

# Space Lifestyle

M A G A Z I N E

Bigger and Better  
Yuri's Night  
2008

The Mounting  
Problem of  
Space Debris

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Summer 2008

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# CONTENTS

SUMMER 2008 • ISSUE 3 NO. 1



## Features

25

### ISCD Report

The future of space development was a hot topic in Washington DC this summer at the International Space Development Conference.

26

### Evolution of the Spacesuit

Spacesuits have come a long way, baby, from the early days of space flight. While not exactly a fashion statement, spacesuits are the must-have accessory for any astronaut.

35

### Yuri's Night 2008

Everyone loves a party! Here, SLM spans the globe, detailing the revelers of Yuri's Night 2008. Find out how the rest of the world celebrated, and who knows, you just might recognize someone in the plethora of pictures included.

50

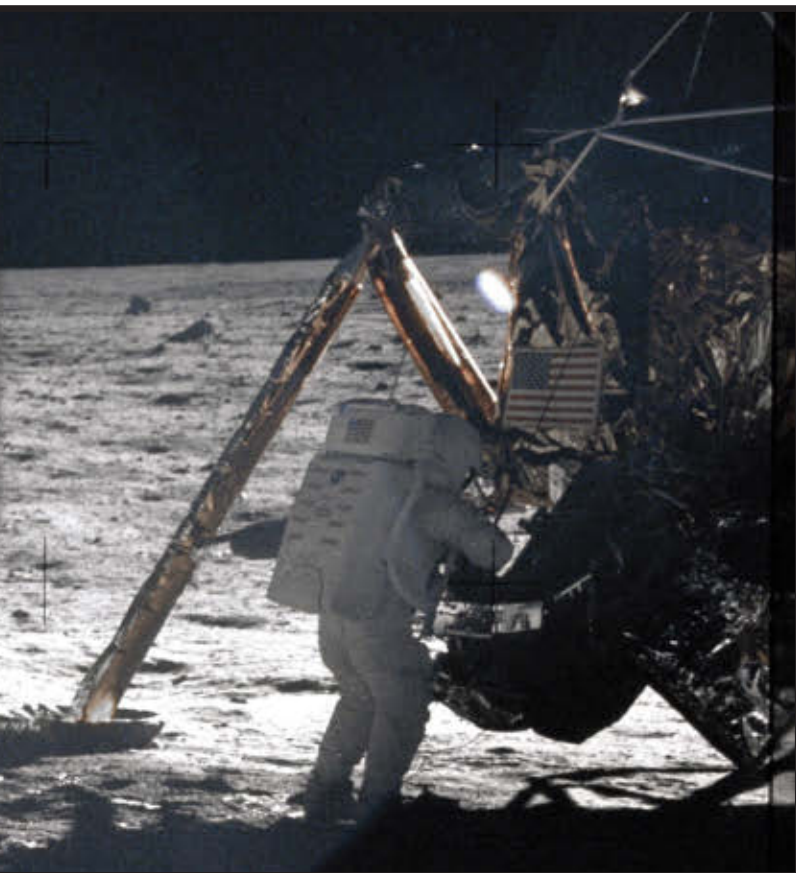
### Destination: Space

Looking for the ultimate in getting away from it all? Maybe a space hotel would fit the bill. Find out what accommodations and amenities would be included, and when the first hotels in space might be ready for customers. It could be sooner than you think.



# Space Lifestyle

M A G A Z I N E



## Departments

- 6 Editor's Letter
- 8 New and Notable
- 19 New and Notable
- 48 Book Review
- 72 Op Editorial
- 77 Flip Side
- 78 BackPage

## About the Cover



Taken by professional photographer Lance Thorn during a late evening in the fall, a full moon and the sky of downtown Grand Forks, North Dakota are vibrantly illuminated. A few contrails cross the sky from passing jets. The photo was taken with a Nikon D70 at 200 iso, with a 3.5 aperture and 6-second shutter speed. More information on the photographer can be found at <http://www.lancethorn.com/>

## 56 XCOR Aerospace

Slow and steady might win the race for XCOR Aerospace, vying to capture a share of the space tourism market. Lower prices and the best seat in the cockpit might be just what space travelers are looking for.

## 64 Space Junk

50 years of spaceflight has produced spectacular discoveries and leaps in technology. But someone forgot to take out the trash. Space debris has gone beyond



## editor's letter

### Welcome to the fourth issue of Space Lifestyle Magazine!

While I've written hundreds of articles on space exploration and astronomy, my latest assignment has left me with writer's block and a sense of trepidation. The assignment? My first editor's letter for Space Lifestyle Magazine! Where do I begin and what do I hope to convey to our readers?

First of all, I want to thank our publisher David Bullock for trusting me with this opportunity. David has been alongside almost every decision, supporting my instincts and offering astute advice. He's a forward-thinking entrepreneur with a great vision.

Then, a big thank you to our staff who have been great to work with. Returning writers Michael Ricciardi, Eligar Sadeh and David Bullock continue their solid and intriguing contributions, and I'm sure you'll enjoy the fascinating articles from our new writers Katie Kline and Talia Page. Original SLM videos are available and have been edited by Eric Power of Austin, TX. Besides being in this digital edition, the videos and any upcoming ones can be found on our YouTube page. Our cartoonists Wes Oleszewski and TJ Sullivan continue to provide a little dose of humor, and I'm sure you'll agree that Michael Delia's layouts are works of art.

But most of all, thank you to our readers for supporting this publication by sharing your thoughts about SLM with us, and by spreading the word to others about our online magazine. As some of you have said, this is a truly unique publication in the space media world, as it's completely digital, while having the look and feel of a full-color printed magazine. And in these days of energy woes and concern about the environment, this totally "green," zero-carbon-footprint publication is surely the wave of the future.

The future. Isn't that what space is all about? Come join us on the adventure!

Best always,

Nancy Atkinson

Editor-in-Chief  
*Space Lifestyle Magazine*

## Space Lifestyle

M A G A Z I N E

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(ISSN 1939-411X) issue 4, Space Lifestyle magazine is published quarterly by New Forks, LLC 11115 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](mailto:spacelifestyle@newforks.net)



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# GLAST Blasts Off



**O**n June 11, NASA launched the Gamma-ray Large Area Space Telescope (GLAST) on board a Delta II rocket to begin its orbit around the Earth. Already the satellite has begun to relay information about subatomic particles and gamma-ray radiation to its two remote science centers (the Stanford Linear Accelerator Center and the Goddard Space Flight Center) bringing scientists closer to discovering new laws of physics. Visit the official NASA GLAST website at <http://glast.gsfc.nasa.gov/>.

## Glant launches

**Credit:** Carleton Bailie for United Launch Alliance (from NASA site: [http://www.nasa.gov/mission\\_pages/GLAST/main/index.html](http://www.nasa.gov/mission_pages/GLAST/main/index.html))

# Satellite to Monitor Ocean Levels, Global Climate Change

**T**he Ocean Surface Topography Mission/Jason 2 satellite launched in June to monitor our planet's oceans. The results of ocean topography and currents, and levels of the sun's energy stored by the Earth's oceans will shed light on global climate change and general weather forecasting. This is joint mission between the United States and France. For webcasts, videos and animations explaining the mission, visit [http://www.nasa.gov/mission\\_pages/ostm/main/index.html](http://www.nasa.gov/mission_pages/ostm/main/index.html).



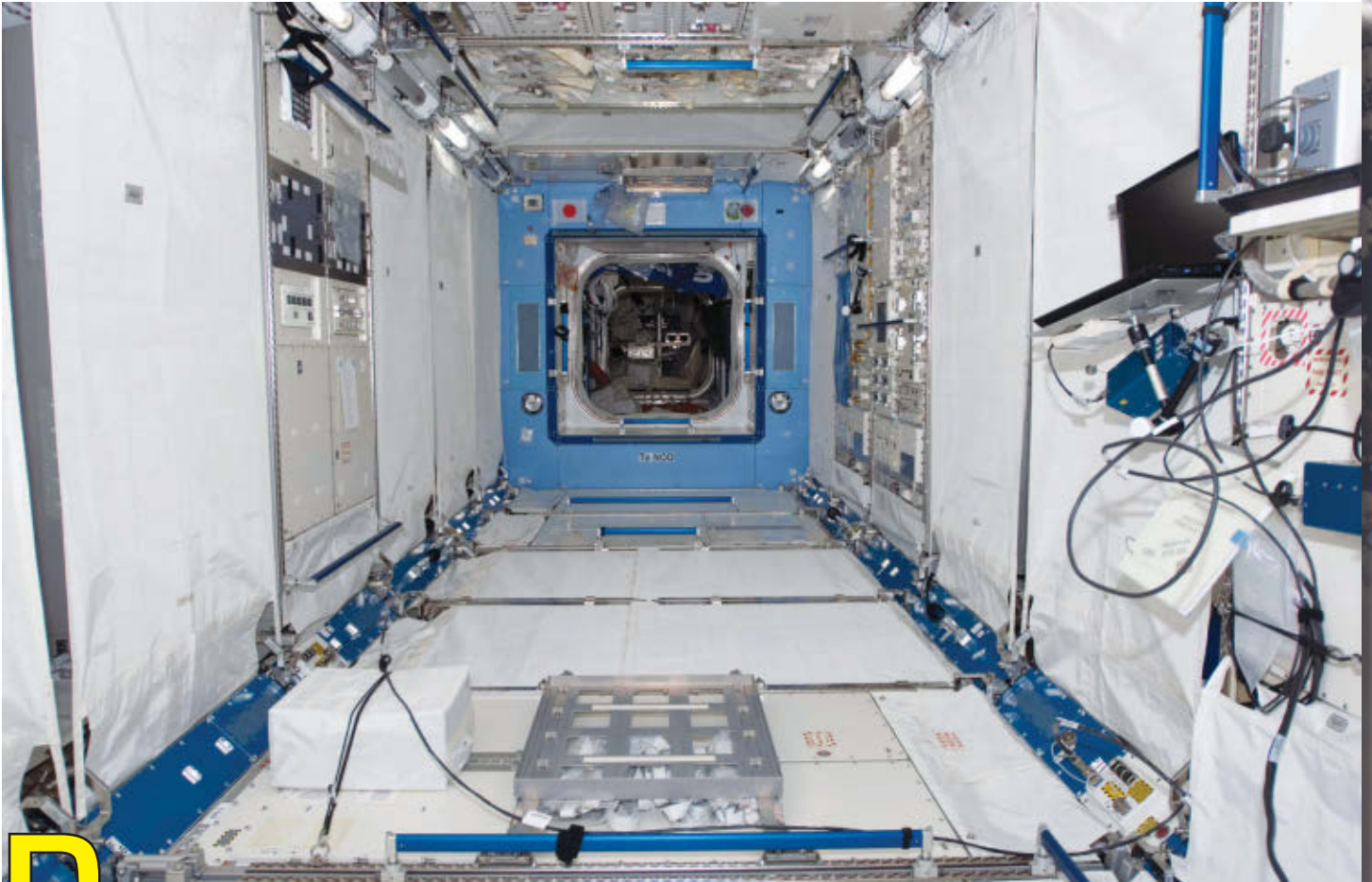
**Artist's rendering of  
OSTM/Jason 2 in space**

**Credit:  
NASA/JPL-Caltech**



# Discovery Delivers Japan

Kibo Interior Photo credits: NASA



**D**iscovery's record-setting STS-124 mission brought the main component of Japan's \$1 billion Kibo Laboratory to the International Space Station in June. It is the second of three total flights to attach the largest addition of ISS to date; Endeavour delivered the first section in March and the final section will be added in 2009. The crew, who also installed a replacement part for the ISS toilet, returned safely from their 14-day flight on June 14. Visit <http://www.spaceflight.nasa.gov/gallery/images/shuttle/sts-124/ndxpage1.html>, for a photo gallery of the STS-124 Shuttle Mission.

# ese Contribution to ISS

Discovery





**new & notable**

C

# MESSENGER Reveals Source

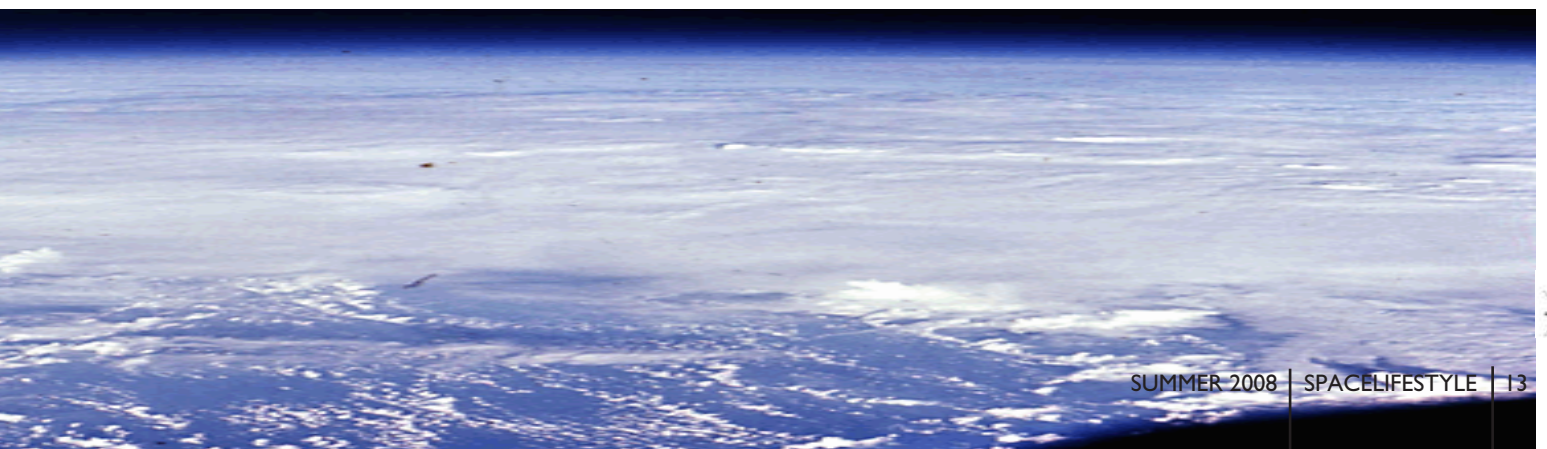


# Composition of Mercury's Composition

**D**ata from the Mercury Surface, Space Environment, Geochemistry and Ranging (MESSENGER) mission's flyby of Mercury in January 2008 helped scientists determine that Mercury's plains were created by volcanic activity, and the planet's puzzling magnetic field originates from its super-dense core. The findings were detailed in a series of papers published in the July issue of Science. MESSENGER also made the first ever observations of ionized particles found in Mercury's exosphere, a thin outer atmosphere. For the latest news on the upcoming orbital study in 2011, visit [http://messenger.jhuapl.edu/news\\_room/telecon4.html](http://messenger.jhuapl.edu/news_room/telecon4.html).

