, Senator Hillary Clinton and Senator John McCain have all issued position papers on space. Pulham is pleased that Senator Obama, who just a few months ago advocated taking money out of NASA, has now included a platform in his campaign in favor of space exploration.

Each year, the foundation’s research and analysis department publishes The Space Report, a comprehensive overview on what went on in the space industry during the previous year. It contains economic and revenue data along with information about the foundation’s education programs.

Pulham says the gap between those who work in the space industry and space enthusiasts isn’t all that big. “I can’t tell you how excited people in our industry are



Student tour participants at the 22nd National Space Symposium



2007 Space Technology Hall of Fame honorees and presenters

Tracking Orbital Businesses: The Space Foundation Index

By Lois Elfman

Established in 2005, The Space Foundation Index (spacefoundation.org/spaceindex/) is a weighted index that tracks the market performance of 31 publicly traded companies that derive a significant portion of their revenue from space-related endeavors and activities. Initially introduced as an annual report, the Index went live, in December 2007, with a Web-based version. This version is updated each business day, just after the close of the markets. Performance comparisons are given with the NASDAQ and S&P 500 in daily, weekly, monthly, quarterly and annual intervals.

"My former company, SpaceVest Capital, did a lot of work during the '90s to try and characterize what the space industry is," says John Higginbotham, a member of the Space Foundation's board and the initial force behind the Index. "At SpaceVest, we started to look at various ways you could create an index. When I officially retired from SpaceVest Capital in early 2006, we donated all of our intellectual property on the space industry studies and the early work on the index to the Space Foundation.

"It is perfectly appropriate for the Space Foundation to do the Index," he adds. "By virtue of this Index they are able to communicate to the marketplace in a very efficient manner the performance of the space industry, which is absolutely required to be able to get credibility in the capital markets."

"In my mind, it made sense to take the Index live because people watch the stock market on a daily basis," said Marty Hauser, vice president, research and analysis. "The feedback so far is fairly positive. People appreciate having a way to track space and the major companies that are players in the space marketplace. I also think it has room to grow."

Kevin Leclaire, formerly a senior associate with SpaceVest Capital and now managing director of ISDR Consulting, did much of the research behind the Space Foundation Index and now maintains it on a daily basis. The companies in the Index are divided into two distinct categories, each with two subcategories. Infrastructure Companies break down into Space Segment Sub-System Manufacturers & System Integrators and Ground Segment & Satellite Component Manufacturers. Satellite Service

Companies are broken out as Consumer/Retail Services and Enterprise/Government Services.

In terms of how a public company rates inclusion in the Index, Leclaire explains some factors. "For small companies, about 40 percent of their revenues have to be related to space," he said. "For larger companies, it's tougher, because companies like Lockheed, Boeing, Northrup and Raytheon all have large components of their business that are not related to space, but they're very well known as space companies. So, if they are large and they've got over a billion dollars a year in revenue from space, I will relax that 40 percent requirement down to around 25 percent."

Periodic reviews take place where Leclaire reviews the composition of the Index. Once a year, he'll check that a company's space revenue is in line with the Index's guidelines. On a regular basis, he checks if any of the companies have changed their tickers or if they've been acquired or acquired other companies.

Because the Index only tracks publicly traded companies, Hauser explained, it cannot really give insight into cutting-edge private companies that are the pioneers in commercial space travel. "The potential is there, but there are certainly some long pulls that the industry has to overcome," Hauser said. "It's one thing to build a rocket that puts a satellite into orbit. It's another thing to build a rocket or some other sort of space craft that is going to put a human being into orbit." Last year, Northrup did acquire Scaled Composites, which has a contract with Virgin Galactic to build SpaceShipTwo.

Leclaire also said there is a company in Europe listed on multiple European exchanges, European Aeronautic Defense and Space Company, which has proposed a vehicle for commercial space travel and spent money on the design concept. Should a U.S. company solely in that arena go public, Leclaire would track it. "After an appropriate period of time, assuming they meet certain criteria, they would be added to the Index," he says.

The Index has often outperformed the overall market, which Higginbotham attributes to growth sectors in the economy.

virtual lab that's available now is on the Asteroid Apophis," he explains. "Folks can learn about asteroids and their history. They can take quizzes. They can also take part in a scenario and put forth some solutions to Apophis. Should it slip through a certain keyhole in 2029, there's a fair chance it may slam into Earth in 2036. A similar asteroid is what is believed to have wiped out the dinosaurs. This is something that should be of interest to us all."

Pulham notes that the Space Foundation will continue to work with both the public and private sectors to push forward space exploration. "Space is a long-term investment," he says. "It takes a vision-ary to put in place a plan and funding for the plan that will continue to assure U.S. leadership. I'm encouraged by what's going on in the private sector." While in New York for meetings on an inaugural conference of the financial community scheduled for June, Pulham attended the unveiling of Virgin Galactic's SpaceShip Two model.

"Virgin Galactic is not measuring their perform-



Students participating in tours of the exhibit center at the 23rd National Space Symposium

"What we're seeing today is a renaissance of private interest in space flight and in developing commercial, sustainable models for commercial activity

in space. In addition to space travel, we have to keep in mind all the space applications—GPS, satellite radio, satellite television, etc., that is already being done on a commercial market.... What NASA does is less than 8 percent of what's going on in space. Space is already a commercial domain and it's going to become more and more a commercial domain as we go ahead.

"The Space Foundation needs to continue to foster the dialogue, which we do at our trade shows and conventions, so that all parts of the industry continue to talk to each other and participate in what's going on. We have to continue to inform policy makers of the needs and requirements of these young

companies. Any time you create a business, the government is going to want to regulate it. So we need to be there on the ground floor to make sure regulations don't choke off the industry as it's being born. Then we have to continue in the classrooms to make sure that our kids are inspired enough to take these jobs."



(Above Left) The Honorable Robert S. Walker presenting Eileen Collins with the 2007 Douglas S. Morrow Public Outreach Award. (This award recognizes outstanding contributions toward increasing public awareness of and support for the exploration and development of space.) At the time Walker was the Chairman of the Space Foundation Board of Directors. His term concluded in January 2008 and he is now Chairman Emeritus of the Space Foundation Board of Directors.)



(Above Right) Walker with Robert Bigelow, founder and president of Bigelow Aerospace. Bigelow Aerospace was the recipient of the 2007 Space Achievement Award.

ance on a day-to-day or quarter-to-quarter basis. They're measuring on their 15-year plan and they are making progress because they're in this for the long haul," he says. "Government programs, by definition, are extremely bureaucratically managed, because it's public dollars involved. You can't take the kinds of risks with public dollars that you can with private dollars.

A photograph of an astronaut in a white spacesuit standing on the lunar surface. To the left, an American flag is planted in the ground. The background shows the dark, cratered landscape of the moon under a black sky.

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s economic and environmental pressures increase around the world, emerging organizations are helping many different countries sustain and profit amid these times of change.

One organization, the International Water Management Institute (IWMI)

(www.iwmi.org), is using resources of the space sector to help find solutions to maximize the potential for gathering what may be the Earth's most precious resource: water.

Working with other national and international institutes from around the globe such as the World

Bank, the IWMI hopes to show users of its data where there is variability in water productivity. The Institute accomplishes this goal through its collection of data from a group of remote sensing satellites orbiting Earth.

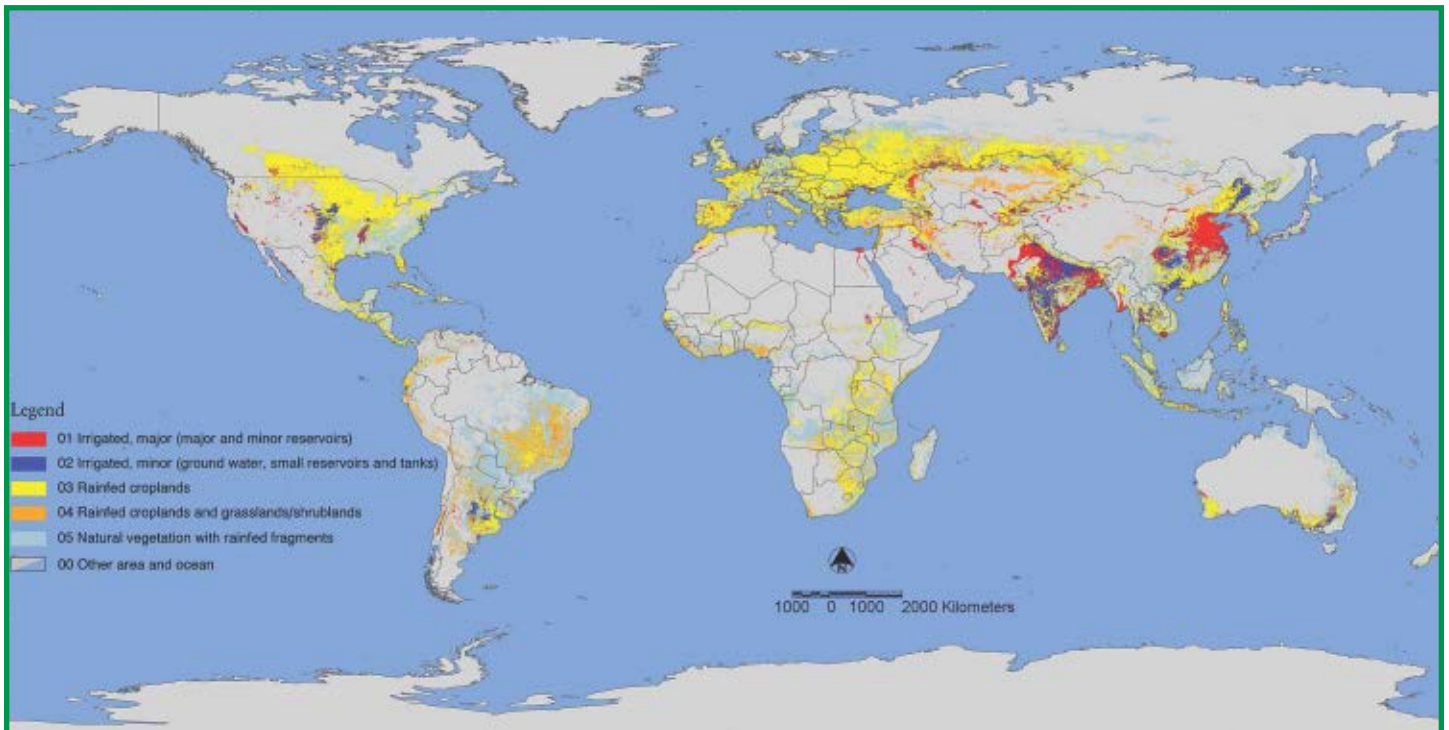
If finding oceans, lakes, or rivers seems to be an obvious task to someone walking around a given area, why would one need maps made from expensive satellites to show you where water is on the Earth? A lake is a lake, and a river is a river. Sounds simple. The search for water seems over. But, the IWMI is accomplishing more than the obvious and finding what even traditional maps can't tell us.