Colorized Mercury photo

Credit: NASA/JHUAP/Arizona State University



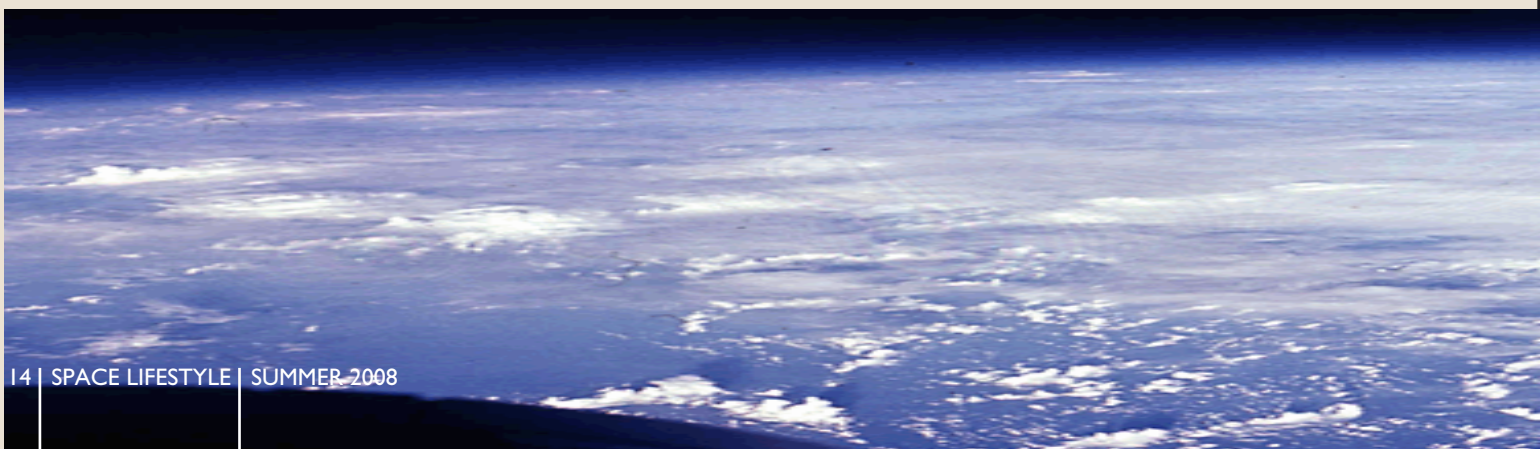




**A**fter completing a four-year primary mission exploring Saturn and its system of rings and moons, the Cassini spacecraft embarks on an extended mission, focusing on the moons Titan and Enceladus, investigating their potential for habitability. The new mission, named the Cassini Equinox Mission, will, among other things, record the Saturn equinox in August 2009 when sunlight passes directly through the plane of Saturn's rings. For more information on the Cassini Mission, visit <http://www.nasa.gov/cassini>.

**Cassini's Perspective on Saturn.**  
Image credit: NASA/JPL/Space Science Institute

## **Cassini Switches Gears to Focus on Saturn's Moons**



# Falcon 1 Launch Dress Rehearsal; Solar Sail to be Part of Payload

**S**pace Exploration Technologies (SpaceX) conducted a launch pad test firing of its Falcon 1 rocket on June 25th. All systems operated at full power, with only the hold-down system restraining the rocket from flight. Falcon 1 is scheduled to launch sometime between late July and early September and will carry a satellite for the US Department of Defense and secondary payloads including a solar sail developed by NASA, the NanoSail-D. Made of aluminum and plastic, and weighing in at less than ten pounds, the sail will harness the sun's energy and engineers will test the sail's orbital maneuvering capabilities. For information on all of SpaceX's endeavors, visit <http://spacex.com>.

For more information on NanoSail-D visit: [http://science.nasa.gov/headlines/y2008/26jun\\_nanosaild.htm](http://science.nasa.gov/headlines/y2008/26jun_nanosaild.htm).

**Falcon 1 on launch pad on Omelek Island**  
**Credit:SpaceX**

**NanoSail-D fully deployed. Image credit: NASA**





**new & notable**

## Trio of Super-Earths Discovered

**T**hree relatively small exoplanets were discovered orbiting the star HD 40307, 42 light-years from Earth. The planets, having 4.2, 6.7, and 9.4 times the mass of the Earth, orbit the star with periods of 4.3, 9.6, and 20.4 days, respectively. Using the High Accuracy Radial Velocity Planetary Searcher (HARPS) at the European Organisation for Astronomical Research in the Southern Hemisphere (ESO) La Silla Observatory, astronomers have found a total of 45 potentially Earth-like planets. Calculations from the sample of stars studied at this facility implies that one solar-like star out of three harbors planets with masses below 30 Earth masses and an orbital period shorter than 50 days. For the latest research on extra-solar super-earths, visit <http://www.sciences.univ-nantes.fr/geol/SuperEarths2008/>

**Artist's rendition of trio**  
**Credit: ESO**

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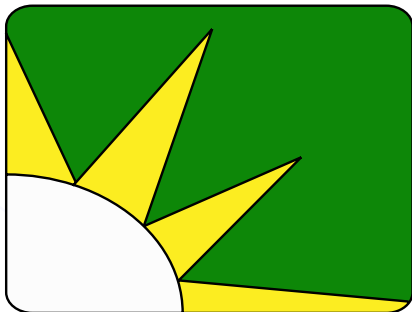
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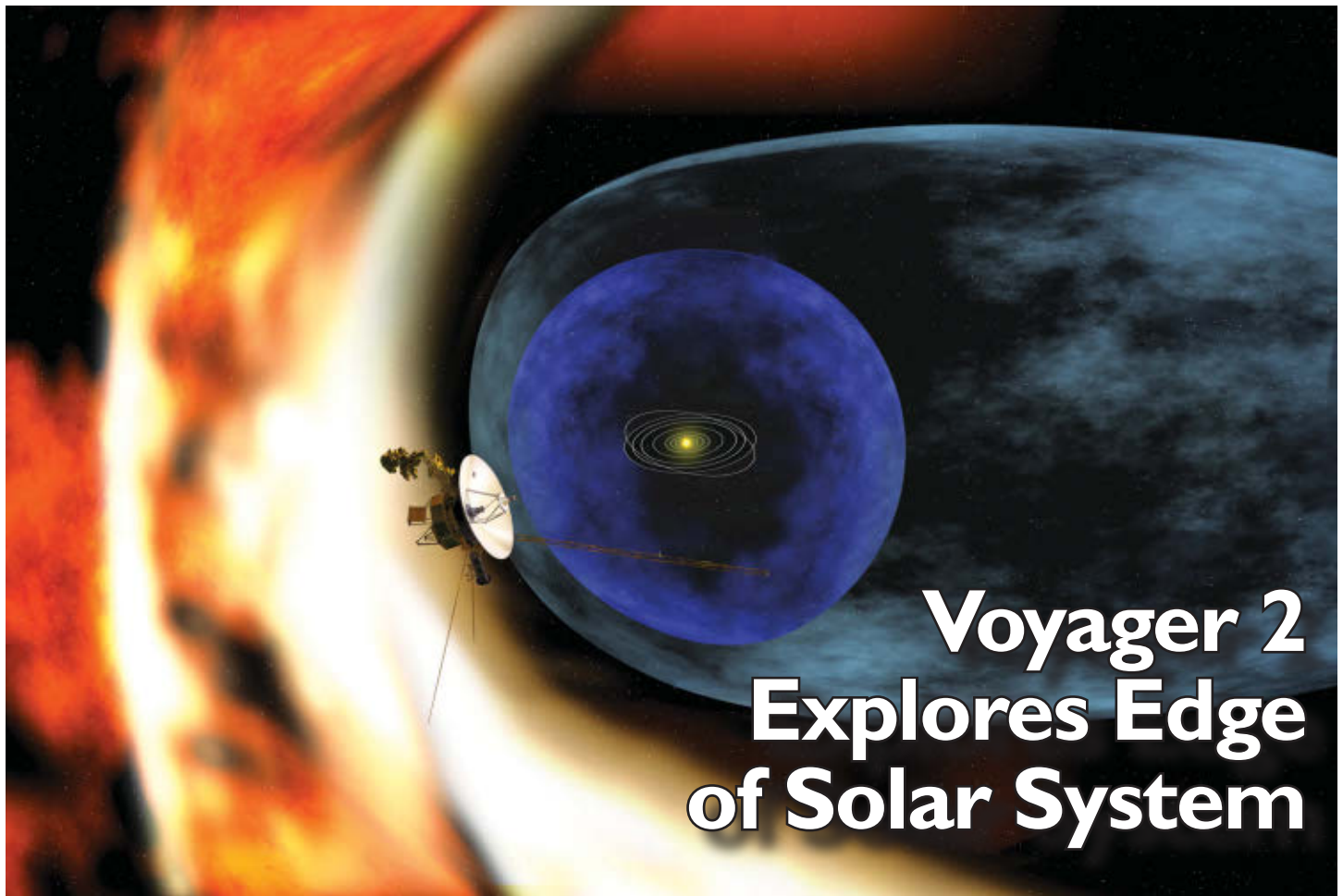
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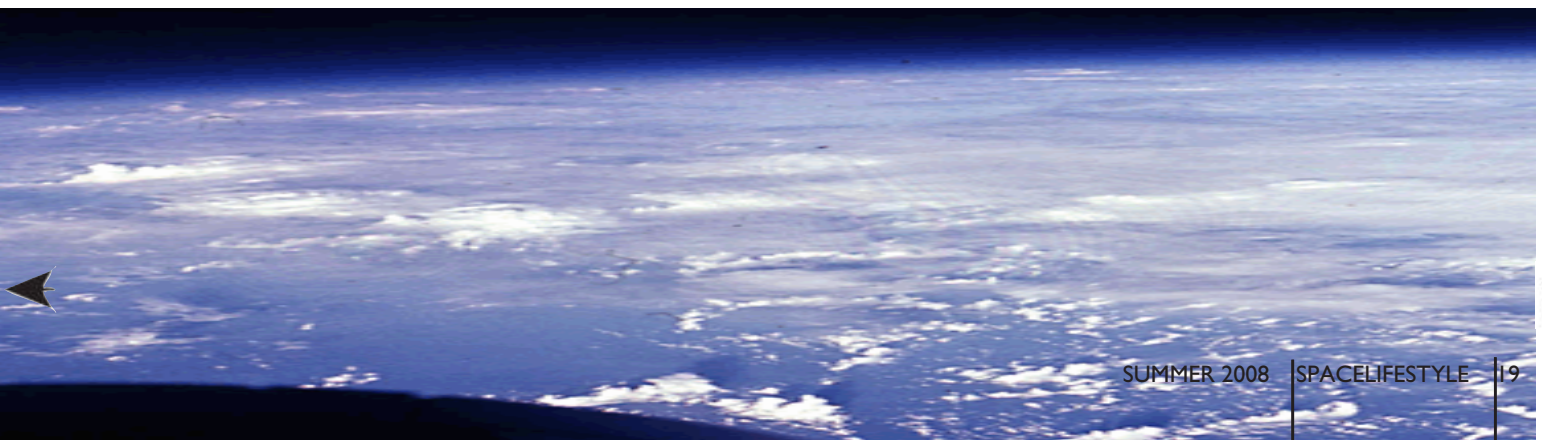
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**T**he two Voyager spacecraft continue on their journeys, and recently Voyager 2 sent back data on the edge of the solar system, known as the heliosphere. The spacecraft confirmed this “bubble” of solar wind is, in fact, egg-shaped. At 7 billion miles from the sun, Voyager 2 reached the southern edge some four years after Voyager 1 recorded data at the northern edge. Comparing data from both spacecraft allowed astronomers to confirm the shape, and it showed the southern end of the solar system is pressed inward. For thirty years of Voyager history, visit <http://voyager.jpl.nasa.gov/mission/mission.html>.

**Artist's rendering of Voyager 2 at the southern end of solar system**  
**Credit: NASA**

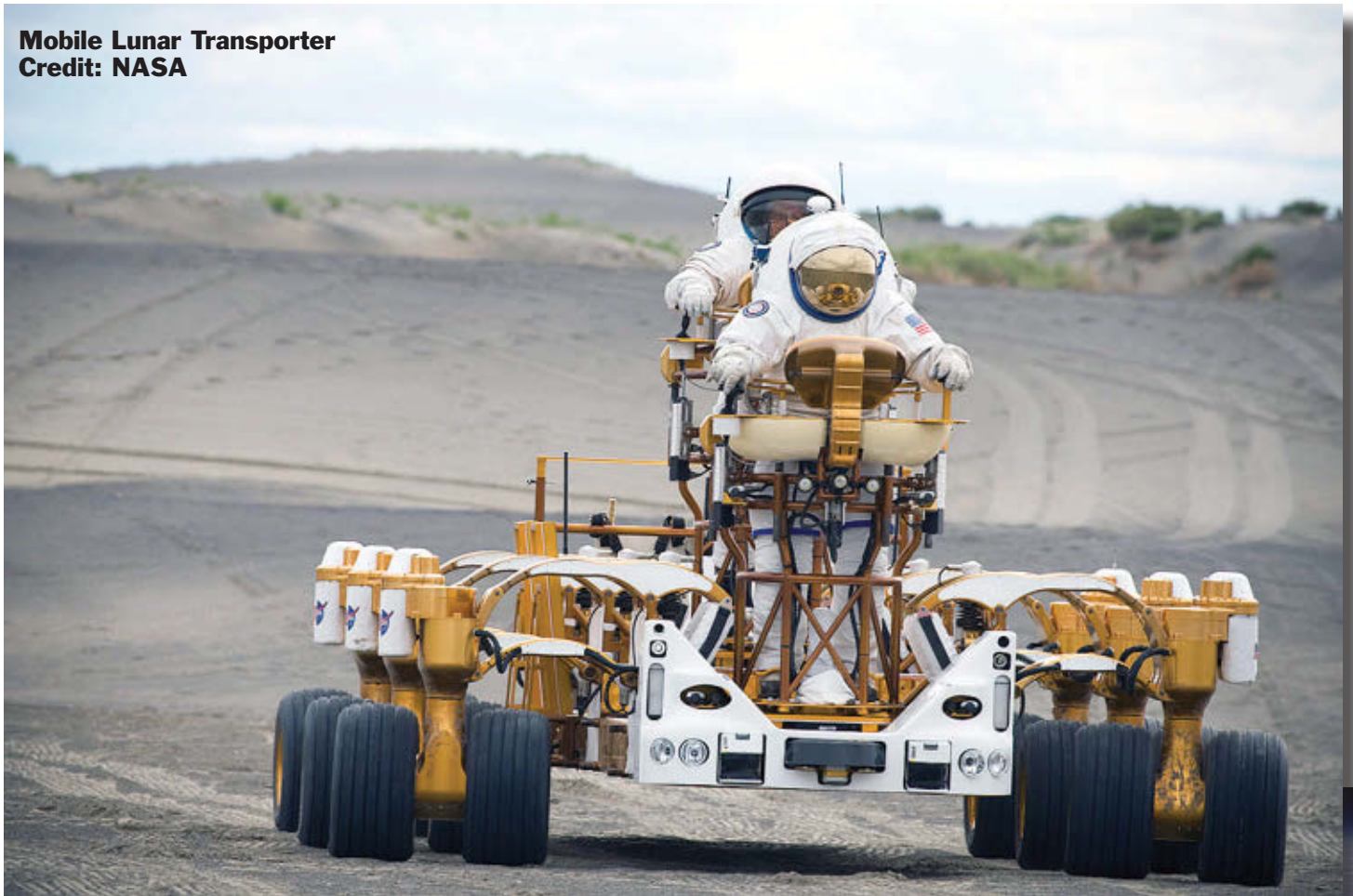




# Astronauts Test Lunar Vehicles

**N**ASA tested prototypes of rovers, robots, cranes and other lunar vehicles in the rough, dusty terrain of Lake Moses, Washington this summer. Fully-suited astronauts drilled, drove, delivered, bulldozed and walked through the many field tests in preparation for an eventual lunar outpost. For more images and greater detail of the vehicles, visit <http://www.universetoday.com/2008/06/17/new-lunar-prototype-vehicles-tested-gallery/>.