Led by Dr. Prasad S. Thenkabail, the Sri Lankan headquartered institute has collected maps of the Earth from space to help its users find where water can be managed, even if this means managing water found from space, which is *under the ground*.

Issues related to where water is used and to keeping food resources secure can easily be determined, said Thenkabail, "by having a good irrigated map." With 80% of water consumption currently going to irrigated areas, this type of mapping becomes very important.

But how does one find water, uncharted, or from

Global irrigated areas (in blue and red) and rainfed areas (in orange and yellow) by color. Image provided by IWMI



A photograph of a person wearing a wide-brimmed hat and a light-colored shirt, working in a rice field. The person is using a long-handled tool to work the soil. In the background, there are other people and a line of trees under a clear sky.

CAN THE REALM OF THE STARS GIVE LIFE?

By David Bullock

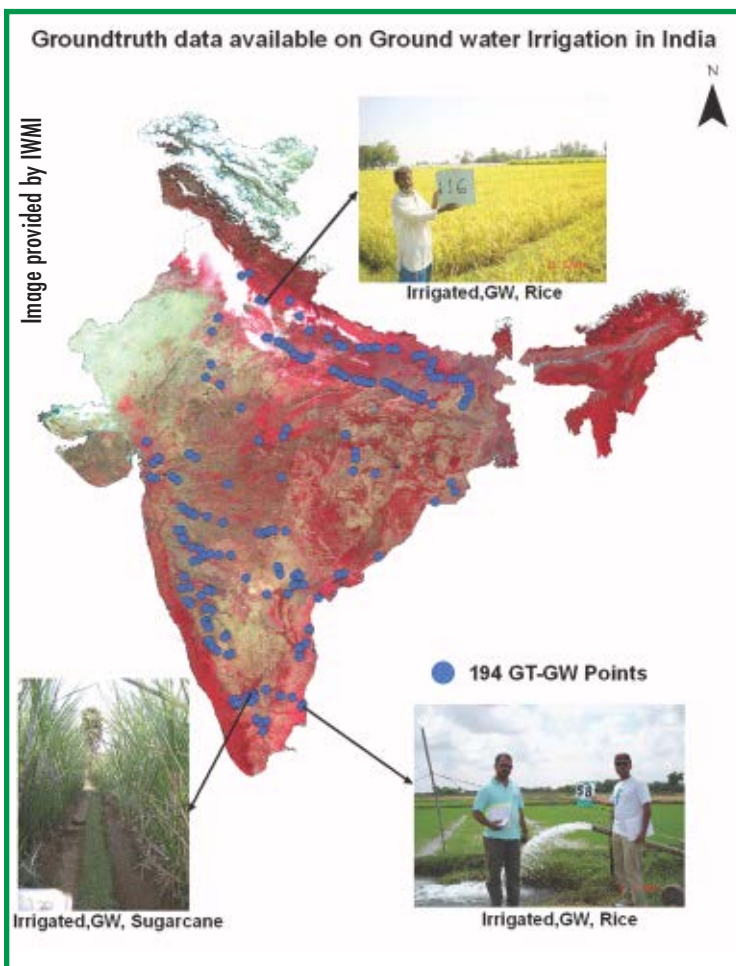
**How Water Management on Earth Is
Aided by Space-Based Remote Sensing**

underneath the ground, using satellites, which are far away in space, orbiting the Earth itself?

"We try to look at plant productivity," Thenkabail gave as an example. To look where plants are thriving on the Earth, one can make a strong connection that those areas are the locations where water can be found. On the ground, water management techniques can then be used to maximize that area's water potential. "The idea," Thenkabail emphasized, "is to grow more food from a set amount of water."

As an IVMI map user looks at irrigated areas from space, they are looking to eventually determine what the different levels of water productivity are for an entire country or region. Thus, the technologies of space give much usefulness to scientists and decision-makers. "Remote sensing offers a globally consistent pattern for collecting data," explained Thenkabail, "You are not bound by the varying system [of information collection] across nations." Before, scientists and analysts would use data from the acquired from surveying an area on the ground, solely.

When ground data is used by itself, maps can become inconsistent with each other in many ways. Remotely sensed maps are different in that they are made from captured reflected light wavelengths bounced off the Earth and onto a satellite's image capturing device, which operates much like a typical camera. The satellite's "camera" however, can capture not only visible light, but can be equipped to capture infrared light. This allows for even better distinctions of what can be found on the Earth. Further use of computer algorithms applied to the maps generated can bring even more distinctions of what a user is actually looking at on the Earth and maybe even its properties. Traditional maps may have looked at irrigated areas by counting crops, for exam-



ple. But remote sensing can tell you not only the area of cropland, but the density of crops and what crops are planted for a given area. The data, thus, becomes not only consistent with other maps taken by the same satellite within a short time period, but over years.

And when looking at any form of global change, remote sensing becomes an important tool for other reasons. "Accurate and reliable information on various parameters that contribute to global change are essential for humans to adapt and mitigate some of the effects," said Dr. Santhosh Seelan of the University of North

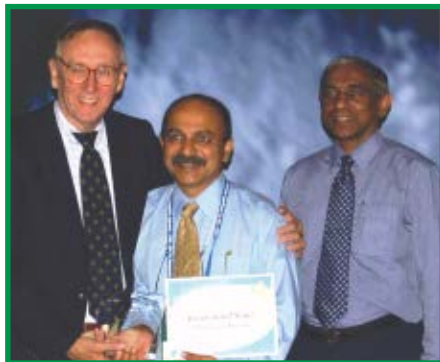
Dakota's Space Studies Department, "Remote sensing is the only way to obtain these parameters in a quick and reliable manner." So in times of disaster, speed and reliability can help better save property, resources and even lives.

One of the maps systems used by the IVMI, called Global Irrigated Area Mapping, or GIAM, covers all the irrigated areas of the world. The mapping system has within it images taken from many well-known satellites in the remote sensing world.

These include the United States government owned satellites LANDSAT and MODIS and the privately owned French satellite SPOT.

The IVMI has been a model of remote sensing and Global Information System (GIS) applications. "The International Water Management Institute, like most other institutions working on global change or natural resource studies, make excellent use of the remote sensing data," said Seelan. But the IVMI, in particular, beat out over 300,000 organizations that use GIS software and won the Special Achievement in GIS (SAG) Award at the 27th Annual ESRI International User Conference in San Diego, California, June 20, 2007. ESRI is a company that is a leader for GIS software.

The institute won the award for its Data Storehouse Pathway (DSP) website (www.iwmidsp.org). The site provides several terabytes of high scientific quality remote sensing and GIS products. Decision makers and scientists can use this data to better help their countries. For example, in the year 2007 the site has helped over 2,000 users analyze tsunami damage and assess



The president of the Global Information System (GIS) software company ESRI, Jack Dangermond, awards Dr. Prasad Thenkabail the Special Achievement in GIS (SAG) Award for the work the International Water Management Institute (IWMI) made in creating its Data Storehouse Pathway (DSP) remote sensing information archives. Photo provided by IWMI

related recovery needs. Now the site boasts 3,500 users from more than 80 countries.

One of fifteen research centers, the IWMI, is supported by a network of over 60 governments, national and international organizations collectively known as the CGIAR – Consultative

Group for International Agricultural Research. The IWMI also has regional offices in Asia and Africa.

Upcoming projects for the IWMI include the study of linking approximately 20 large rivers in India. Called the National River-Linking Project in India (<http://nrlp.iwmi.org/main/maps.asp>), the IWMI is trying to study the ecological and environmental impacts of this project and help analyze food security and water issues in India.

Most people tend to focus on large riverways, said Thenkabail, but there are 6,100 smaller riverways in the Indian River Basin, for example. “[remote sensing] opens an eye for them,” he explained.

Currently working for the IWMI is Yale graduate student Noel Aloysius. He looks at the details of river basins and the amount of water they supply. Before coming to the IWMI he worked on smaller system level projects. “As a next step, I [then] did some water resource planning at the river basin level,” said Aloysius. He now looks at things from remotely sensed data giving him a broader picture from the individual level work he originally performed.

Working for organizations like the IWMI, professionals like Aloysius are changing the way water is managed here on Earth, using tools found, literally, amongst the stars.



Ideal Spectral Signatures of Land use/land cover (LULC) Classes in China

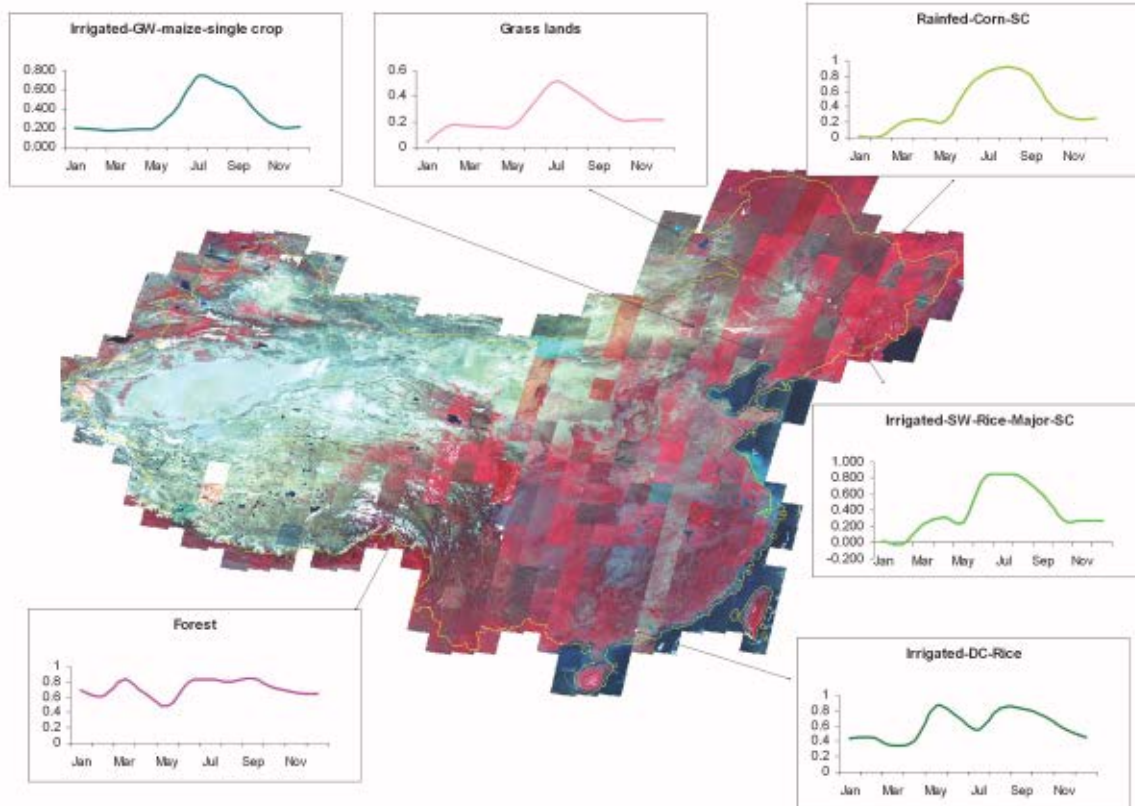


Image provided by IWMI

A New Race to the Moon:

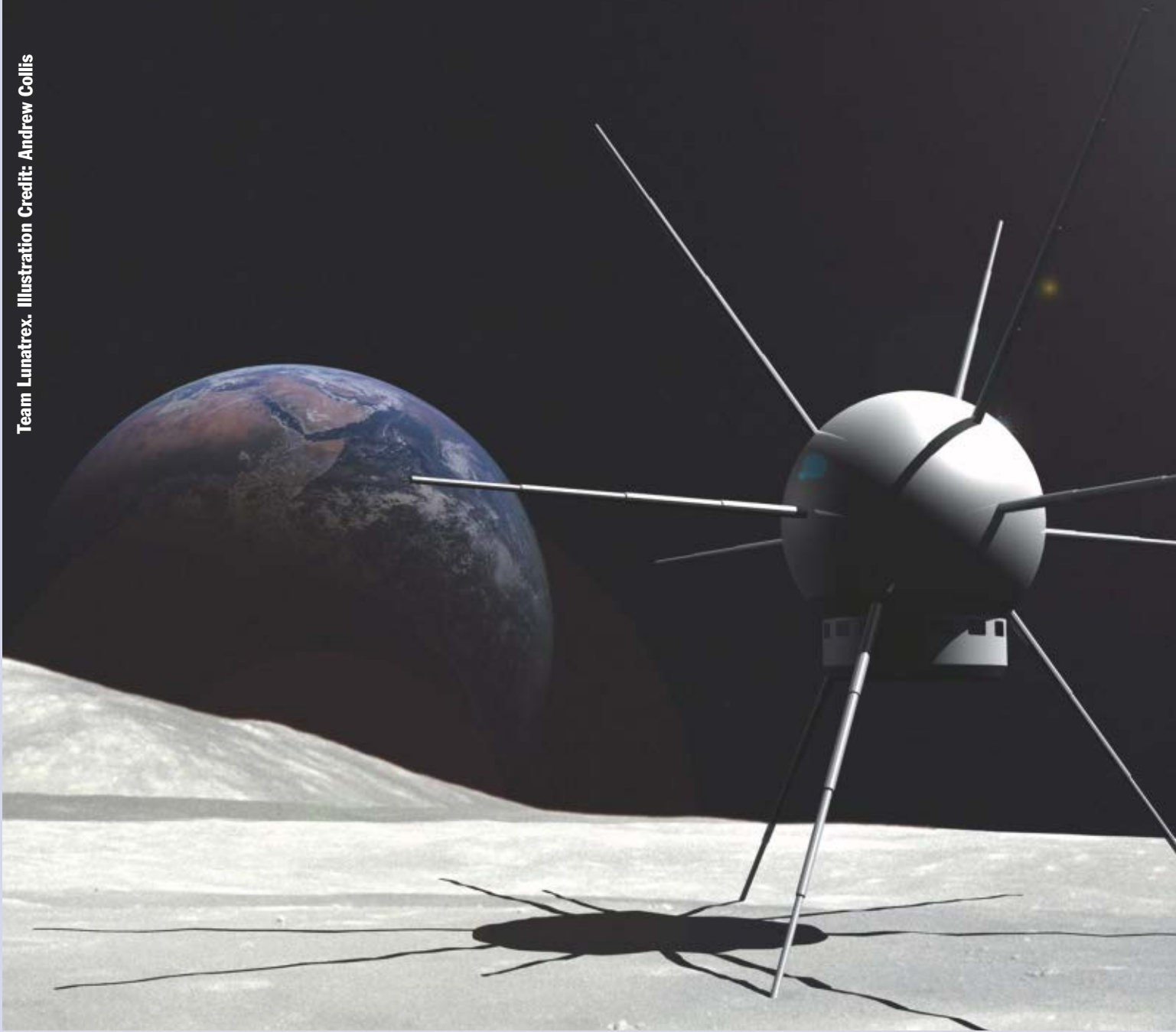


Team Southern California Felene Group. Illustration Credit: Andrew Collis



Competitors Gear Up For Google Lunar X-PRIZE

By William I. Lengeman III



**The Pomerantz Report;
Video Blog from Google HQ**

<http://www.youtube.com/watch?v=eAg8VckFmdY>

n the annals of space exploration and human history as a whole, July 20, 1969 holds a particular place of honor. It is, of course, the day that human beings - American astronauts Neil Armstrong and Buzz Aldrin - first walked on another world.

Another significant event – one could argue that it was as important and perhaps even more so - came nearly a decade earlier. On September 14, 1959, the Soviet Union's Luna 2 probe, which had been launched two days earlier, impacted on the Moon's surface. Though it destroyed itself in the process, this marked the first time that mankind had made contact with another world.

The excitement of lunar exploration dwindled

considerably following Armstrong and Aldrin's Apollo 11 moonwalk, but in recent years the Moon is again being touted as a popular destination. In 2004, President George Bush announced that the United States would begin sending unmanned probes to the lunar surface as early as 2008, with manned missions to the Moon planned for 2020.

The United States won't be alone as it attempts to reestablish a lunar exploration program. In late 2007, Japan launched Selene - also known as Kaguya - a lunar orbiter that's expected to circle the Moon and collect data for up to a year. A few weeks later the Chinese launched a lunar orbiter called Chang'e 1. India is expected to enter this scaled down version of the space race in April 2008, with Chandrayaan I, a craft that will orbit the Moon for as much as two years and send out an impact probe.

One day before Japan's Selene was lofted moonward came an announcement of no small import for the field of lunar exploration. In this case the news came from the private sector. On September 13, 2007, the X PRIZE Foundation and Google



Members of the X PRIZE foundation and contenders in the Google Lunar X PRIZE gather for a group shot.

The following pages show an artists rendition for each of the entries of the Google Lunar X Prize. Note that these designs may change throughout the competition.

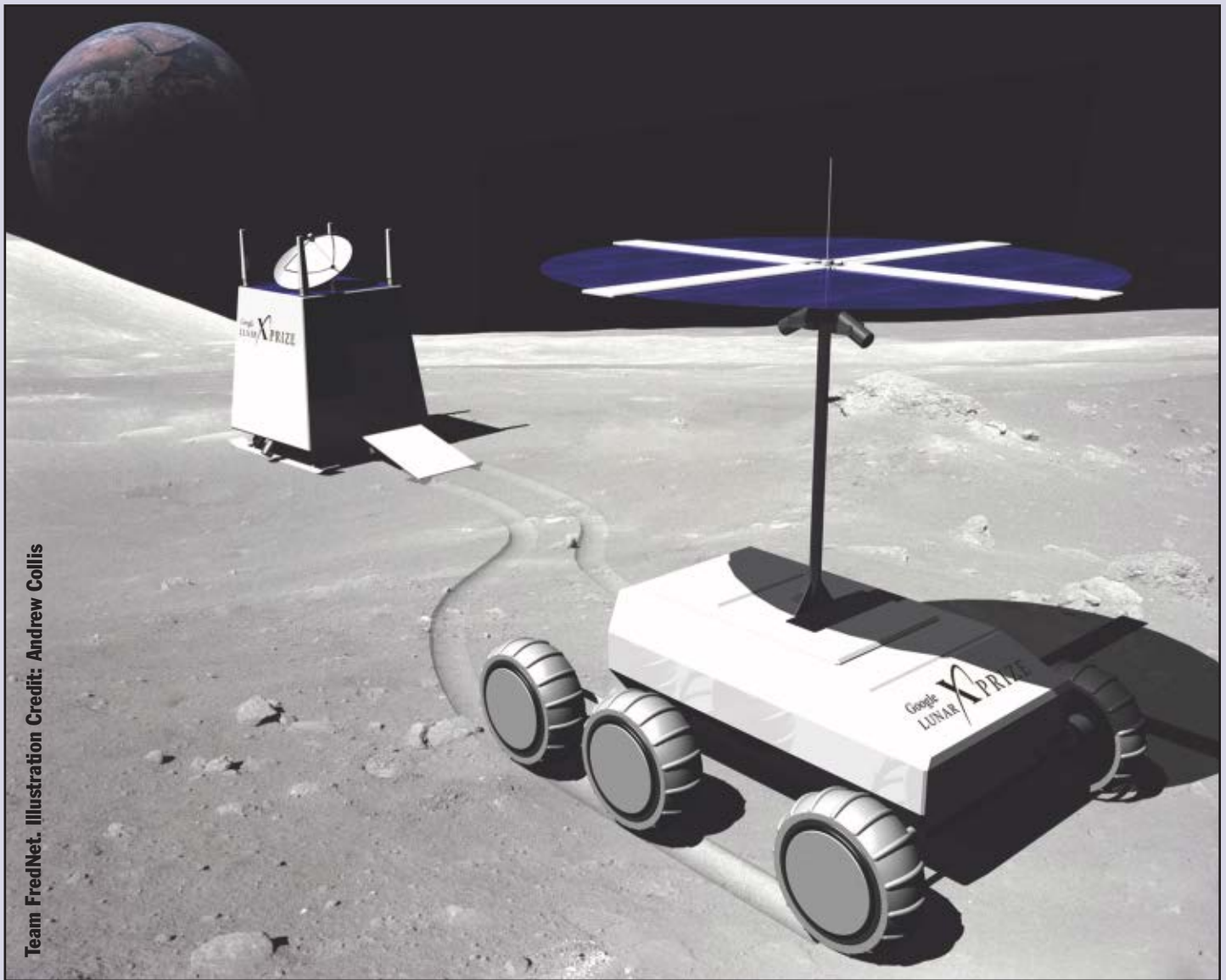
announced the Google Lunar X PRIZE. In the words of its founders, the prize is described as "a robotic race to the moon to win a remarkable \$30 million prize purse."