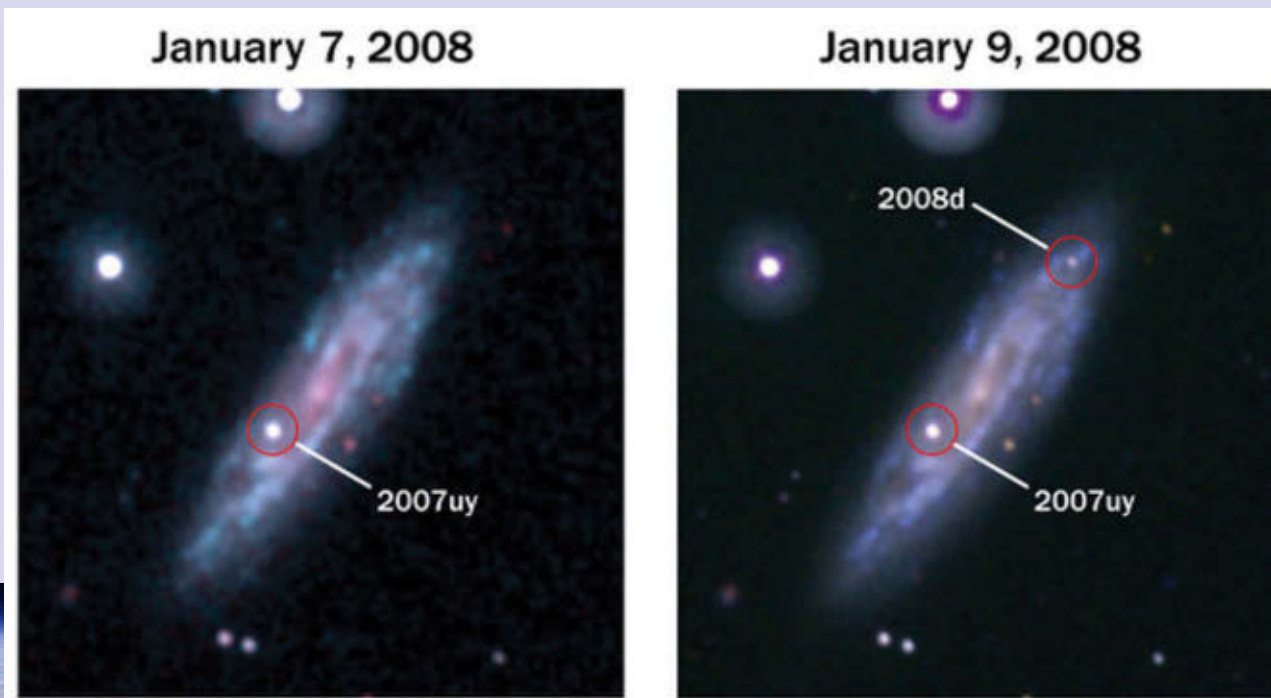
**Mobile Lunar Transporter**  
Credit: NASA



# Astronomers Record Supernova in Real-Time

**F**or the first time, astronomers caught a glimpse of a supernova explosion in real-time through the Swift satellite's X-Ray Telescope. Scientists were gazing at star SN 2007uy in galaxy NGC 2770 before the neighboring star SN 2008D exploded, making astronomical history. For a full account of the event, visit [http://www.nasa.gov/mission\\_pages/swift/bursts/swift\\_supernova.html](http://www.nasa.gov/mission_pages/swift/bursts/swift_supernova.html).

**Image credit: Alicia Soderberg, Princeton University**

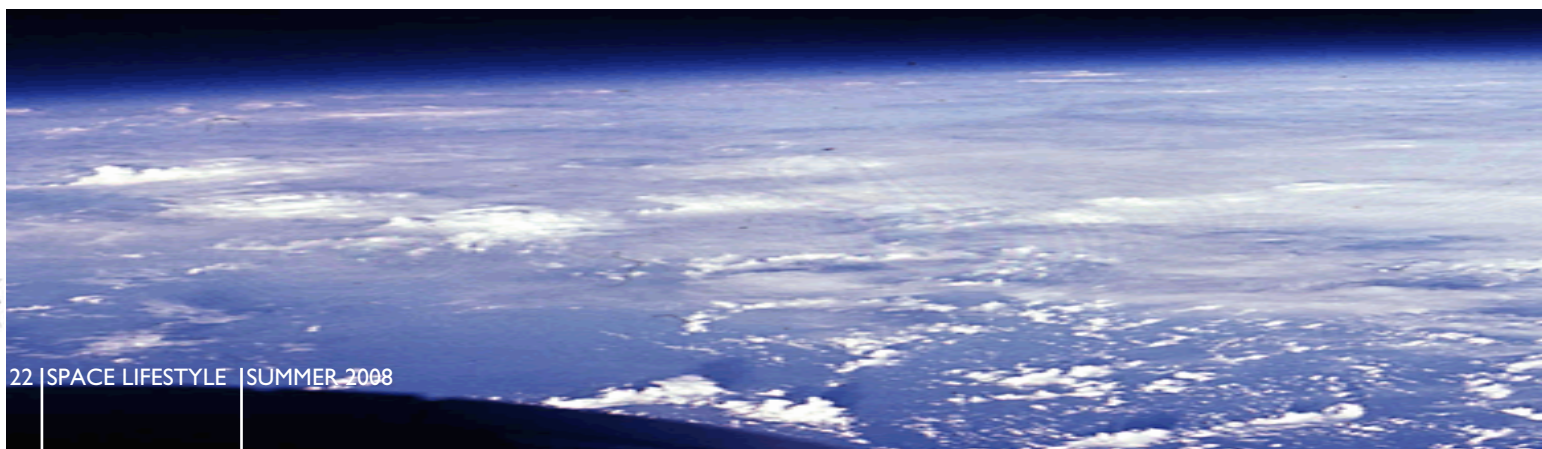
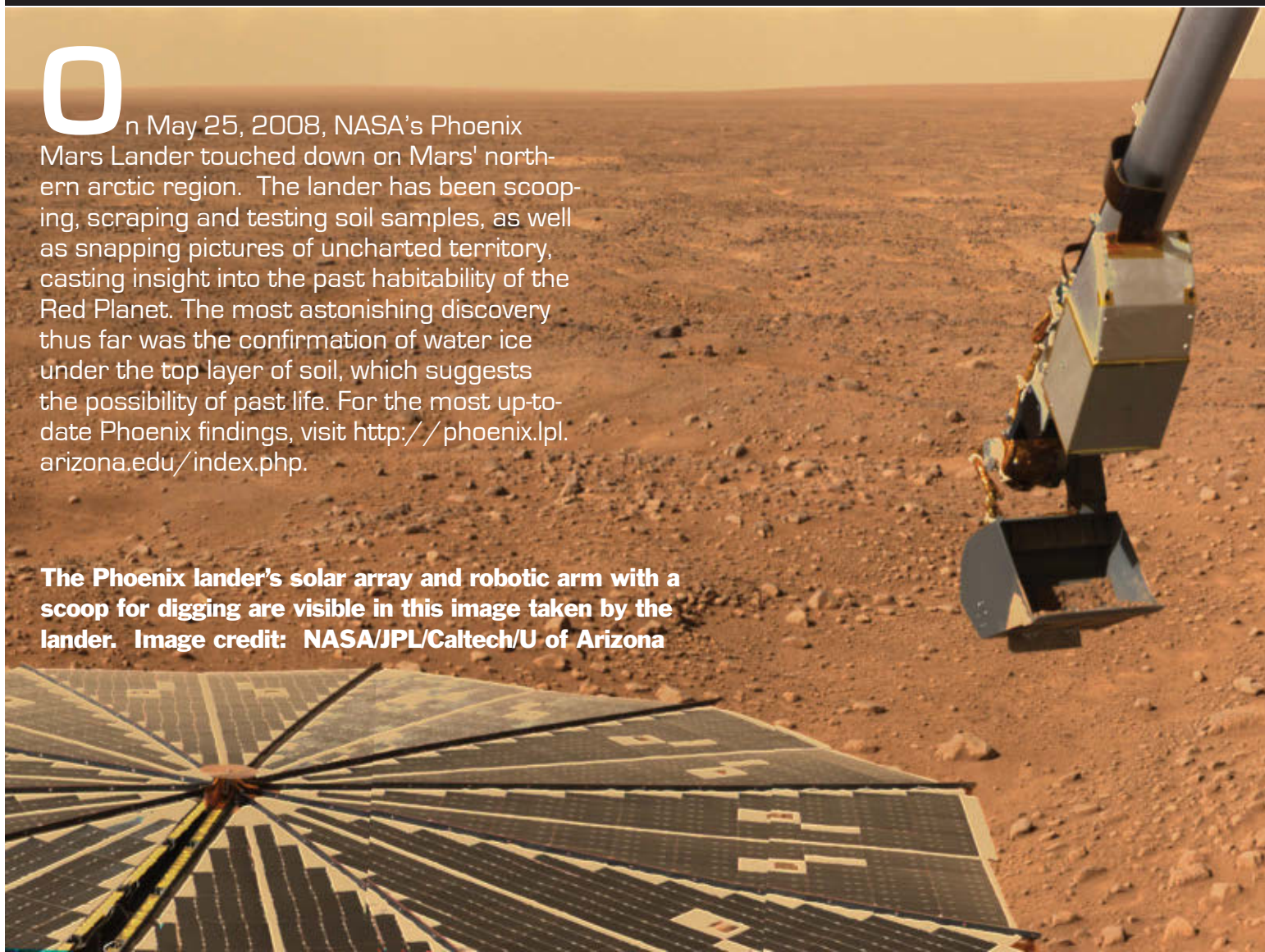




# Phoenix Mission to Mars

**O**n May 25, 2008, NASA's Phoenix Mars Lander touched down on Mars' northern arctic region. The lander has been scooping, scraping and testing soil samples, as well as snapping pictures of uncharted territory, casting insight into the past habitability of the Red Planet. The most astonishing discovery thus far was the confirmation of water ice under the top layer of soil, which suggests the possibility of past life. For the most up-to-date Phoenix findings, visit <http://phoenix.lpl.arizona.edu/index.php>.

**The Phoenix lander's solar array and robotic arm with a scoop for digging are visible in this image taken by the lander. Image credit: NASA/JPL/Caltech/U of Arizona**



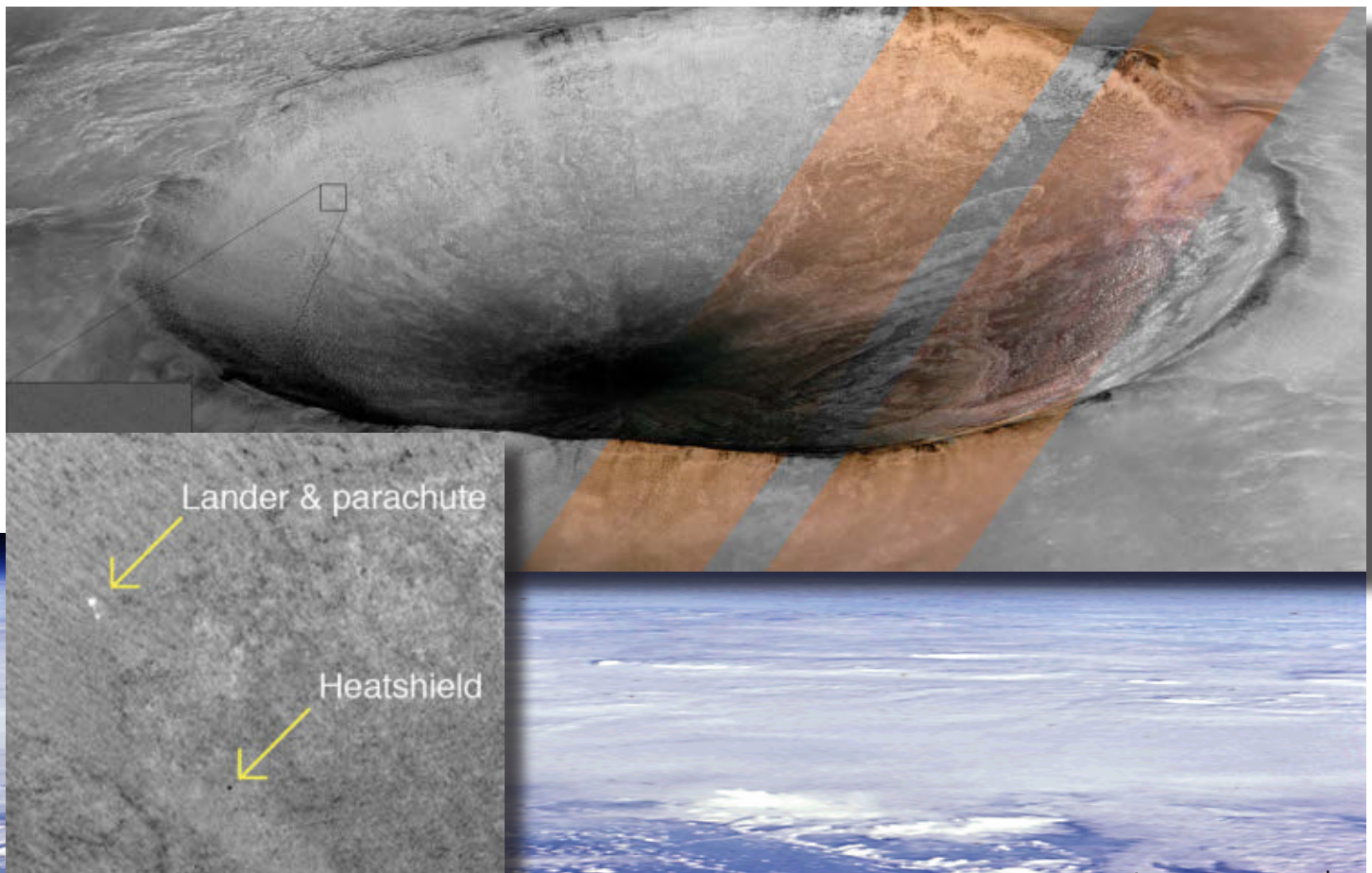


# Astounding Image from the Mars Reconnaissance Orbiter: Phoenix Descending

**T**he HiRISE Camera on board the Mars Reconnaissance Orbiter (MRO) took one of the most astounding images ever on May 25th, when it captured the Phoenix lander descending through Mars' atmosphere with its parachute. Although Phoenix appears to be descending into a large crater, it actually landed 20 kilometers (12 miles) away. MRO was about 760 kilometers, or 475 miles, away when it pointed the HiRISE camera toward the vicinity engineers believed Phoenix would be. Visible in the inset is the fully inflated 10-meter (30-foot) wide parachute, with even the lines connecting the parachute and aeroshell apparent as well. Later analyses revealed the spacecraft's jettisoned heat shield, a small dark dot just below the lander. HiRISE made history by taking the first image ever of a spacecraft as it descended toward the surface of another planetary body. For more information about the Mars Reconnaissance Orbiter see <http://mars.jpl.nasa.gov/mro/>