The X PRIZE Foundation has been in place for over a decade and has drawn quite a bit of notice during that time. It was founded in 1995 by space entrepreneur, Dr. Peter Diamandis. He was inspired by pilot Charles Lindbergh, whom we know best for winning a similar prize in the field of aviation in the early part of last century. The stated goal of the X PRIZE Foundation is "to bring about radical breakthroughs for the benefit of humanity" by creating large incentive prize competitions.

Among the Foundation's projects: the Archon X PRIZE for Genomics, which got underway in 2006 and which will award \$10 million to the first team to



Team ARCA. Illustration Credit: Andrew Collis



Team FredNet. Illustration Credit: Andrew Collis

sequence 100 human genomes in 10 days. The upcoming Automotive X PRIZE will go to the first team that wins a stage race for clean, production-capable vehicles that exceed 100 miles per gallon-equivalent fuel economy.

The Ansari X PRIZE for Suborbital Spaceflight, announced in 1996, is probably the X PRIZE Foundation's best-known award to date. Originally known as just the X PRIZE, it awarded \$10 million to the first privately financed team to build and fly a three-passenger vehicle 100 kilometers into space twice within two weeks. In all, 26 teams from seven nations invested more than \$100 million in pursuit of the prize, which was awarded in 2004 to Mojave Aerospace Ventures. The name of the prize was changed to recognize a multi-million dollar donation from entrepreneurs Anousheh Ansari and Amir Ansari in 2004. Initial support for the prize came from the New Spirit of St. Louis, a group of 100

individuals who each contributed \$25,000.

The Google Lunar X PRIZE's top award of \$20 million will go the first private company (all teams must be at least 90% privately funded) that lands a vehicle on the Moon before the end of 2012 and successfully completes a series of tasks, which include traveling across the surface for at least 500 meters, transmitting images and video back to Earth and collecting scientific data.

If there is no winner during this time frame, the prize drops to \$15 million for any team that completes the task before the final deadline - December 31, 2014. The second company to reach the Moon also takes home \$5 million and there will be \$5 million bonuses for other achievements, such as taking photographs of man-made artifacts (such as equipment left by Apollo missions), driving at least five kilometers across the Moon's surface and surviving the 14-day lunar night.

In the six months following the rollout, the Google Lunar X PRIZE received 560 requests for information from more than 53 countries. Of those, 11 teams had started or completed Letters of Intent. On December 6, 2007, at the Space Investment Summit in San Jose, California, Odyssey Moon became the first team to throw its hat in the ring.

Odyssey Moon is a private commercial lunar enterprise headquartered in the Isle of Man. It's headed by Dr. Robert Richards, founder of the International Space University, which provides graduate-level training to future leaders of the emerging global space community, and Dr. Ramin Khadem, former CFO at satellite communications company INMARSAT.

A representative for Odyssey Moon said the team isn't ready to share any concrete plans yet, but Richards said in a press release the company's goal is to lower the price of getting to the Moon by an order of magnitude and in doing so help catalyze a



Dr. Robert (Bob) Richards (left image) and Dr. Ramin Khadem (right image) of Odyssey Moon at the podium during the Odyssey Moon Announcement at the Space Investment Summit in San Jose. Photo Credits: X-Prize Foundation

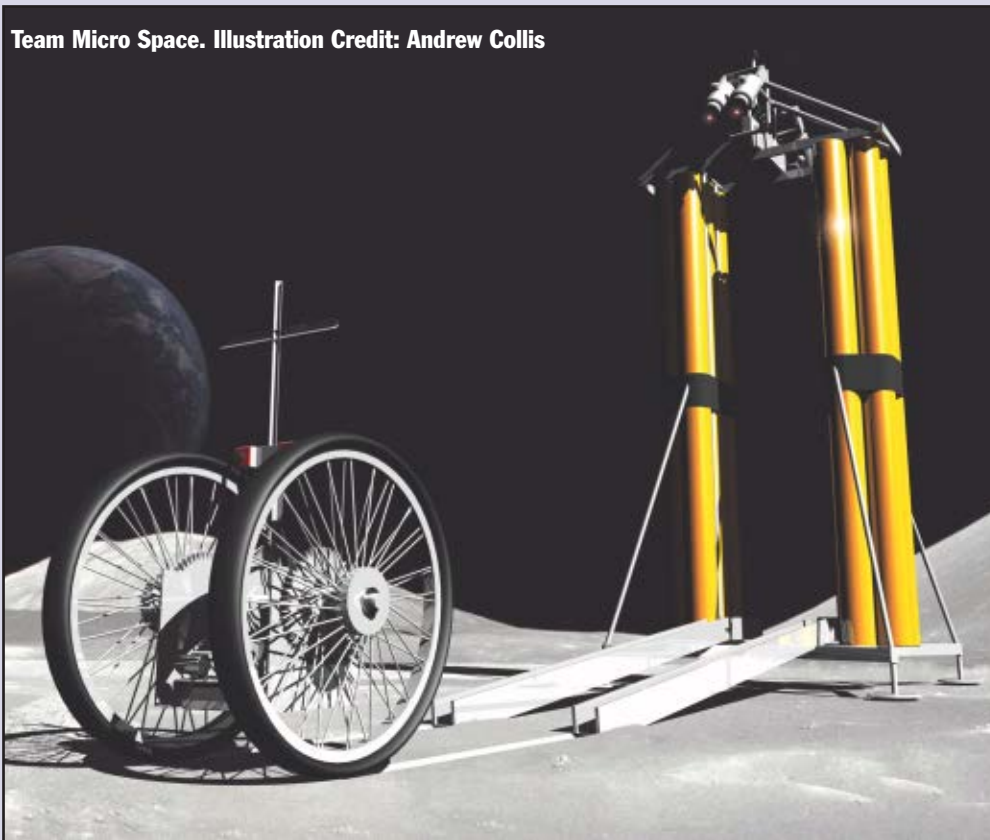
"Moonrush" to Earth's sister world. Richards likens the Moon to an eighth continent rich in energy and resources floating just offshore. He said the group's long-term vision is to make missions to the Moon accessible and commercially viable. Odyssey Moon's

prime contractor will be MDA of Canada, a company with substantial experience in providing robotics on the Space Shuttle and International Space Station, among other things.

Lunar X PRIZE officials speculate the first successful landing will come in the next three to four years, an estimate the Odyssey Moon team agrees with. Most connected with the prize also agree that the cost of a successful project will be more than the value of the prize. Diamandis guesses it will be in the \$20-40 million range.

Odyssey Moon believes the cost of sending their craft, MoonOne (M-1), could reach the \$100 million mark. Given

Team Micro Space. Illustration Credit: Andrew Collis



Google Lunar X PRIZE Field Gets Crowded

Not long after Google and the X PRIZE Foundation announced the creation of the Google Lunar X PRIZE, on February 21, 2008 nine more teams joined Odyssey Moon in the race. Of the nine new competitors, seven were based in the United States, and the other two were from Italy and Romania.

Quantum3, which is led by Paul Carliner, intends to launch a small craft from the East Coast and land their Moondancer on the Moon at the Sea of Tranquility. According to Rachel MacKnight, Communications Director for Quantum3, the launch is planned for June 2009. MacKnight says team members - Carliner, Courtney Stadd and Liam Sarsfield - bring more than 50 years experience to the table. "There is no institutional bureaucracy or baggage," MacKnight says. "Together they can make decisions and move quickly as conditions and opportunities develop."

Pete Bitar, leader of LunaTrex, feels that teams aiming to launch in mid-2009 are setting a difficult task for themselves. "Giving ourselves 3 1/2 years to do this fits the budget, the engineering schedule, and the overall parallel business model of small satellite launch as well." Among the individuals, companies, and universities that make up LunaTrex are some who also competed for the Ansari X PRIZE.

Bitar expects that it will cost from \$12 to \$18 million to get their craft - Tumbleweed - to the Moon. "We are attempting to 'invent' as little as possible, working with combining in a unique way, proven technologies that have already been space-tested. Since we are launching a prototype, there is no need to add unnecessary engineering time and expense - and risk - to the equation."

Harold Rosen, leader of the Southern California Selene Group, has credentials that include forming and leading the team that designed and built the first successful geostationary satellite, in 1963. Team members hold more than 130 space-related patents and have participated in over 500 space missions.

According to SCSG Associate Team Leader, Deborah Castleman, the design of their Spirit of

Southern California is so simple that the spacecraft could be available for launch in less than two years. "The problem," Castleman says. "Is that the lowest cost launch vehicles may not be available in that timeframe." Castleman says the team is holding to their original \$20 million cost estimate, but that the \$5 million cost margin built into that estimate is "rapidly disappearing" due to various factors.

Richard Speck, of Colorado-based Micro-Space, Inc., says his is "one of only two teams (presently registered) which has significant rocket development and operation experience, and the only one who has achieved the sort of rocket control necessary for a soft landing." Micro-Space also competed in the Ansari X PRIZE and the

Northrop Grumman Lunar Lander Challenge. Speck says the projected cost for sending their Human Lunar Lander to the Moon is \$10 million.

One of two international teams vying for the prize, Aeronautics and Cosmonautics Romanian Association (ARCA) is a non-governmental organization which promotes innovative aerospace projects and which is based in Valcea, Romania. ARCA, which was one of the lead-

ing contenders in the Ansari X PRIZE, will attempt to land a craft called European Lunar Explorer on the Moon. The other international contender, Team Italia, is collaboration between several universities under the leadership of Prof. Amalia Ercoli-Finzi. Team Italia is considering many different possible rover designs, ranging from traditional wheeled rovers to more advanced robotics.

Team Chandah - which is Sanskrit for "moon" - is headed by Texas-based energy industry entrepreneur, Adil Jafry. He says he found out about the contest by running across a press release by chance. Though possessing considerably less aerospace experience than other competitors, the self-described "no-name immigrant entrepreneur" suggests that he was also something of an underdog when he launched an energy company in 2002.

Jafry says his team is still being developed, but says that "In addition to defining the scope of the problem



The current team leaders of the Lunar Google X PRIZE.

posed by the competition and its potential solutions, our team will analyze potential commercialization opportunities for each discrete technology developed, and build the project capacity accordingly." Chandah's craft will be named Shehrezade, for Jafry's daughter.

As a measure of just how much interest there's been in the Google Lunar X Prize, consider that at the six-month point of the Ansari X PRIZE, there were only two teams registered, as opposed to the ten teams who have already registered for the Lunar X PRIZE. Given the amount of interest thus far, it's likely that this race will heat up even more as time goes on.

Team Web Sites:

Odyssey Moon

<http://www.odysseymoon.com/>

Team Astrobotic

<http://www.astrobotictech.com/>

FREDNET

<http://www.frednet.com/>

Quantum3

<http://www.googlelunarprize.org/lunar/teams/quantum3>

LunaTrex

<http://www.googlelunarprize.org/lunar/teams/lunatrex>

<http://www.lunatrex.com/>

Southern California Selene Group

<http://www.googlelunarprize.org/lunar/teams/scsg>

Micro-Space

<http://www.googlelunarprize.org/lunar/teams/micro-space>

<http://www.micro-space.com/>

Aeronautics and Cosmonautics Romanian Association (ARCA)

<http://www.googlelunarprize.org/lunar/teams/arca>

<http://www.arcaspace.ro/>

Team Italia

<http://www.googlelunarprize.org/lunar/teams/team-italia>

<http://team-italia.com/english/>

Chandah

<http://www.googlelunarprize.org/lunar/teams/chanda>

the cost of government-sponsored robotic missions, M-1 is a relative bargain. The estimate is not farfetched, given that the Ansari X PRIZE winners spent more than two and a half times the amount of the \$10 million prize.

On February 21, 2008, the X PRIZE Foundation and Google announced that nine more teams would be joining Odyssey Moon in the race, among them Team Astrobotic and Team FREDNET. The seven other teams include Aeronautics and Cosmonautics Romanian Association (ARCA), from Romania; Team Italia, from Italy; and Chandah, LunaTrex, Micro-Space, Quantum3 and Southern California Selene Group, who are all based in the United States [see sidebar].

Team Astrobotic, consisting of participants from defense contractor Raytheon, Carnegie Mellon University and several other universities, announced that they would attempt to send their Artemis Lander and Red Rover to the Moon.

Led by William "Red" Whittaker, this team has extensive experience in robotics. Whittaker has referred to the group as "a robotics and aerospace dream team." As director of Carnegie Mellon's Field Robotics Center, Whittaker has overseen such robotics initiatives as searching for meteorites in Antarctica, retrieving gas samples from inside a volcano, and competing in DARPA's Urban Challenge and Grand Challenge competitions for self-driving vehicles. Other projects include Scarab, a rover produced for NASA to test robotic drilling on extraterrestrial surfaces.

Whittaker said he's advocated sending privately financed robotics missions to the Moon for at least a decade. His team hopes to raise money by selling as much as \$75 million in advertising. The team wants to land near the Apollo 11 site on July 20, 2009, 40 years after Armstrong and Aldrin made history at the same location. The team's Web site says, "a modest rover aimed solely at winning the Google Lunar X PRIZE could be launched from the Mid Atlantic Regional Spaceport on a small booster."

David Gump, President of

Transformational Space Corporation and adviser to the Carnegie Mellon participants, is forthright when it comes to the group's intentions. "This is a race, so Carnegie Mellon intends to win it by moving out very quickly. An initial functional model was designed, constructed and put into testing by early January. Our goal is to land a rover with multiple high-definition video cameras near the Apollo 11 site in July 2009."

Gump said the team isn't ready to release more specifics regarding funding yet, but says that the eventual cost for a successful mission will likely be double the prize amount and quite possibly a lot more. Gump believes the launch vehicle is a key factor and he will set weight and size limits on the design of the rover that are absolute. "We have visited launch suppliers around the globe," Gump said. "To determine what's available in the short time frame we need, and at a cost that we can fit into our budget. A decision will be made in the next few months."

The disadvantages of doing such a mission in the private sector, according to Gump, include the need to attract investors, sign up customers, and the possibility that a competitor may be smarter and faster. "In short," he said, "All the joys of impartially ruthless capitalism, which weeds out the big talkers and rewards those who are the most competent."

On the other hand, there are benefits that help counterbalance those points. 'We can make a different assessment of risk vs. reward than a government planner,' Gump pointed out. "There's almost no upside in the government to quick, decisive action; any short-circuiting of normal processes will earn a manager lots of enemies and almost no rewards. Any acceptance of higher risk (from using newer gear that hasn't been used before in space) will be severely criticized if it should fail in operation. The fact that it would have improved the capabilities by 50% or saved 20% of the mission cost is pretty much irrelevant in the government economy. In the



Team Chandah. Illustration Credit: Andrew Collis



Team Astrobotic. Illustration Credit: Andrew Collis the X PRIZE foundation did not give illustrations for Team Italia and Team Quantum3.

private sector we will get rewarded - we can sell more capabilities to more customers and we can get the project rolling with less cash and/or earn a higher return for investors."

You could probably call Team FREDNET the little team that could, or perhaps the team with a difference. As they note at their Web site, they are "the first and only 100% Open Source Competitor for the Google Lunar X PRIZE." In an interview posted at the site, Fred Bourgeois - the Fred in FREDNET - says that as far back as 1984 he was dreaming about constructing his own personal spacecraft and building a city on the Moon.

Bourgeois goes on to say that "Team FREDNET is competing for the Lunar X PRIZE in what some might call a dangerous format. Everything from the system specs to the operational source code will be posted on the project's web site for the world to see. How can Team FREDNET remain competitive when the whole thing is 'out there' for every competitor to copy and use? That remains to be seen, but presumably other competitors will have their own unique ideas and goals, many of which may be incompatible with our solutions."

Team FREDNET has created a prototype of their rover that's about the size of a toaster and the final product may be even smaller. They'll face the same hurdles as the other teams, but are more conservative with their cost estimates. They've mentioned a figure of \$12-15 million for the mission and have discussed circumventing the costly launch phase of

the smaller number."

Bourgeois feels there could be substantial benefits to doing such a mission in the private sector. "We foresee a variety of very profitable off-shoots in the not-so-distant future," he said. "Those would be most difficult to pursue if this were a government project. We have less overhead, more freedom, more creativity, and [being open source] a wider variety of talented and dedicated people to participate in the development."

The X PRIZE Foundation also announced that Space Florida will be the first preferred launch site for the competition. Space Florida will award an additional prize of \$2 million to the Grand Prize winner, if the winning flight is launched from Florida. Space Florida is the principal organization charged with promoting and developing Florida's aerospace industry. Preferred partners taking part in the competition will offer additional prizes or strategic services to teams at a discounted rate.

The Google Lunar X PRIZE isn't currently the only game in town when it comes to competitions designed to spur non-governmental space missions. America's Space Prize, put in motion by entrepreneur Robert Bigelow in 2004, will award \$50 million to the first competitor who can send five people into Earth orbit twice within a 60-day span. The deadline for the contest is January 10, 2010. With all this in mind, it looks like the next few years are shaping up to be an exciting time for privately funded space exploration.

the project by catching a ride on the Space Shuttle or paying for a ride on a Russian missile.

Elaborating on the cost aspect, Bourgeois said that a successful mission could range anywhere from \$10 million to \$1 billion, depending on the approach taken. "If someone wants to deposit an SUV on the Moon, then they are going to spend something closer to the larger number. Our approach should come in somewhat closer to

THE NAVIGATORS:

GUIDING OUR SPACECRAFT TO BEYOND (AND BACK)

*"All I ask is a tall ship and a star to steer her by." –
English poet John Masefield*

Navigating a spacecraft through the heavens has been compared to sailing a ship on the open seas or driving a vehicle on a long, cross country journey. Analogies are necessary, since spacecraft navigation is performed by a relatively small sampling of the human race, and the job usually involves doing things that have never been done before. Those of us who have trouble making sense of a road map here on Earth stand in awe of what these celestial navigators can accomplish.

In simplest terms, spacecraft navigation entails

determining where the spacecraft is and keeping it on course to the desired destination. But it's not as easy as just getting from Point A (Earth) to Point B (a planet or other body in our solar system.) These are not fixed positions in space. Navigators must meet the challenges of calculating the exact speeds and orientations of a rotating Earth, a rotating target destination, as well as a moving spacecraft, while all are simultaneously traveling in their own orbits around the Sun.