**HiRISE captures Phoenix's descent. Inset shows close-up of the lander with parachute, and heat shield. Image credit: NASA/JPL/U of Arizona**

**For more HiRISE images visit <http://hirise.lpl.arizona.edu/>**







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# 2008 ISDC's Hot for Space in the Nation's Capital

By Katie Kline

**A**s the first heat wave swept across the nation's capital, so did the 27<sup>th</sup> Annual International Space Development Conference hosted by the National Space Society. With featured speakers like President of Virgin Galactic Will Whitehorn and Space Adventures CEO Eric Anderson, the 2008 ISDC focused on the future of NASA and private space travel. Topics ranged from the progress of Project Constellation to Generation Y's future contributions to human space flight, and everything in between.

Popular space advocates, such as Loretta Hidalgo Whitesides, participated in events catered to the Generation Y crowd. Whitesides candidly shared stories about recent Yuri's Night parties, including the NASA Ames party in the SOFIA Hangar that began with talks from rocket scientists and ended with "the requisite gogo dancers in bikinis."

Other speakers discussed the future issues associated with private space flight and space real estate in general. Mark Sundahl, assistant professor at Cleveland-Marshall College of Law, addressed many important questions—and perhaps proposed even more hypotheses—in his breakdown of current space laws and their application to space tourism. He explained, for example, how many space laws, especially regarding human space flight, force the launching state to be liable for damages, not the individual operator or private company.

This led to an audience member's question about Russia's responsibility if a Soviet craft were to land



on private property in the U.S.

"I don't know, but I can see them saying, 'We didn't launch that, the old Soviet Union did,' Sundahl replied. "Moreover, it was launched by the Ukraine, so it certainly wasn't us." The Soviet Union and present day Russia, both launch their spacecraft

from what is currently known as Baikonour, Kazakhstan.

Many speakers, however, discussed the future of space exploration and space flight. Pascal Lee, co-founder and chair of the Mars Institute, openly supported the switch to outposts for scientific investigations on the Moon and beyond as a more reliable source of data. While sortie missions satisfy exploration and immediate scientific curiosities, he claimed, they do not build an infrastructure to be used for long-term data collection.

"You couldn't, for example, launch a deep-drilling program in a sortie mission. You are only doing a shallow exploration—literally and figuratively," Lee proposed.

Other conference highlights included the live launch of Discovery, a proposition for Space Based Solar Power and a Google Lunar X PRIZE panel that featured many of the contestants. Next year's conference will take place from May 6-10, 2009 in Orlando, Florida. For a more detailed description of the 2008 and 2009 conferences, see <http://www.nss.org/>





# Not your Daddy's Diggs:

By Talia Page

## The Evolution of the American Space Suit

Astronaut Ed White in the  
Gemini spacesuit during the  
US's first  
spacewalk in 1965.  
Credit: NASA

**W**hen was the last time you were connected to your mother via a life-supporting cord, floating in lieu of walking, and thought it normal to urinate and defecate on yourself? If your answer is, "When I was living in embryonic fluid, in my mother's belly" you've clearly never gone on a space walk.

Despite the numerous aforementioned similarities between our behavior before birth and the required activities of astronauts, space walks require space suits— which are a lot more complicated than birthday suits. Over the past

few decades, though, astronauts and space suit designs have come a long way, baby.

One of the many challenges of traveling in space comes from the lack of atmospheric pressure and oxygen. Luckily, in 1935 the first pressure suit was made...but not for an astronaut, of course. It was designed for balloonist Mark Ridge, who tried it out inside a high altitude chamber, and again inside a giant ice box in order to test the suit's capability to sustain pressure at low temperatures.

The B F Goodrich Company of Akron, Ohio made a full pressure suit that allowed aviator Wiley Post to make stratospheric flights without losing consciousness. It was a small suit for that man but suitable for giant leaps by mankind. Almost a quarter century later, on January 29, 1959, the first spacesuit conference was held. Bidders had approximately six months to come up with a feasible spacesuit design, and on July 22, B F Goodrich was awarded the NASA contract to design the Mercury space suit. The company modeled the space suit after their famous Navy Mark IV pressure suit.

The Mercury suits were not exactly fitted for fashion. Miles Alex, a self proclaimed independent "flaming fashion designer" from Chelsea, New York took a look at photos of those first space suits and nearly squealed. "Ohhhhhh! Bravo for new fabrics and high tech design, but what a waste. Those boys are in the best physical condition of their lives. What a shame to hide their beautiful,

steel abs behind puffy fat suits."

Fashion aside, those suits were successful in keeping the astronauts with perfect bodies alive and healthy. Not zipping up the puffy "fat suit" would have been a fatal fashion faux pas. Without a space suit, astronauts risk unconsciousness from a lack of oxygen. If they would be lucky



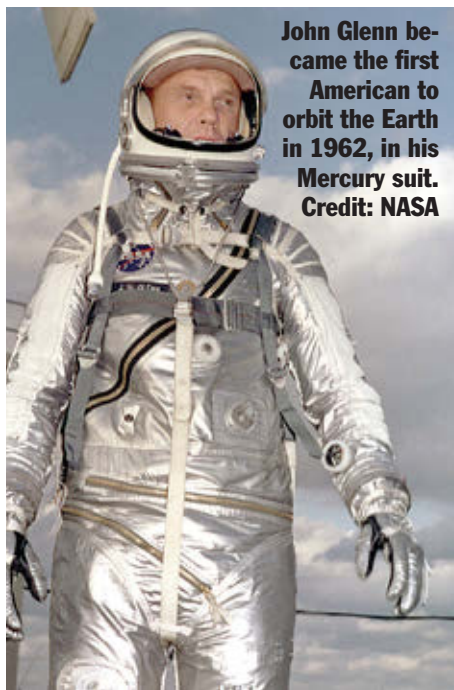
**Wiley Post's  
pressurized suit,  
circa 1935.  
Credit:  
Stanford  
University.**

enough to ever wake up, [which is virtually impossible] they would probably suffer some significant discomfort as their bodily fluids would boil, and then freeze due to the lack of air pressure. Their organs would expand and their faces would morph into a different shape due to the extreme temperature changes.

To be more precise, Pablo De Leon, head of the University of North Dakota space suit laboratory and Argentine Ansari X-PRIZE contender, points out: "Well, actually, their faces will not morph Total Recall style due to the changes of temperature. For sure, they would look pretty ugly just from the pain."

Also, regardless of the sun-block they might be wearing, they would be also exposed to all sorts of scary radiation. De Leon tries to offer comfort by emphasizing that "...just a few seconds of being exposed to the vacuum might be survivable with minor injuries, just like astronaut David Bowman in 2001 Space Odyssey." But, unfortunately, exposure to longer than a few seconds would, in fact, be fatal. Hence, the importance of the space suits.

The suit design for the Mercury missions may have been high tech for its time — and it certainly did serve its purpose — but the outfits were no walk in the park to wear. For those of us who hate wearing itchy, wool suits to the office in the winter, or think that striding in stilettos is perilous and



**John Glenn be-  
came the first  
American to  
orbit the Earth  
in 1962, in his  
Mercury suit.  
Credit: NASA**





**Ed White and Jim McDivitt wearing the Gemini suits in 1965.**  
Credit: NASA

nightmarish, imagine suiting up with neoprene-coated material, a layer of aluminized nylon, and a layer of rubber garments pressurized at five pounds per square inch. Granted, weight is of no real consequence in a weightless vacuum, but ultimately, the gear was uncomfortable and made the astronauts look a bit like aliens (if only they were green).

Meant for orbital flight, the Mercury spacesuits were not designed for space walking. In 1965, Ed White flew with the crew of Gemini IV and became the first American to perform a space walk. He wore a swanky-looking G4C suit from the David Clark Company, which allowed for more mobility than the Mercury suit. The DC G4C suit consisted of two layers: a gas-tight bladder fitted to the body, covered by a layer of netting woven with Teflon and Dacron. These suits were made in white—not as an aesthetic choice for contrasting with the black atmosphere. The suit was manufactured in white solely for its function: it absorbs less heat than, say, a plush pastel pink or a manly navy blue.

As with the Mercury suit, which had to be improved upon for space walking, the David Clark G4C wasn't quite the right fit for a stroll on the moon either. Like Michael Jackson's high-maintenance suit that was custom designed for the music video where he "moonwalked" on tables, an entire wardrobe of event-appropriate suits had to be designed for astronauts doing a "real" moon walk (one certainly cannot go on a moon walk in the same gear in which one lounges around the cabin eating freeze-dried space ice cream).

On July 21, 1969, Neil Armstrong's "small step" on the moon was made possible, in part, by ILC Dover, a small company in Delaware that

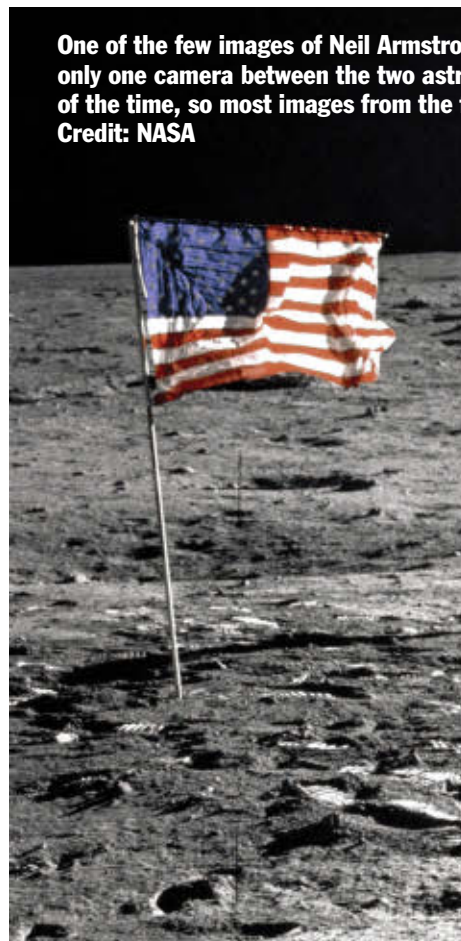
won the NASA contract to engineer the moon space suit. The moon suit weighed about 180 pounds (on Earth) and was comprised of many layers, a total of 11 in the cross-section, to be exact. Within the layers was a cooling and ventilation system, pressure garments, material to protect the wearer from micrometeoroids, and headphones and earphones for communication. The outermost layer was made from Nomex material, and underneath were two layers of a Teflon-coated Beta-cloth, a few layers of neoprene-coated nylon, and a couple final layers of Beta/Kapton spacer laminate.

For Neil and his compatriots, there were no shortages of impressive gadgets: a liquid cooling underwear system, hoses attached to the back of the suit providing life support, gloves made of Chromel-R fabric on the outside with thermal insulation inside and blue silicone rubber fingertips to provide more sensitivity, and an in-suit drinking bag filled with water.

With all this baggage, it's no surprise that approximately 70 percent of the Apollo astronauts' energy was spent simply in wearing the suits, which also looked strikingly similar to the Michelin Man at your local garage. The reason for their tire-like design is due to a need for extra fabric to maintain a constant pressure, particularly around the joints. Volume is lost when joints are bent because the suit folds, thereby reducing the internal volume and increasing the pressure. As one can imagine, this "tire factor" made moving around and actually getting things done extremely difficult. Looks aside, the suit was an impressive engineering feat, to say the least.

But ILC Dover wasn't the only companying vying to have their suits

**One of the few images of Neil Armstrong on the moon, only one camera between the two astronauts of the time, so most images from the Apollo 11 mission are of the moon.**  
Credit: NASA



used on the moon. The space race, which lasted from around 1957–1975, fueled entrepreneurial dreamers with a talent for engineering while capitalism, national pride, and free markets inspired the emergence of a number of innovative companies. All these creative forces were striving to create an out-of-this world design that would win a contract from NASA. A flurry of the space suit prototypes and related accessories were pitched during the third quarter of the twentieth century.