Chris Potts, who helped lead the navigation teams

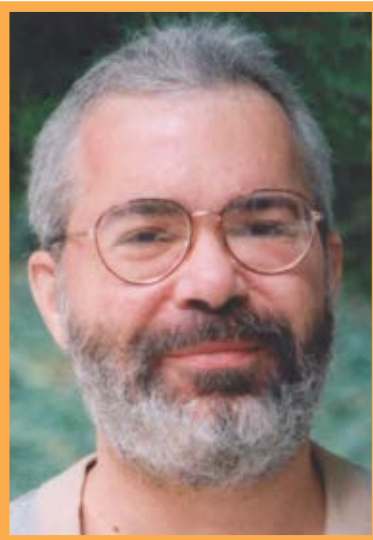
By Nancy Atkinson

for the Mars Exploration Rovers (MER), compared the target requirements of landing the Spirit rover inside a specific crater on Mars to being able to shoot a basketball through a hoop 9000 miles away. "Not only do you have to make the shot perfectly without the ball touching the rim, but the timing has to be perfect, so you make the shot exactly as the buzzer sounds," he said.

Ken Williams was the Navigation Team Chief for the Stardust mission's return of pristine samples of a comet back to Earth. For a successful re-entry and landing at a precise location in Utah, the navigation team had to target the return capsule's entry to a specific point in the Earth's atmosphere to within eight 100ths of a degree, a feat that's been compared to hitting the eye of a sewing needle with a piece of thread from across a room.

Literally, this is rocket science.

Navigation is essential to every robotic mission,



Ken Williams of KinetX, current Navigation Team Chief for the MESSENGER mission to Mercury.

and while mission success hinges on how well the navigation team performs, navigators aren't usually found in the limelight, sitting up on stage for a press conference. Typically that's reserved for the mission scientists and designers. The navigators, seemingly, work behind the scenes, manning the trenches in relative anonymity.

But I recently had the opportunity to talk to a few spacecraft navigators, learning more about their job and discovering the innate qualities of those who guide our spacecraft to places beyond.

Neil Mottinger has been part of numerous missions since he started working at the Jet Propulsion Laboratory in 1967. He assisted with some of the

early lunar and planetary missions, and developed some of the software that navigators still use today.

There are several different sub-disciplines to spacecraft navigation, and one of Mottinger's specialties is orbit determination. "Orbit determination is knowing where the spacecraft is and where it's

The Stardust Mission Navigation Team was presented with Popular Mechanics' Breakthrough Award. Said Team Chief Ken Williams: "The day we took this picture, I felt a strong sense of camaraderie with all these folks after everything had worked so well. They're a very talented group of people who did a tremendous job." FRONT ROW – left to right: Tung-Han You, Ken Williams, Prem Menon. 2nd Row: Roby Wilson, Katherine Nakazono, Julie Kangas. 3RD Row: Daniel Lyons, Ram Ramachand, Bhat Shyam Bhaskaran, Cliff Helfrich, Jeff Tooley, David Jefferson, Dimitri Gerasimatos, Paul Thompson, Neil Mottinger. Last row: Darren Baird, Jae Lee, Chris Potts, Tim McElrath, Brian Kennedy



going,” said Mottinger, who currently works with the Mars Reconnaissance Orbiter (MRO) mission and the upcoming LCROSS (Lunar Crater Observation and Sensing Satellite) mission to the moon. “It starts with predicting the trajectory where the spacecraft will be immediately after launch so that the Deep Space Network (DSN) knows where to point their antenna and on what frequency to expect the signal.” The DSN consists of a network of extremely sensitive deep space communications antennas at three locations: Goldstone, California; Madrid, Spain; and Canberra, Australia. The strategic placement approximately 120 degrees apart on Earth’s surface allows constant observation of spacecraft as the Earth rotates.

Since there’s no GPS in outer space, navigators process the radiometric tracking data received from the DSN to determine the spacecraft’s position and velocity. They also use optical data, where the spacecraft takes a picture of the star background to help refine the spacecraft’s trajectory.

For many years, Mottinger worked with a group that provided navigation support for the launch of over 100 spacecraft. “I never got attached to any one mission since right after a launch we moved on the next mission,” Mottinger said. But now he’s been

with the MRO mission for the better part of three years, and Mottinger is thrilled with the scientific data this mission has returned. “We have to provide accurate predictions of where the spacecraft is going to be. Then the engineers know how to orient spacecraft so that the scientists can make their observations,” he said. “If we do our job, the scientists can see a landslide on Mars or look at specific areas on the planet. If our predictions are wrong, the cameras are pointed in the wrong direction. Navigation is integral to the whole process of ensuring mission success.”

Mottinger said that typically one doesn’t think of navigators as scientists, only as a means to an end for the scientists to get results. However, sometimes scientific by-products come from navigation. The most famous instance involved the Voyager mission when navigator Linda Morabito discovered a volcano on Jupiter’s moon Io from looking at optical navigation images. In the Lunar Orbiter missions, navigators realized there were large concentrations of mass, (now called mascons) underneath the moon’s surface that were accelerating spacecraft in orbit.

Additionally, the science used in navigation has improved dramatically over the years. “When you look at the types of things we didn’t understand when



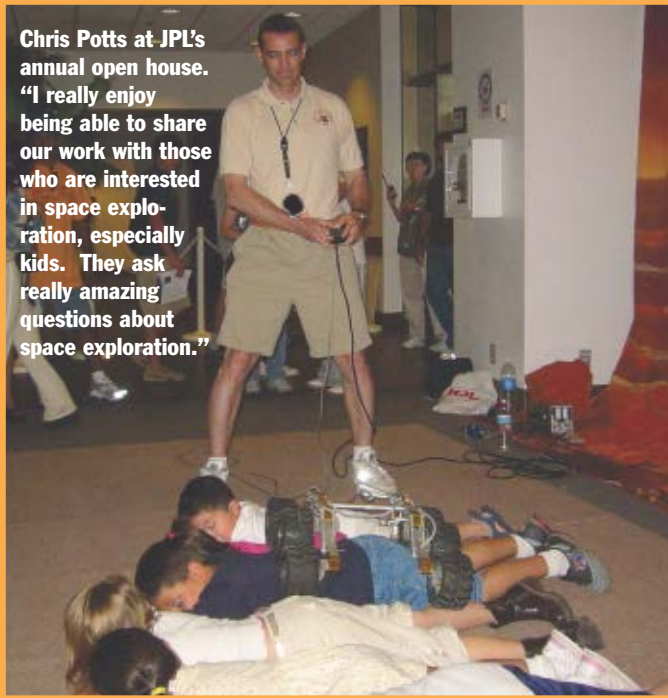
Navigators Chris Potts and Neil Mottinger at JPL with a model of the Mars Exploration Rover.



I first started versus what we know now, it's overwhelming," said Mottinger. For example navigators can now create very accurate models of solar pressure – how particles of sunlight push against a spacecraft and alter its trajectory – which includes not only how sunlight is reflected from different surfaces of the spacecraft, but also the re-radiation of energy absorbed by the solar panels and radiated out the back side. Additionally ephemerides, the tables navigators use to obtain the positions of astronomical objects, have also improved in accuracy over the years. "The devil is in the details," said Mottinger. "Navigation is getting to be an incredibly precise game."

Like many who work at JPL, Mottinger enjoys talking to schools or community groups to share the excitement and recent discoveries of space explo-

Chris Potts at JPL's annual open house. "I really enjoy being able to share our work with those who are interested in space exploration, especially kids. They ask really amazing questions about space exploration."



ration. "It's important to be out there telling our message to get people excited about what we're doing," he said. "And the public is entitled to be excited, because they're paying the bill."

Several years ago Mottinger returned to his hometown of Oswego, Illinois to talk to students about his job as a navigator. Sitting in the classroom was a young Chris Potts, who decided spacecraft navigation was the career he wanted to pursue. Potts, who has been at JPL since

1984, was the Deputy Navigation Team Chief for MER and now works with the Dawn Mission that is en route to orbit two asteroids, Ceres and Vesta.

Potts' specialty is flight path control. This involves firing the propulsion system to alter the spacecraft's velocity or trajectory, known as Trajectory Correction Maneuvers (TCM). "That includes understanding the spacecraft's control capabilities and determining any



The Mars Exploration Rover Spirit snapped this panoramic image of the "West Valley" region in Gusev Crater on Mars. "Husband Hill," the highest point on the horizon is about 800 meters or half a mile away.

limitations,” said Potts. “You determine when you’re going to fire the propulsion system, how often and the objective of each maneuver. You also have to evaluate the delivery requirements, to make sure you can land within a crater on Mars, for example, and minimize risk along the way.”

The design aspect is Potts’ favorite part of the job. “You try to develop a strategy that puts all the pieces together,” he said. “You have to talk with the mission scientists and understand what their requirements are, and then know what the spacecraft can do. It’s like people who have an old car and they’ve been around it so long, they know how to get the most out of that vehicle. Taking advantage of what the spacecraft does well and working around its limitations

change and you’re always designing trajectories and changing commands to make sure the ion engine is firing in the right direction. If there’s any kind of spacecraft fault or hiccup along the way, you have to scramble, and some future events might have to be moved around.” Dawn will arrive at Vesta in 2011.

Potts enjoys being part of the excitement of all the different missions at JPL. “I really enjoy working with some extremely intelligent and talented people here and you can definitely sense the passion for the work that they do,” he said. “Sometimes that can be intimidating, but you realize that everyone has their own talent to offer, and everyone helps drive you to do your best here. We get to do a variety of interesting work, and it’s very challenging. No two days are the same.”



Chris Potts points to Gusev Crater on Mars on January 4, 2004, after the MER navigation team landed the Spirit rover on Mars with unprecedented accuracy.