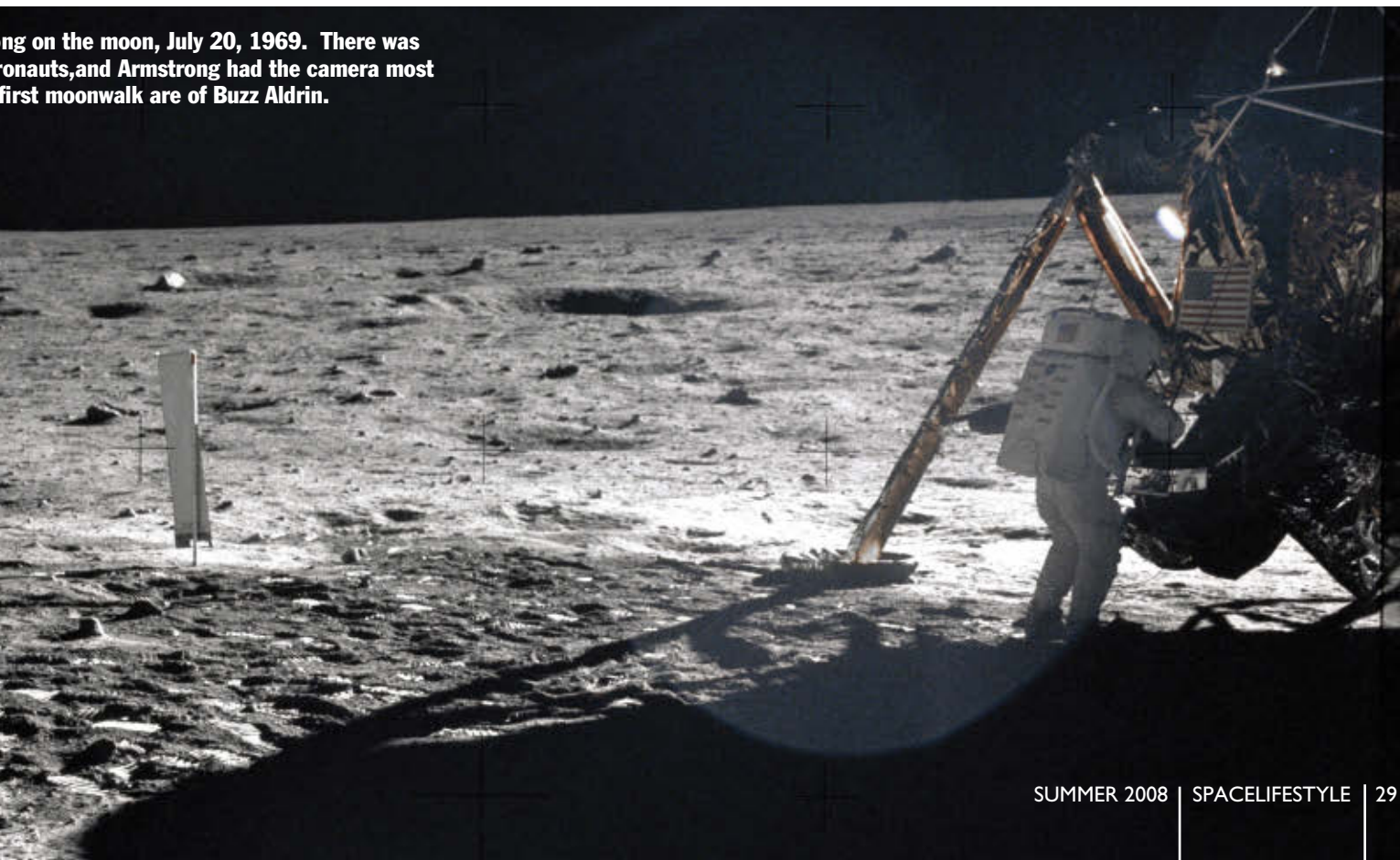
Perhaps the most recognized design was the LIFE magazine favorite, the 1960s Grumman Moon Suit. This get-up was made to accommodate lunar surface operations and allowed the astronaut to take his arms out of the flexible manipulators and into the pressurized “can” that enclosed his upper torso and head. The Republic Moon Suit was another LIFE magazine favorite: this one was a hard suit made for extended lunar activities and is said to resemble a suit from Republic Pictures serials of the 1940s. De Leon explains that the Republic Moon suit prototype actually got its name because it was built by Republic Aviation (a now defunct company). “It’s unrelated to the Republic Commando Cody and Captain Marvel serials,” he says.

Other prototypes featured a closed-cell foam



**One of the early designs of the moon spacesuit. This one was deemed not flexible enough for astronauts to bend over to pick up moon rocks. Credit: NASA**

ing on the moon, July 20, 1969. There was  
onauts, and Armstrong had the camera most  
first moonwalk are of Buzz Aldrin.







**The Advanced Crew Escape Suit (ACES) used by current space shuttle astronauts. Credit: NASA**

suit [initially proposed by Macuh Laboratories], then the S-939, a full pressure suit that made for the x-20A Dyna-Soar program, followed by the S901/970, another full pressure suit, this time complete with a parachute harness, an automatic flotation system, a urine collection gadget, thermal protective fabrics, and integrated subsystems that came in 12 different sizes. Hamilton Standard, now the main NASA contractor for the Shuttle space suit, developed the Integrated Maneuvering Life Support System (IMLSS) for the USAF Manned Orbiting Laboratory (MOL) program. IMLSS allowed astronauts to use an umbilical connecting to the MOL, and even gave them the option of disconnecting to float independently from the station.

Unfortunately, MOL never went to space, so the IMLSS never made it past the lab. Even so, these prototypes were important steps forward in space suit design, and they were used as blueprints for later designs for the space suits used with the Shuttle. Around 1969, the AX-1 [Ames Experimental] and AX-2 were developed by NASA-ARC. These were hard suits that featured avant-garde multiple bearing technology and resulted in the development of the AX-3, a 0.5 bar suit weighing only 23 kg. Naturally, the AX-3 eventually led to the AX-5, which was relatively easy to put on, offered more mobility, and could be tweaked to fit different body shapes without being

entirely custom designed.

After the Soyuz 11 incident in which three unsuited cosmonauts died in a decompression accident, safety precautions became an even higher priority. In 1971, NASA began investigating a prototype for a Mechanical Counter Pressure suit (MCP), comprised of six layers of elastic material and a helmet that resembled a giant bubble. This prototype was not a conventional gas filled pressure suit, so it was easier and less taxing for astronauts to move around. It was also lighter (24 kg) and would not result in a horrifying-but-fast death if punctured. The theory behind this design is that human skin is almost a perfect pressure suit on its own because it has good water retention, virtually no gas permeability, and high tensile strength. Additional applied pressure is necessary in a vacuum, though, to equal the pressure of the breathing gas. Thus, an enhanced “second skin” was created with the use of Mechanical Counter Pressure (MCP) to mock a pressurized environment. Unlike the fully pressurized suits of the 60s, a tear in an MCP would not mean a loss of life supporting gas pressure—it would simply expose an area of the skin to reduced pressure and cause some bruising.

The life support system was also much simpler and more effective: body cooling was accomplished normally, through sweat, which





**De Leon in the North Dakota Badlands with a suit prototype and suit model Fabio Sau.**  
**Credit: North Dakota Space Grant Consortium**

would evaporate through the porous second skin. For life support, astronauts simply carried a tank of oxygen with pressure regulators and a carbon dioxide scrubber.

Nothing is perfect, and there were a few pitfalls to the MCP design. In a vacuum, the body swells and blood pools. The pressure of the suit is what keeps the body in its normal shape. Nevertheless, it is difficult to maintain a constant pressure in concave crevices of the body, like armpits and genital areas. Luckily, little sacs of fluid could be inserted into concave areas in order to prevent arm pits from becoming arm bulges.

Another, more minor issue, is that each suit had to be custom tailored for the astronaut that was to wear it, and although it wasn't as complicated as putting on the suits that resembled the Michelin Man, it wasn't quite like slipping into your old 80s spandex leotard either. There were eight different garments that had

to be fitted absolutely perfectly: the slip layer, a helmet bladder to keep the helmet from rising, a second helmet bladder to help the first one, an arm balancing layer to even out the pressurization of the arms and legs, full body bobbinbet layers, girdles to increase pressure on the torso and thighs, gloves, and one pair of very cute booties for the astronaut's feet. Various forms MCP designs have been studied over the years, most recently in 2005 by MIT developers of the sleek, skin-tight bio-suit. None of these concepts have been tested in space yet, however.

Two different suits are required for space shuttle flights. For launches and landings, astronauts use the Advanced Crew Escape Suits (ACES) which are modeled after the suits of the 1970s for the most part (retro never seems to go out of fashion). Of course, kinks have been worked out and there are some new perks, like detachable gloves and anti-g systems.

**Suit Designer and Ansari X-PRIZE contender Pablo De Leon and model in a De Leon prototype.**  
**Credit: North Dakota Space Grant Consortium**







**Artist's conception of the two spacesuits to be used to return to the moon in 2020.  
Credit: NASA**

For spacewalking from the shuttle or the International Space Station, the EMU, or Extravehicular Mobility Unit is the suit of choice, made by the Hamilton Sundstrand company. The EMU consists of three main parts: a water-cooled under liner, the main pressure vessel, and primary life support system. The design is modular and features many interchangeable parts. Torso, pants, arms, and gloves comes in several different sizes and each astronaut can combine separate



parts for the perfect fit. Astronauts have provided insight for the designers over the years to tweak different parts, particularly the gloves and joints, to enhance mobility and flexibility.

There are about as many space suit design studies as stars in the skies, and at one point NASA considered a completely new design for spacewalking. During the 90s, NASA refined designs and evaluated the use of a series of new suits, like the Mark III, that were heavier yet offered more mobility (astronauts could even do handstands and somersaults in these suits).

Unfortunately, the Mark III was too heavy and the design was vetoed in favor of lighter-weight materials.

Recently NASA created considerable buzz with the newest space suit prototype. NASA awarded a \$180+ million contract to Oceaneering International Inc. to design a new line of suits called Constellation Space Suit Systems (CSS) to be worn in the upcoming Constellation

program using the new, but retro Apollo-like Orion space capsule.

These new modular, more flexible suits will allow an astronaut to roam the moon, climb ladders, and generally get around relatively unencumbered by the typically stiff, bulky old-school design. The new contract with Oceaneering doesn't mean that NASA is breaking up with its retro-designers though; among others, the David Clark company the Harris Corporation will be collaborating with Oceaneering International on the design.

Oceaneering, as the name suggests, has a long history invested in deep sea applications



**NASA recently tested this prototype to be used in the new Constellation Program. Credit: NASA**

"Finally, fashion starts to meet function," says Miles Alex, with an approving look in his eye as he takes a look at the new design by Oceaneering International. "Cat walks are going to be so passé...the future is sexy space walks. How long until you can trade space suits for birthday suits? I'm thinking Calvin Klein models for a better line of space underwear by 2025..."



*Talia Page is a freelance writer and aspiring astronaut. Her first book, *Belbruno's Universe*, will be published in the coming months. She also works as a Project Director for Ira Flatow's non-profit organization, TalkingScience.*

**The most famous spacesuit image ever: Buzz Aldrin on the moon, July 1969. Credit: NASA**



(mostly with regards to the oil and gas industry) and it is believed that they will bring a lot to the table since deep water work involves the use of pressurized suits as well. We'll find out in seven years, when, in 2015, the first suit is slated to be used by the crew of the new Orion spacecraft. And if all goes as planned there will be yet another line to take astronauts back to the moon in 2020. This time, NASA will leave the old fat suits at home with the Michelin Man, on Earth.



**Deke Slayton wearing the Apollo-Soyuz Test Project ASTP Spacesuit in 1975.**



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# YURI'S NIGHT 2008

By Michael Ricciardi

**T**rish Garner, George Whitesides, and Loretta Hidalgo conceived the original Yuri's Night in September of 2000 at the United Nations/NASA's Space Generation Advisory Council Conference. As a truly global way of celebrating the first human in space and the first space shuttle launch, Yuri's Night – World Party for Space is now in its ninth year and spreading like a virus.

This year's Yuri's Night, held April 12, 2008, marked the largest number of registered parties to date, with many locations achieving record attendance. But even if the "parties" were large, exhibition-like events staged at a NASA facility—such as Johnson Space Center in Houston, TX, or first time—and far more modest, educational gatherings—like at an old factory in Kingston, Jamaica, each party was fostered by a similar, growing interest in all things related to space.

Though for some it may just be another

excuse to hold a "really cool" party, the advent of human space exploration—marked by the iconic figure of Yuri Gagarin (and secondly by the Space Shuttle Columbia)—was and remains the initiating idea of a truly global event. And despite the original, nationalistic impetus of our first voyages to space, history making space events are now often viewed as achievements for all of humanity. They continue to hold out the promise of a human future amongst the stars, or at least, amongst the solar system. In turn, each year on the 12<sup>th</sup> of April, space enthusiasts all over the world gather in large or small groups to commemorate Yuri Gagarin's inauguration of human-kind into the Space Age.

## **YN at the TOP and BOTTOM of the WORLD**

In credit to the iconic power of the first human space flight, YN events are found nearly everywhere that humans live or work. This is no less true for two of the most remote locations on

**Not Just a "Far Out" Party...  
But a Growing, Worldwide  
Space Community**





the planet: the North and South Poles. Located on Axel Heiberg Island, Nunavut, Canada, the McGill Arctic Research Station (M.A.R.S.) hosted a “small party at the top of the planet”—and one couldn’t imagine it being too over-crowded up there. M.A.R.S., established in 1960, is so tight that it consists of a small research hut, a cook house, and 2 temporary structures. Normally, it can comfortably accommodate 8-12 persons. This is one “small party” indeed! Though more of a prolonged Yuri’s “Day” celebration—due to the current axial tilt of the Earth towards the sun—this more impromptu party had been organized by McGill University resident geologist Dr. Wayne Pollard. A handful of research scientists, who happened to be conducting research there at the time, attended the tight gathering.

Of course, at the opposite pole of the Earth, the situation on April 12 was a prolonged Yuri’s Night. The party at

Amundsen-Scott South Pole Station, Antarctica, roughly marked the commencement of six months of night of relative darkness, due to the earth’s axial tilt away from the sun. There, the elevation is above 12,000 feet and the mean temperature was  $-80^{\circ}\text{C}$  ( $-110^{\circ}\text{F}$ ). Perhaps due to its vast, foreboding, “other-worldly” landscape, station scientists here have been celebrating Yuri’s Night since 2001. At that time, the first party occurred in the station’s ‘Skylab Lounge.’ It was here that the traditional YN vodka toast was informally established. The only place for the 2001 residents was the ‘Geodesic Dome at the Pole’, but since then, the station has expanded to include a new Elevated Station, with its new ‘B1 Lounge’.

Their YN party, organized by Station Science Leader J. Dana Hrubes and heads the telescope program at the South Pole, has been a convivial initiation to life at the bottom tip of the world. The “winterovers,” the informal name of those staying there for the winter, had been isolated from February 14th until the last week of October, but still have a unique YN experience. Fortunately, several of the station’s residents, including Hrubes, had been musicians with their own band and provided entertainment.

The station has 60 winterovers, which are mostly station support, with 9 scientists conducting experiments.

Lest we forget, the single greatest advantage







to this remote locale is indeed space related; with the sun having set in late March, residents enjoy an astoundingly clear view of the stars, auroras, satellites, and iridium flares over the ghostly beautiful, high Antarctic plateau.

## COOL BEGINNINGS FOR YURI'S NIGHT – JAMAICA

Many YN events organized in other countries were mapped onto existing commemorative events, such as in Bulgaria's month long astronomical observance. Many others were smaller, more educational gatherings, like Kingston, Jamaica. "I must confess," said event organizer Errol Rickman, "that we got into this

**Residents of Amundsen-Scott South Pole Station raise a glass to Yuri Gagarin for YN 2008]**





**Participants in Jamaica's YN "Star Party" and members of organizer Errol Rickman's family: Mignonette and grand children Amanda, Tina and Kevin.**



only 4 months ago, and this was our first Yuri's Night."

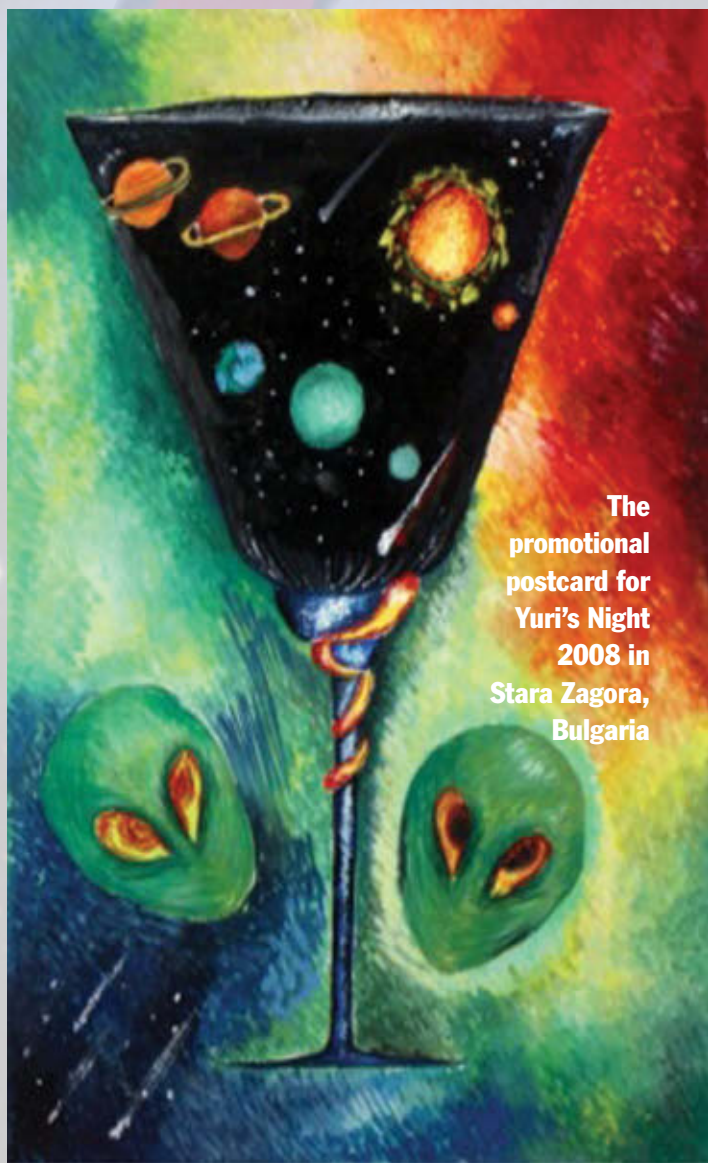
Errol Rickman is Vice President of the Astronomical Association of Jamaica at the University of the West Indies, Mona Campus, Kingston, Jamaica. "Our party was not the usual music and dancing, but took the form of what we call a Star Party, which entails more viewing and astronomical talks and we did serve refreshments during the night. We just fitted it onto Yuri's Night. I must say though that our visitors had fun while learning. We have recommended that next year's party would be able to set up a visible display from the space station."

The Kingston YN event—Jamaica's first—was attended by about 20 persons. Most attendees, according to Rickman, had never before looked through a telescope. "We set up three instruments for them to view the first quarter Moon and Saturn," Rickman explained. "The North Star was also viewed, as we explained that it was the only star not moving through the field in the telescope." About half the group was students from the university, but everyone was invited to take pictures through the 18 inch reflector telescope. Also shown was a slide show called "Beginnings" which depicted the "rise of mankind from the cradle of humanity in Africa four hundred thousand years ago to the breaking of earthly ties when Yuri broke the shackles of

**On 12 April 1961, Yuri Gagarin blasted off the launch pad in Baikonur at 9:08 AM local time. His call-sign for the flight was "Cedar." Sergei Korolev, the Program's Chief Designer, would call from the ground, "Dawn" calling 'Cedar.'" Gagarin made his historic 108 minute flight (orbiting around the whole Earth once) and parachute landed near his Vostok 1 capsule in the plains of Russia. This flight made him the first human to orbit the Earth and an international hero. Yuri was only 27 years old. Seven years after his flight, on Wednesday 27 March 1968, Yuri was piloting a MiG-15 when he got into a tragic crash that ended his life. He was 34. People say that that is why John Glenn was not allowed to fly again for so long - to protect him. Yuri is survived by his wife Valentina and his two daughters, Lenochnka and Galochka.**



**Attendees of YN Bulgaria in Stara Zagora watch a video presentation on the history of manned space flight.**



**The promotional postcard for Yuri's Night 2008 in Stara Zagora, Bulgaria**

gravity in April 12, 1961.”

Many of the YN events outside of the U.S., such as Kingston's, were specially assisted by contacts (“spocs”) from the Space Generation Advisory Council, who typically help with program content. ‘Beginnings’ was prepared by Marc Cornwall, the SGAC contact person, residing in London UK. The Kingston YN event was also assisted by Stanley Smellie. “Our venue was at a local factory named ‘LASCO Consumer Products,’” offered Rickman, “just outside of Kingston where the sky was very dark.”

## **BULGARIA CONTINUES ITS ASTRONOMICAL TRADITIONS – YN 2008**

Westerners may be somewhat surprised to learn that in Bulgaria many towns have their own public astronomical observatories. These sites became the natural choices for hosting a Yuri's Night party. This year the four locations of Stara Zagora, Silistra, Haskovo, and Varna together drew over 500 participants. Yuri's Night Stara Zagora was the largest party with over 120 people attending. The Stara Zagora event was organized by the Yuri Gagarin Public Astronomical Observatory and Planetarium and Solar-Terrestrial Influences Laboratory of the Bulgarian Academy of Sciences.



**As if by cosmic coincidence (the launch had to be slipped two days to fix a computer glitch), the US Space Shuttle's maiden voyage fell on April 12th 1981, exactly 20 years later. The ship was Columbia, and her crew for STS-1 (Space Transportation System, flight 1) was Commander John Young and Pilot Bob Crippen.**



**Spacey revelers at Manhattan's Rebel Lounge at YN NYC!**

The preparations for Yuri's Night actually started with Sun-Earth Day, March 20. On this Spring Equinox, a series of six lectures by Dr. Alexey Stoev began in the Stara Zagora art gallery. The series was titled "Astronomy in Culture" and described as "an exciting journey through time and the history of science."

The Stara Zagora event initiated with a recording of Yuri Gagarin speaking during the launch of the VOSTOK 1 spacecraft, and a video on the history of manned space flights. There were also numerous slide shows, celestial observations, an art exhibition entitled "The Beauty of the Earth" (consisting of children's drawings in honor of the Year of Planet Earth – 2008,) free food, and a space-themed quiz game.

"Usually we have had more official celebrations on April 12." explained Dr. Penka

Maglova – Stoeva of the Solar-Terrestrial Influences Laboratory. "Last year, at first, along with the International Heliophysical Year, we had organized 17 Yuri's Night parties at 15 locations. We were very impressed with the idea of celebrating Yuri's historic flight and the first space shuttle flight in such free manner, everywhere. It was very attractive!"

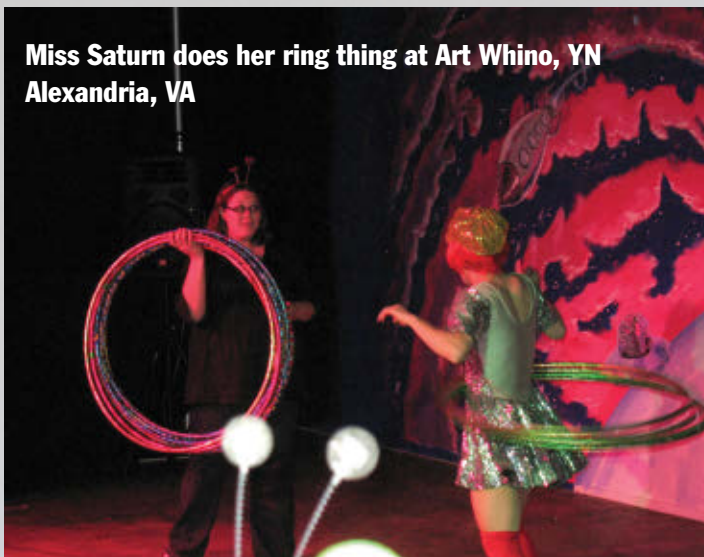
"Moreover," added Dr. Stoeva, "we Bulgarians have two cosmonauts: Georgi Ivanov (1979) and Alexander Alexandrov (1988), and traditions in space research."

## **YN IN THE USA – PARTY LIKE IT'S 1961!**

No surprise that the country with the most YN parties and special events is the United



**Miss Saturn does her ring thing at Art Whino, YN Alexandria, VA**



States. Several NASA Centers held sizable events and many universities played host to “space parties.” But a fair number of YN parties were held at art studios/galleries, like the Alexandria, Virginia gala at Art Whino, or at swanky night clubs.

“Last year, I spent my Yuri’s Night sitting in a lecture hall,” says Lois Elfman, SLM reporter and party attendee. “I found my first Yuri’s Night incredibly informative but a bit staid. This year’s was all about a party.” Staged at Manhattan’s Rebel Lounge, and produced by the Space Tourism Society, this “Party in Outer Space” offered attendees a “space survival pack” (with “actual astronaut snacks,”) an informational space video, and a live DJ spinning 1980’s synth pop and British New Wave. Also in attendance was wine maker John Caldwell offering samples

of his new wine Rocket Science. Elfman acknowledged meeting a few admitted space enthusiasts, but found that most showed up because “it sounded like something interesting and different.”

Moving up state to Buffalo, Yuri’s Night was celebrated with a decided mix of real space science and good time partying. Staged at The University’s North Campus Arts atrium, and organized by The University at Buffalo Chapter of Students for the Exploration and Development of Space, YN Buffalo offered scientist guest speakers, food, informational material, giveaways and live music by local band favorite The Waves. University at Buffalo professors Dr. Tracy Greg and Dr. John Crassidis were the speakers.

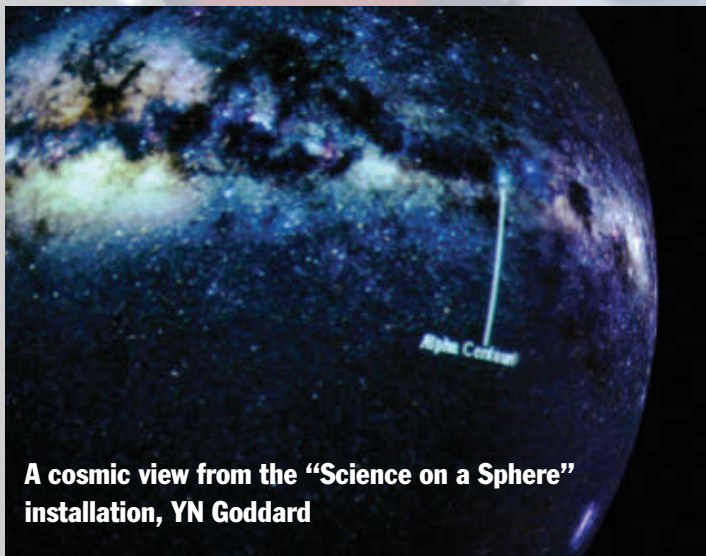
**Astronaut Dave Leestma talks about spacewalking at YN JSC**



**JSC’s Heather Paul gives a demonstration about spacesuits**



**A cosmic view from the “Science on a Sphere” installation, YN Goddard**



Tracy Greg, a planetary geologist, gave a talk about Martian geology, and John Crassidis, an Aerospace Engineer, gave a talk about some of the satellite missions that he had worked on, including WMAP, GOES, TRMM and SAMPEX.



**A robotic, fire-spouting sculpture by the Flaming Lotus Girls art group, featured at YNBA 2008**



"Over all the event was highly successful," says event co-organizer Richard Linares, "with a turnout of about 120 guests, of ranging ages. We created an excitement about space exploration on our campus and off it as well. This was accomplished with fun events. We were able to connect with people outside the technical world and teach them something about space sciences."

Of course, an art gallery like Art Whino in Alexandria, Virginia was the place to go on YN if you were looking for something a little different. The "Out of This World Party," co-produced by ABJ Productions and first time YN event for the city, featured the Spacey Burlesque Revue, hosted by the enigmatic Master Uranus and starring Miss Saturn who performs with "40 orbiting rings" (hula hoops). More space drama delights were offered up by the science fiction theatre company Landless Theatre, who performed excerpts from their production of "Space Battles, The Musical." And for those with live band tastes, there was Mr. Moccasin, a seven member post punk "wopop" band whose lead vocalist howls lyrics in Russian and English—in an odd, but fitting, tribute to the Soviet/US Space Race.

NASA, of course, was not to be left out of the celebrations and had at least three major events

hosted at research centers. NASA has a bit of an edge on the "geek cool" factor: they can offer real astronauts and real rocket scientists.

The famed Goddard Space Flight Center just outside Washington D.C. offered live music by the popular local band The Cassettes and the hip hop infused beats of DJ Scientific. Also on offer: presentations by actual rocket scientists, a "Moon Bounce," space-themed contests, and access to a Mercury (Redstone) Capsule. Other installations/exhibits included the "ultimate disco ball," the Science on a Sphere Exhibit, and a continuous visual feed of extrasolar planets.

In Houston, Texas, the main YN Celebration was hosted by the Johnson Space Center. Astronaut Dave Leestma gave a talk on spacewalking, and JSC's Heather Paul gave a spacesuit demonstration. The event included a "station call" from the International Space Station Alpha, whose occupants gave an update on their own YN part. Finally, to get the blood flowing, Texas music legend Billy Joe Shaver and his band took the stage, closing out the evening in high-octane, two-stepping Texas fashion.

Jumping over to the West Coast now... Yuri's Night Bay Area at NASA Ames Research Center, in Mountainview, California, was the largest YN event held anywhere on the planet. YNBA 2008 descended onto NASA grounds like a time-warped space invasion by way of 'Burning Man'—offering an impressive array of 'infotainment,' speakers, performance, new media art installation, and sci-tech exhibition. Occupying the full interior of Ames Research Center's Hangar 211, and extending out 200 yards onto the tarmac just south of the famous Moffett Field, YNBA 2008 was attended by nearly 8000 people.

YNBA also offered some special, celebrity highlights, such as an inspiring public address by Apollo 11 astronaut Edwin "Buzz" Aldrin, and the debut performance of Telstar-Grateful Dead member Phil Lesh's new band. Over 25 different acts performed throughout the 12 hour event,



with DJs spinning continuously in the Orbital Lounge.