One of the rewards of his job, Potts said, is seeing the fruition of his work come to light in scientific discoveries. “With the Stardust sample return, to watch the capsule land right where it was supposed to in Utah was very rewarding,” he said. “And to see the scientists get their hands on that data and start to perform their investigations, you sense how thrilled and excited they are to finally get to work

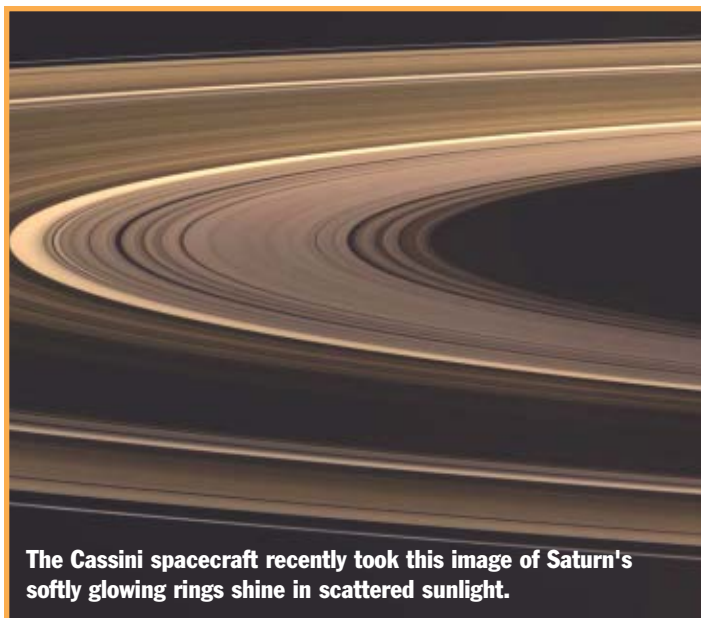
feeds into the design of a strategy that pulls it all together to make it work.”

Much of Potts’ work involves simulations and testing. “We see how the spacecraft behaves, and try out different strategies to improve it for our situation,” he said. “The navigation section has a whole ‘toolbox’ of software that we’re able to use.”

The Dawn spacecraft uses an ion engine, and this is the first time Potts has worked with a low thrust propulsion system. “It’s quite a different mission,” he said. “The concerns are little bit different than other missions because the thrust is so efficient. One of the things you worry about is not having enough time to make any corrections that are needed. Although the thrust is low, over time it builds up quite a velocity

on their lifelong ambition.”

Potts and Mottinger both worked on the Stardust mission under the leadership of Ken Williams. Williams worked at JPL for several years, but currently is employed by KinetX, a private engineering firm specializing in aerospace technology and software development. At present, KinetX provides navigation support for the New Horizons mission to Pluto, as well as the MESSENGER (Mercury Surface Space Environment Geochemistry and Ranging) mission to Mercury, and Williams is MESSENGER’s navigation team chief. Unlike Mottinger and Potts, Williams hasn’t always been involved in space missions and his career in navigation evolved from a background in physics. He worked at the Applied Physics Lab at Johns Hopkins University before coming to work at



The Cassini spacecraft recently took this image of Saturn's softly glowing rings shine in scattered sunlight.

JPL in 1994.

Williams' favorite part of being a navigator is finding and solving interesting technical problems. "That's what gets my interest," he said. "MESSENGER certainly has a number of those. We flew by Earth once, Venus twice and Mercury once. We'll have to fly by Mercury two more times before we finally go into orbit on the fourth encounter. Finding a trajectory that does all those things successfully is a very interesting technical problem that I'm very glad to be involved with. We have to consider all sorts of constraints, too, such as keeping the spacecraft pointed away from the sun so that the components don't get too warm."

As a Navigation Team Chief, Williams coordinates all the sub-disciplines of orbit determination, flight path control, and optical navigation along with the needs of mission scientists in terms of observations when they encounter a planet or comet.

Williams, too, enjoys the exhilaration of being in the thick of the action in important space missions. "I suppose it's like being in a battle, or in a basketball or football game," he said. "You feel the excitement of seeing events unfold, and responding to any anomalies or surprises that come up. And when it's all done you have a tremendous sense of satisfaction."

His experiences with Stardust's return to Earth stand out as a highlight. "Getting all that effort coordinated and getting the spacecraft down successfully was probably the single most rewarding experience in all the time I was at JPL," he said. "On nearly every mission I've worked on there has been a time where you have a sense of euphoria about having the space-

craft be in the right place at the right time. That's a good feeling to have."

Although leaving JPL was a difficult decision, Williams enjoys his experiences at a private company. "It would have been easy to stay at JPL and be what they call a 'greybeard' in terms of having experience, but after Stardust, I liked the challenge of leading a navigation team and growing in technical areas," he said. "I thought there would be a better opportunity to do that with a small team in a small company, and I thought KinetX was a good place to accomplish that."

Quite the opposite of a 'greybeard' is navigator Emily Gist. She has been at JPL for only 3 years and is part of the navigation team for the Cassini mission at Saturn. Like Potts, she works in flight path control, helping to plan the trajectory and estimate the future position of the spacecraft, and to control the corrections required to achieve the mission objectives.

She takes great satisfaction knowing she is helping to facilitate exploration. "The Saturnian system is more beautiful than most would have imagined and more diverse than previously known," she said. "The information Cassini has provided has enlightened us all. More specifically I love how much I learn each and every day at JPL and working on the Cassini Mission."

As part of the 'next generation' of navigators, Gist enjoys the challenging environment that JPL provides. "We had an Operations Readiness Test on Cassini where the team was tested to see how we would react to a failure or fault on the spacecraft in an operational environment," she said. "The senior engineers weren't in play so the newer generation had to figure it out on our own and we did an excellent job. It made me proud of all the folks I work with. They are truly talented people."

Gist said gender has never been an issue in her job as a navigator. "JPL has a wonderfully diverse staff and while there are not very many female navigators we are not treated differently," she said. "I am pretty biased, but I think what we lack in quantity we make up for in quality. I work with some amazing women."

"Additionally, I feel fortunate to live in a time and society where regardless of gender one can find the thing they want to do and do it to the best of their ability. I love being an engineer and what I try to convey to young women is that they can love anything they want, even if it's math and science, without fear that it's a less feminine job."

The hardest question for all the navigators to answer was if they had a least favorite part of the job.

They cited the usual problems with any job: not enough time and too much paperwork. And stress comes with the job. "Deadlines, especially working at JPL, are very real," said Potts. "If you're not prepared for a critical event in the mission, you usually don't get a second chance. There's a lot riding on getting your job done properly."

But all the navigators emphasized the importance of the team aspect in their job. "You look for the inherent quality of the team," said Mottinger. "I had a project manager who said that a team catches each other's mistakes and the whole is greater than the sum of the parts. Everything is done in a spirit of camaraderie, and there's no such thing as a stupid question."

But seeking individual limelight just doesn't seem to be in a navigator's makeup.

"I'm more comfortable working behind the scenes than doing an interview," said Potts. "When I know I've done my job, and contributed to the mission success, that's enough for me."

"I am fine with my work being behind the scenes," added Gist. "However when I consider the work the

engineers before me and around me have done I sometimes feel they should get more recognition."

Williams feels, in general, the field of navigation itself should get more recognition. "I think scientists and people who do purely hardware systems underestimate the difficulty of what navigators have to do," he said. "It would be nice if we got more recognition from our peers just from the standpoint of being able to influence how missions are planned and designed to begin with so that navigation issues can be addressed before launch and not only left for us to deal with after launch. I feel more strongly about that than any recognition of my own accomplishments."

Williams said that what navigators do is more of an art form. "It's not reducible to a set of algorithms that can be stored on board a flight system like power or propulsion, for example. It's constant refining."

And are navigators bothered by the sometimes long and odd hours their job requires? "No," said Mottinger, "I wouldn't trade it for anything. There's nothing else like it."



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Commercial Space Challenges Facing a New American Administration in 2009

By Eligar Sadeh

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The economic prosperity and national security of the U.S. depend on commercial space assets. These assets provide for transfers of information, which enable economic transactions across the globe underpinning globalization. Commercial space assets allow for space launch, telecommunication, and remote sensing activities. These functions are critical for the U.S. economic infrastructure and essential for more effective warfighting. It is important that a new American Administration and Congress will develop as part of their economic policies a robust commercial space sector. The key issue is how to move forward into a "new" space age driven by space commercial activity. This presents a number of policy challenges.

Since the rise of the space age in the 1950s, the U.S. government sought the development of a commercial space sector. This led to the use of governmental subsidies of one form or another to foster commercial space. One policy challenge is to determine the "best" role for government. There is a regulatory role in ensuring safe and reliable commercial space activities, such as those directed at space launch and remote sensing. The model of development for commercial space travel that is emerging is akin to the development of the aviation industry. The policy challenge is to find the right way forward that strikes an appropriate balance between the need to regulate and the desire to create a political environment that encourages future commercial space development.

There are a number of policy options when thinking about the "right ways forward." The predominance of the U.S. government as a user of space creates economic opportunities in the form of lucrative, cost plus contracts that support a robust space industrial sector. These contracts are leveraged to transfer technology and know-how acquired in developing U.S. government space systems to commercial space systems and activities. This is the "tradition-

al" way forward. A more cost-effective contractual relationship will emerge in shifting contracts away from cost-plus to fixed price and reward based.

Further consideration needs to be given to other, non-contracting ways. One way involves tax based incentives. A number of legislative initiatives in Congress, e.g., Space Tourism Promotion Act, Zero Gravity Zero Tax Bill, Invest in Space Now Act, and the Spaceport Equality Act, have advocated this approach, although these initiatives have not become public law. Prizes for technology development are another way forward. Entrepreneurial or "new" space has advanced due to the Ansari X-Prize and the hope is that same movement forward will take place with the Google Lunar X Prize. There is Congressional support to fund prizes, such as DARPA's (Defense Advanced Research Projects Agency) Grand Challenge and NASA's Centennial Challenges. Acting to establish public law aimed at tax incentives and the continued and expanded use of prizes are productive ways forward for commercial space.

A third way forward lies in public-private partnerships. These partnerships need to be directed toward developing "disruptive" technologies that could dramatically change the space commerce paradigm. "Experimentation" in space, in areas like operationally responsive space launch, smallsats, and partnerships with both private space companies and non-space companies, is crucial. DARPA contracting with new space companies to develop disruptive technologies is one example. NASA is implementing

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partnerships with the private sector, e.g., NASA COTS (Commercial Orbital Transportation Services), Space Act Agreements with new space companies, and non-space partnerships with Google, Microsoft, Sun, and biotech firms. All this should be supported by a new Administration.