While the day was filled up more with guest lecturers, new product demos, science exhibits, and video docs (the evening phase being marked with an air show featuring two Soviet-era aircraft and the venerable American Pitts Special biplane), and the night over-taken more by dancing, fashion shows, aerial acrobatics, and general partying...the entire event was constantly stimulating and almost over-whelming in its scope and ambition

Not every exhibit or installation lived up fully to YNBA's official theme of 'Radical Technologies for a Sustainable Future.' There were some thematically related offerings, like a demonstration of urine-water reclamation, the 2008 Roadster show car from Tesla Motors—world's first high performance electric vehicle, now in production, an exhibit from the California Cars Initiative—promoting plug-in hybrid electric cars, and a kid-friendly exhibit dealing with the Earth's fragile ecosystems. To be sure, the 'radical technology' was there, like NeuroSky's brain-controlled, virtual world game, a Nintendo Wii controller interactive art installation, and QuakeFinder, an earthquake early detection system/network. These exhibits may have not embraced the dual theme of 'radical technology' and 'sustainability,' still, it was aesthetically and intellectually enriching to see them at the event.

The YNBA event was the result of both NASA administration support and the creative work of many members of the growing 'space art' community (i.e., artists interested in space, working with astronauts, or using space science in their art) such as painter Frank Pietronigro of the Zero Gravity Arts Consortium who helped curate and produced the "S.T.E.A.M. Screen" space art documentary program and who was featured in a parabolic flight video with him attempting to paint in micro-gravity. One of the most significant happenings at YNBA was the exhibition of a pre-recorded video message from astronauts on board the International Space Station Alpha. The "message" was actually a collaborative work of art organized by the Deep Space Signaling Group, who are affiliated with The Center for Creative Inquiry at Carnegie-

Mellon, and was titled "I See the Earth and it is Beautiful – A Cosmic Antiphony." ISS Astronauts Garrett Reisman and Peggy Whitson quoted Yuri Gagarin—"I see the Earth and it is beautiful."—and both did symbolic, reverse direction flips in zero-g

SLM spoke with one of the group's members, Lowry Burgess, about the project. "It was about opening up a portal between Space and Earth," explains Burgess. "We wanted to see what could be done between 'us' and 'them', artistically, to signify that link."

Some might raise an eyebrow at the idea of utilizing the space station's astronauts in this way, but enough NASA officials liked the idea to help make it happen. "General Peter Warden (Director of NASA Ames) and his staff (Gary Martin and Jim Alwyn) were amazingly supportive of the project" said Burgess, adding "It was something to build on for the future." Next year, the Deep Space Signaling Group (comprised of Andrew Kaiser, Franco Sciannameo, Vashti Germaine, Jonathan Minnard, and Lowry Burgess) hope to go one step beyond with a live link-up, or some mass symbolic action, between folks on the ground and the ISS passing overhead.

The idea that NASA would open its doors (or hangars) and actively support a public event such as Yuri's Night, as well as assist artists in "cultural usage" of the space station (and host such a massive "space rave"), can only be described as a "very cool thing". It is indeed something to build on for the future. In a conversation with Lowry Burgess, General Warden stated that the ultimate purpose of NASA was to "facilitate the evolution of human habitation in the Universe." ...that's one small step...

**DISCLOSURE NOTE:** This author attended the YNBA event and presented a short video ('My Name is HAM'; an 'imagined memoir' of the first chimp in space) and two slideshow presentations (Forgotten Animals / Forgotten Space Junk), and also provided some coverage for Space Lifestyle Magazine.



**Groovin' for Yuri, South of the Equator, Bogata D.C., Columbia**



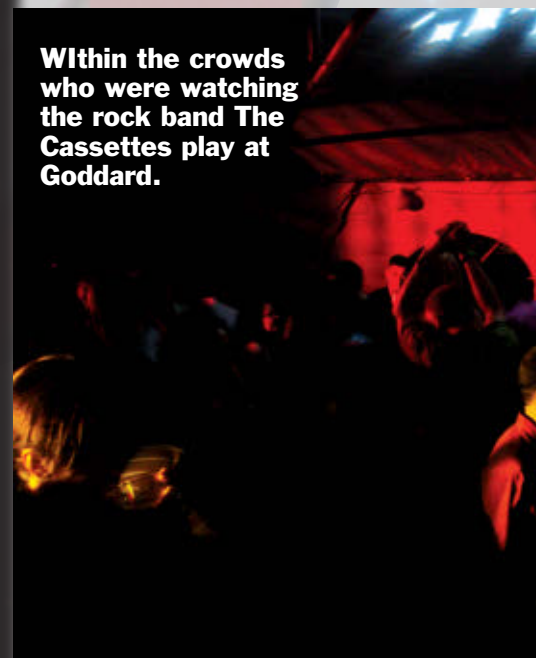
**YN Houston sponsor Jones Soda supplied a special YN soda**

**ADDITIONAL YN PHOTOS**  
(all photos published anonymously at [www.yurisnight.net](http://www.yurisnight.net), except 'robotic fire sculpture', courtesy of [www.serpentmother.com](http://www.serpentmother.com))



**Three party-goers including Michele Bugenhagen (center) and Peggy Grab (far right) enter the NASA Goddard Visitor's Center, as the DC Yuri's Night begins.**

**Within the crowds who were watching the rock band The Cassettes play at Goddard.**







**"Bird girl", winner of the YNBA costume contest; she won a parabolic flight--those wings won't help her in microgravity!**

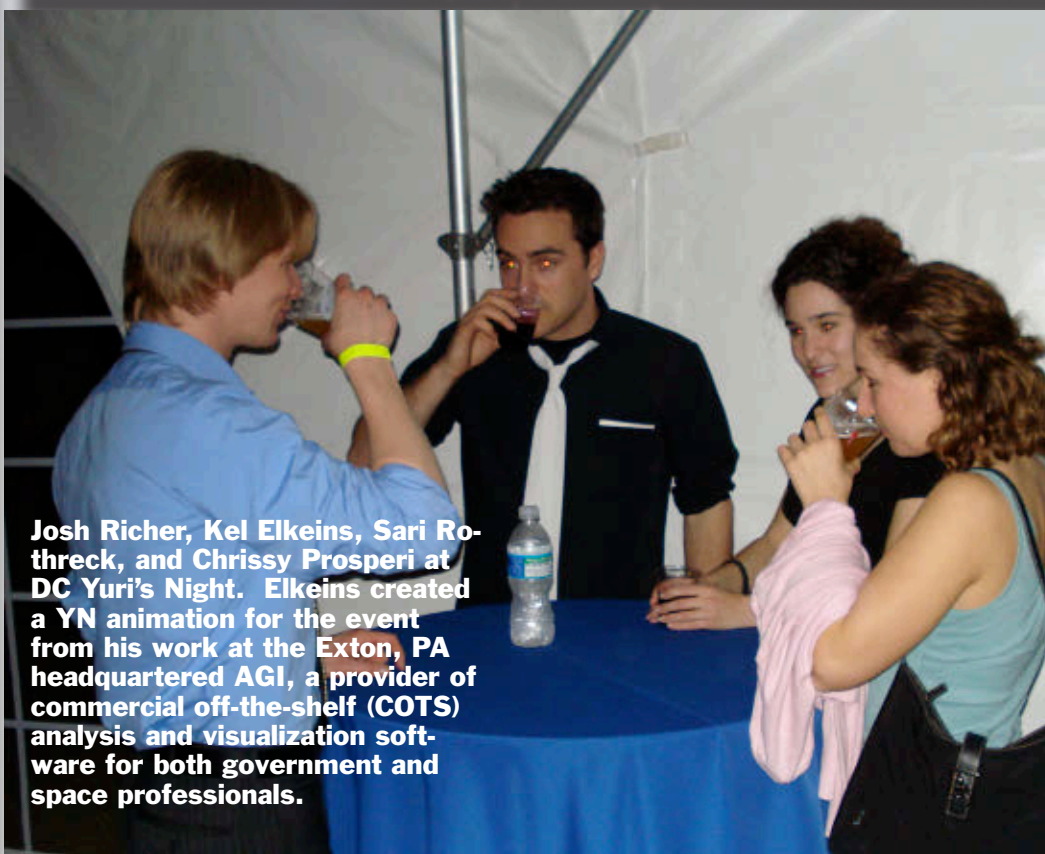
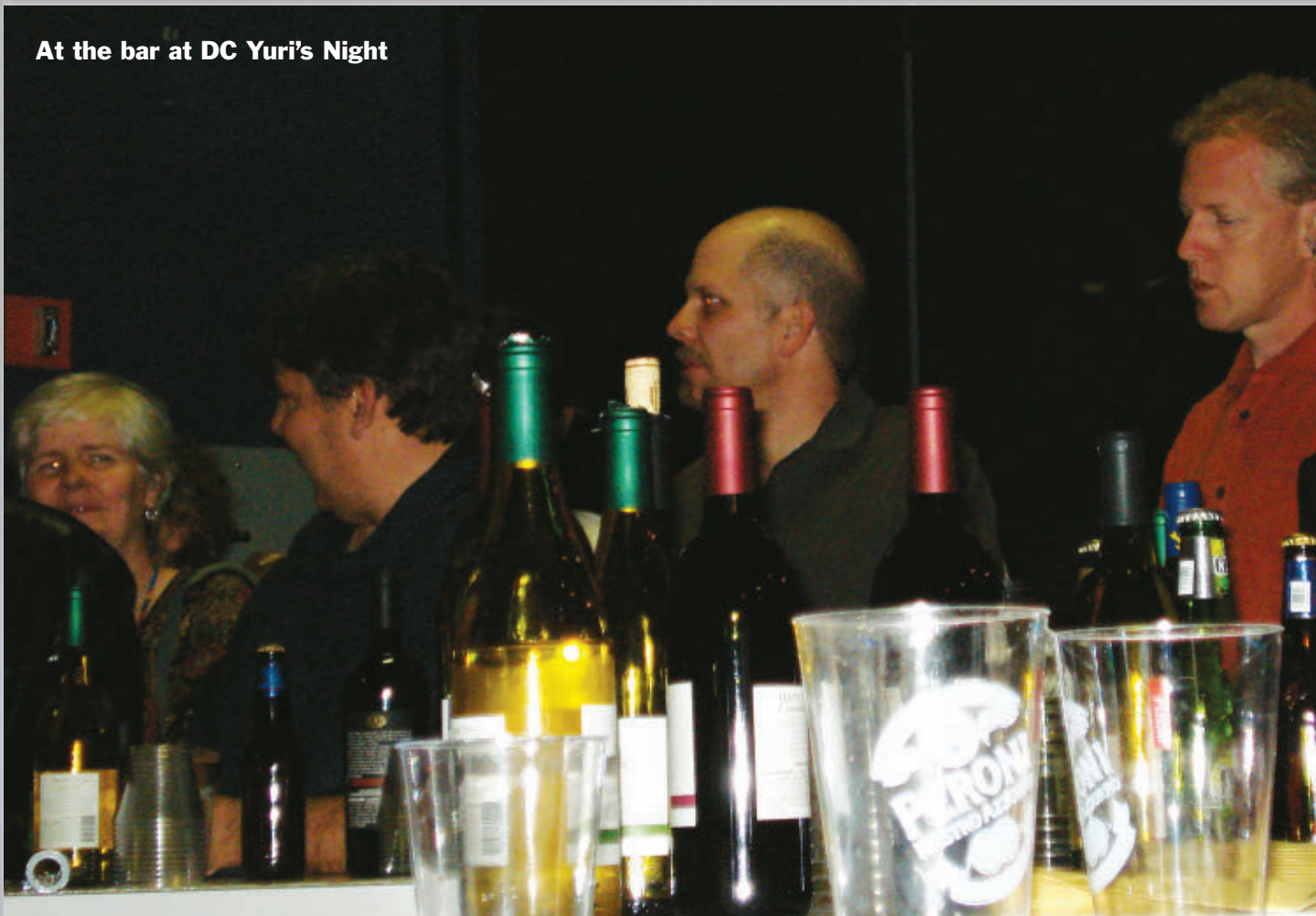


**Sunset behind the NASA Goddard Visitor's Center DC Yuri's Night.**





**At the bar at DC Yuri's Night**



**Josh Richer, Kel Elkeins, Sari Rothreck, and Chrissy Prosperi at DC Yuri's Night. Elkeins created a YN animation for the event from his work at the Exton, PA headquartered AGI, a provider of commercial off-the-shelf (COTS) analysis and visualization software for both government and space professionals.**



**DJ Nigel a.k.a. DJ Scientific a.k.a. DJ Goddard Scientist by day and DJ at night spins that wheel. The C... a rock band also played at the... sponsored by XM Satellite Radio**



**DC YN attendees gather at the Goddard Visitor Center entrance for a night of fun.**



Goddard

**DJ Nigel a.k.a. DJ Scientific a NASA Goddard Scientist by day and DJ by night spins that wheel. The Cassettes, a rock band also played at the event sponsored by XM Satellite Radio.**



**Besides dancing and drinking the night away, people who attended the event at NASA Goodard were able to watch video presentations and participate in the Visitor Center's interactive museum displays.**





### *SpaceShipOne: An Illustrated History*

by Dan Linehan  
Zenith Press, 2008  
Review by David Bullock

**S**paceShipOne: An Illustrated History provides a thorough account of the background, construction and flights surrounding the winner of the Ansari X-PRIZE. Author Dan Linehan details both technically and emotionally the facts and stories behind first private spaceflights ever.

In ten chapters, Linehan gives the history of the X-PRIZE along with the technical aspects of how SpaceShipOne and its rocket engine were constructed, with action-filled accounts how each of the test flights went up until eventually the Ansari X-PRIZE was won. These first hand-accounts are particularly interesting because the participants not only talk about a contest which was the first of its kind, but because Linehan discusses a spacecraft which nothing else has been constructed quite like it.

Around the story of SpaceShipOne, large, vivid pictures are given, making the coffee table, hardcover book enjoyable for either the engaged peruser or the light reader who flips through it.

While the beginning of the book really draws you in, the technical details could be a bit much for someone unfamiliar with aviation or engineering terms. The

book is also primarily on SpaceShipOne. Early conceptual and promotional images of SpaceShipTwo are provided, but early construction of the soon-to-be unveiled craft and its latest images are not included.

Thrilling quotes are prevalent and come from some of the dynamic people behind the story of SpaceShipOne, completing the book. These include statements from Diamandis and Ansari of the X-PRIZE, the three test pilots of SpaceShipOne, Brian Binnie, Mike Melvill, and Matt Stinemetze,

and the craft's designer and head of Scaled Composites, Burt Rutan.

This is the book on the first ever spacecraft to take someone into space other than a craft created by a government initiated operation.