Further expansion of public-private partnerships paves the way for space infrastructural development. A new Administration and Congress need to direct such partnerships to enable development in emerging space businesses and efforts in areas like space tourism, reusable launch capability, and developing areas such as space based solar power, space based zero-gravity manufacturing research, propellant depots, point-to-point sub-orbital travel, and information technology repositories in space. These technologies, if developed, will be huge contributors to the long-term prosperity and success of the U.S. and global economy in the future. They will also provide motivation for the youth to pursue higher education in sectors that have been waning in recent years, and provide them with exciting employment opportunities.

A second policy challenge is to address the barriers to commercial space development. There are three barriers that must be addressed: (1) evolving legal regimes to address space commercial development; (2) reforming export control policies and laws; and (3) prioritizing educational efforts and workforce development.

It is necessary to clarify international space treaties and laws, which prevent or inhibit commercial exploitation of space resources. Property rights need to be extended beyond Earth to cover resources harvested in the future from the Moon or asteroids. For the U.S. and other spacefaring nations, bringing space into the global economic sphere of influence hinges on shifting the thinking in international space law from space resources as a collective or common good to resources as a private good.

A new Administration and Congress must place the government as an enabler of commercial and private space activities. The government should be a customer of commercial space services and try to keep a hands-off, noninterference attitude unless and until regulations for safety reasons are necessary. Any regulations need to consider the stage of the industry and its potential for growth. The U.S. government should act on behalf of these industries to cre-

ate and ensure an open, free-market environment in global space commerce.

The space environment is another key issue that affects space commerce. There is a mission cost to mitigate environmental dangers, like orbital debris proliferation. Also, there are issues related to scarcity of resources and their efficient use, such as spectrum allocations. International standards are a key towards addressing many of the space environmental issues and challenges, and also necessary for space businesses to exercise due diligence in their safety and liability concerns and legal obligations. Space traffic management is another issue that requires attention as there is currently no U.S. government policy or any set of "rules of the road." This is of growing concern as space is more crowded with more commercial (and governmental) players.

Better governance of space depends on the ways space situational awareness data is shared between governments and commercial entities. The current U.S. approach to data sharing is the CFE (Commercial and Foreign Entities) program. An advance phase of this, CFE II, is now being implemented. This is all positive for commercial space, yet moving this in the direction of integrated data architectures is still needed to move from a CFE "on a need to know basis" policy approach with limited transparency, to more full and open transparency, at least for commercial (and civil) space assets.

There is a strong case to be made that space is in the national security interest, but a much weaker case is to be made that space is in the national economic interest. In the U.S., national security tends to trump commercial space concerns leading to policies and laws, like export control, that undermine space commercial development. This approach needs to change, i.e., space is in the U.S. national economic interest, and national security interests should not override economic interests.

The current approach to export control of commercial space, namely ITAR (International Traffic in Arms Regulations), is obtrusive, broken, and obsolete. ITAR has prevented international partnerships in commercial space, or made them exceedingly more difficult and bureaucratic to implement. It has dramatically reduced U.S. domestic manufacturing capabilities for vital space-related hardware and components. The great irony is that ITAR, in stark contrast

to its intended goal of retaining domestic preeminence in the aerospace and defense fields, is having exactly the opposite effect. ITAR is not only harmful to commercial space, but it also damages national security by placing legal and bureaucratic restrictions on the U.S. military use of commercial space assets that rely on a robust satellite industry and space industrial base. America's leadership in commercial space capabilities has eroded, while Russian, European, and Asian entities have expanded and deepened their growing dominance. The U.S. has fallen behind in the global space commerce competition due in no small part to its counterproductive export control regime.

A new Administration must address this export control issue at the level of policy by reforming the "rule set" for how ITAR is applied. The current Presidential Directive on export control reform is a start. But, much more needs to be done. This encompasses a reassessment of what technologies need to be controlled, and dealing with issues of timing, review processes, transparency, and cost. A new Congress needs to take on the issue by updating export control laws to better match 21st century global space commerce. This starts with reforming the current approach to ITAR by moving jurisdiction on all dual-use commercial space technologies from

the Department of State to the Department of Commerce, to legislating new export control laws that update and replace the antiquated "Cold War" legislation that is still in place, e.g., Arms Export Control Act and Export Administration Act.

Education and workforce issues are critical for space commerce development and foundational for anything the U.S. wants to do in space. Where will space commerce get the next generation technical workforce? High-percentages, more than 50% in some cases, of STEM (Science, Technology, Engineering, and Math disciplines) graduate students in U.S. universities and colleges are foreign nationals. Unless the U.S. desires to establish a policy that depends on foreign nationals as a future workforce solution, there is a need to emphasize a national commitment to STEM education at all levels. A fruitful model to examine is that of the National Defense Education Act of 1958 that led to STEM educational reforms and fostered education in these foundational disciplines for space. Another option is to focus on addressing global infrastructural challenges, like alternative energy production from space, i.e., space based solar power, as a national goal. A challenge of this magnitude can then motivate and inspire STEM education, as the Apollo program did in the 1960s.





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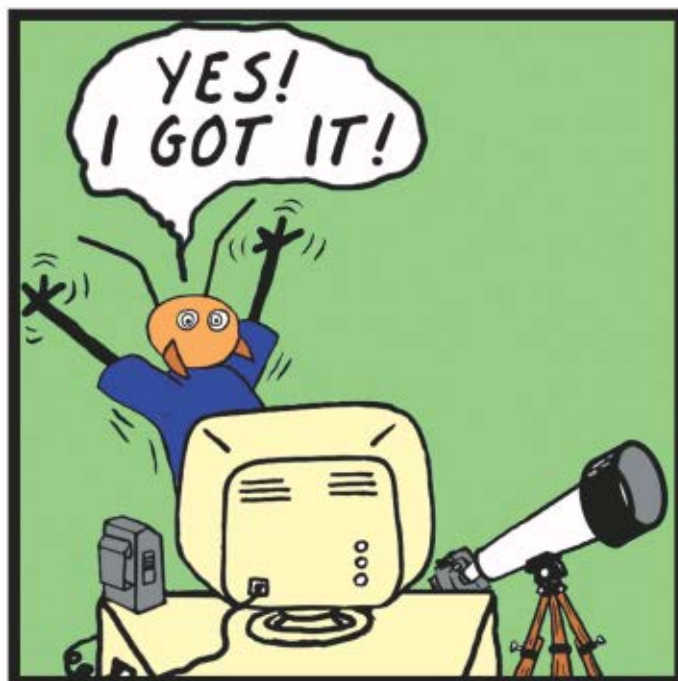
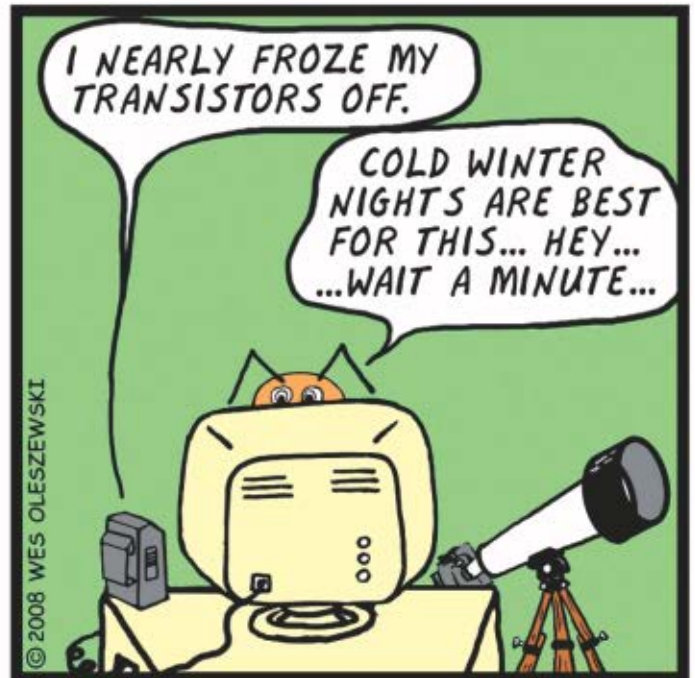
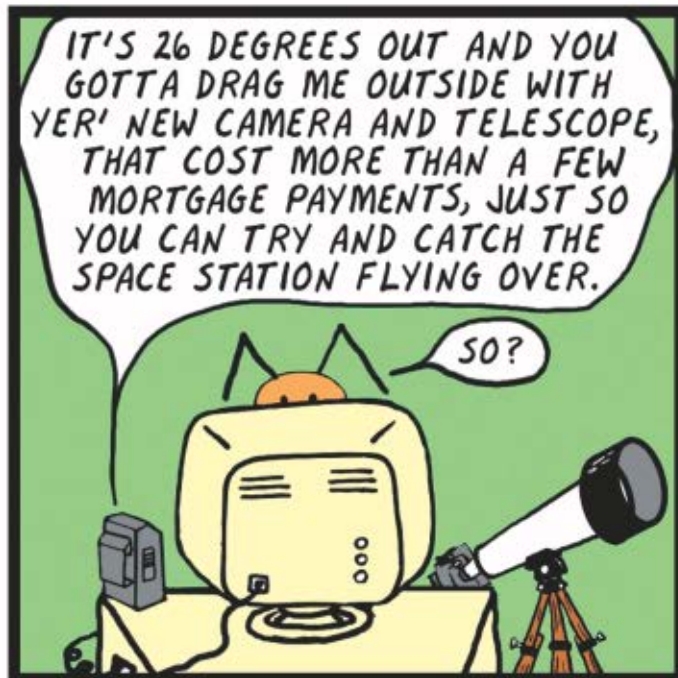


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Klyde Morris by Wes Oleszewski



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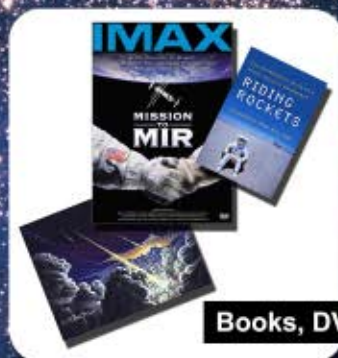
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