It's truly one-of-a-kind.



## The Universe in a Mirror

by Robert Zimmerman  
Princeton University Press, 2008  
Review by Nancy Atkinson

It seems almost inconceivable now, but originally many astronomers doubted whether a space telescope should be built. Some were skeptical about the practicality of a telescope in Earth orbit or opposed it believing the costs and technologies needed could be insurmountable. Others feared such a telescope would take funds away from ground-based astronomy. But a group of strong-willed astronomers and engineers persisted, and sometimes sacrificed their careers or family lives, to build the first and only optical telescope in space—the venerable Hubble Space Telescope. Their stories are told in Robert Zimmerman’s new book, *The Universe in a Mirror*.

Zimmerman’s well researched and readable account of the early days of HST provides a pertinent and political history of the Hubble telescope and those who made it possible. As Zimmerman writes, “Stories of the unsung or forgotten heroes whose contributions to build Hubble should not go unmarked.”

But *The Universe in a Mirror* also provides the current status on the telescope, its scientific discoveries, and the potential future of Hubble and other space telescopes.

Of course the Hubble Space Telescope has revolutionized the field of astronomy with its astonishing scientific discoveries and perhaps most important, the incredible pictures of the far reaches of space, showing how those destinations would look to the human eye if we could actually travel there. Zimmerman relates how Hubble has changed the public’s perception of astronomy and science, as well as changing the way astronomers do their business. The book



details how Hubble has altered the way astronomers work with telescopes and each other, how it has changed the way astronomical results are shared with the public, and how it supplements other space and earth-based telescopes to make observations across the entire electromagnetic spectrum. As Zimmerman says, “Hubble epitomizes the inevitable and irresistible lure of the unknown.” Zimmerman focuses on the stories of the astronomers involved over the years with Hubble, and provides only a quick account of fixing the spherical aberration of Hubble’s

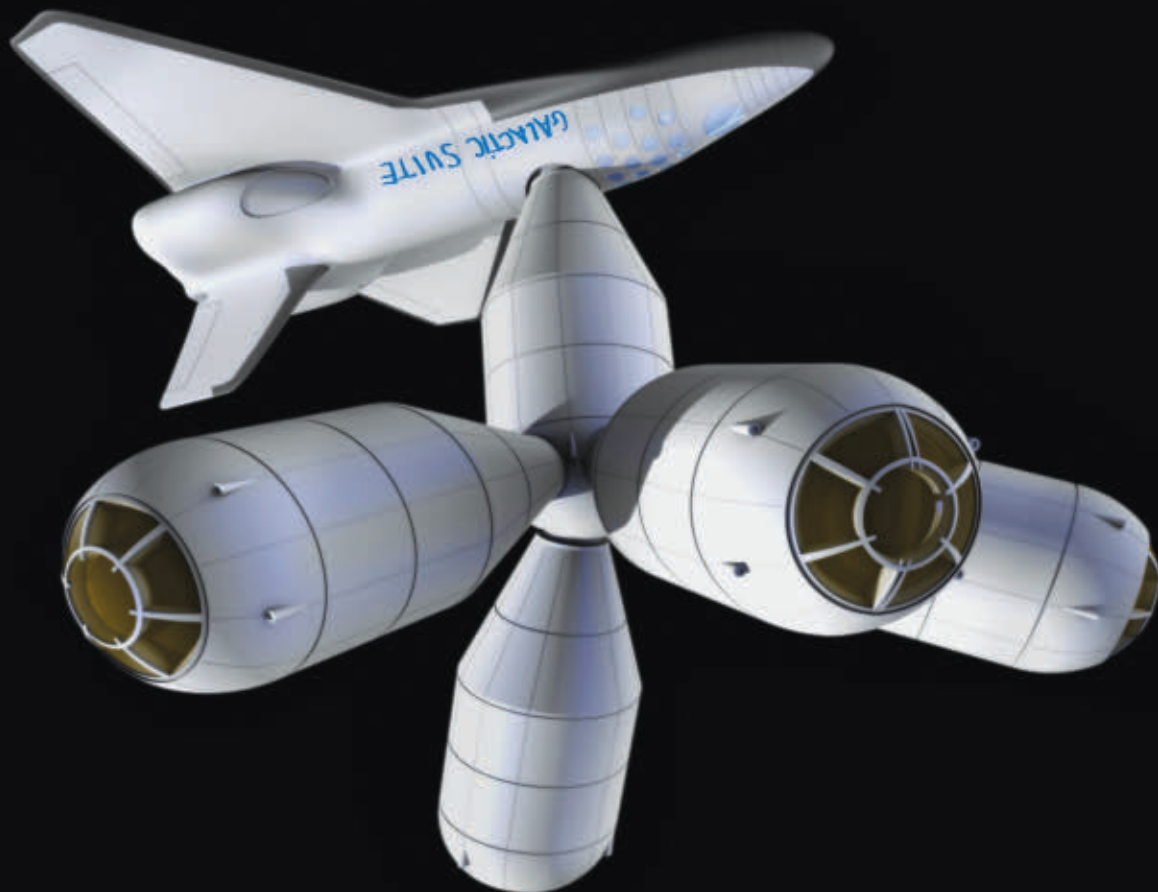
primary mirror, and subsequent servicing missions to the telescope, (details of these repairs can be found in other books) but uses the opportunity to point out the foresight of Hubble’s designers who made the telescope fixable and maintainable.

A later chapter discusses the outcry from astronomers and the public when it was announced that Hubble would be “abandoned” for shuttle safety reasons, and how that decision was reversed.

As we await the upcoming final servicing mission to Hubble later this year, the timeliness of this book is striking. As new generation of those participating in and following astronomy emerges, they may need to know the stories of those who went before; who made the field of astronomy what it is today, and on whose shoulders the next generation of space telescopes will stand.

Robert Zimmerman is a space and science journalist and author. His previous books include *Leaving Earth: Space Stations*, and *Genesis: The Story of Apollo 8*.

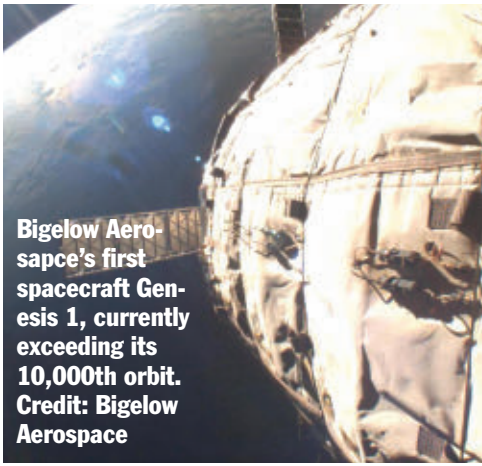




Artist's rendition of the Galactic Suite SpaceResort with a docked spaceship. Credit: Galactic Suite

# DESTINATION 2012:

**Bigelow Aerospace's first spacecraft Genesis 1, currently exceeding its 10,000th orbit. Credit: Bigelow Aerospace**



In 1968 the movie "2001: A Space Odyssey" offered a glimpse of the future. With a brief depiction of the fictional Orbiter Hilton, director Stanley Kubrick, author Arthur C. Clarke and hotel mogul Barron Hilton all seemed to agree that the future is epitomized by a space hotel. Just a year before the release of the epic film, Barron Hilton presented "Hotels in Space" at an annual American Astronomical Society meeting. He suggested there is only one way to establish an orbiting or lunar hotel: "Whether on earth, in space, or on the moon, [a hotel] should not be built unless there is a proven need for it. No hotel should ever be built that will cost more than it can earn." This feat probably sounded less complex in 1967 than it does today.

From what we have gathered over the last forty years of space endeavors, funding is only one of many requirements for a company to build and maintain an orbiting or lunar hotel. In short, it would need to design a radiation-proof, debris-resistant, architecturally-sound structure. Additionally, the builders would have to stay within the guidelines of the 1967 United Nations Outer Space treaty, as well as transport passengers

and cargo to and from the hotel, and even feed a demand for affordable, commercial space travel.

Humanity has, in fact, proven these capabilities already: we have defied gravity with rockets, built debris-resistant (or at least deterrent) spacecraft, found funding for innumerable space programs and initiatives and even established a demand for private space flight. Yet, Hilton and Clarke's 2001 vision is seven years past due—where are all the space hotels?

## Bigelow Aerospace

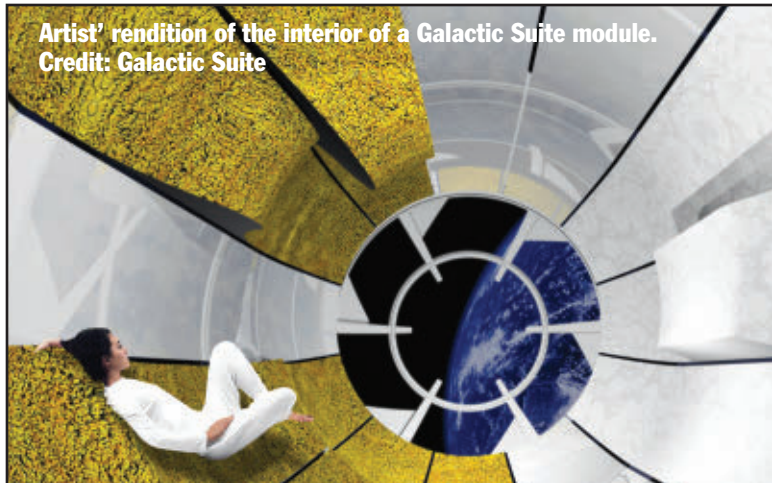
What began as crew quarters for the International Space Station turned into a dream of affordable space living for Robert Bigelow, owner of Budget Suites of America and founder of Bigelow Aerospace. TransHab, a concept originally proposed by NASA as a go-between during missions to Mars, eventually progressed into the privately-funded Genesis I. As of the date of this publication, Genesis I has been in space for two years, with more than 10,000 orbits around Earth. While Genesis I, and its currently-orbiting sister spacecraft Genesis II, are not capable of supporting a human crew, Bigelow Aerospace promises the Sundancer will be the company's first commercial space station.

Publicist for Bigelow Aerospace Chris Reed suggested that Sundancer and any future inflatable habitats can be leased as a space hotel but that they also have other applications, including pharmaceutical research, educational

use and materials manufacturing. Robert Bigelow specifically considers the company as "a wholesaler of destinations that clients can use for whatever purpose they wish," Reed said.

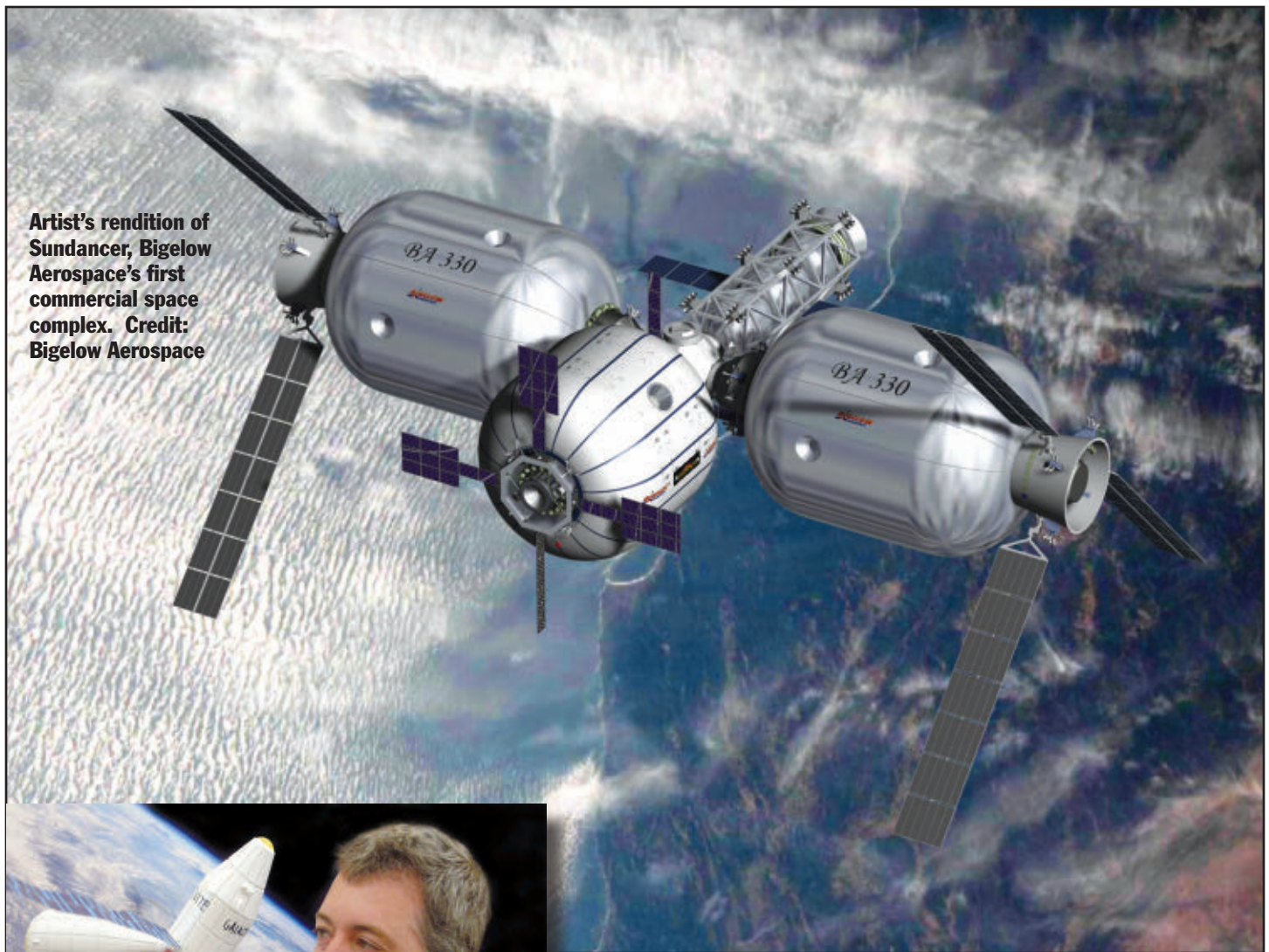
Regardless of its application, however, Sundancer sets itself apart by its

**Artist's rendition of the interior of a Galactic Suite module. Credit: Galactic Suite**



# HOTELS IN SPACE





**Artist's rendition of Sundancer, Bigelow Aerospace's first commercial space complex. Credit: Bigelow Aerospace**



**Founder and Director of Galactic Suite Xavier Claramunt poses with a model of his SpaceResort. Credit: Galactic Suite**

inflatable, durable construction, which allows for easy maneuvering and set-up. In "International Space Station History" on NASA's website, the 1997 TransHab design consisted of layers of insulation totaling up to a foot-thick. In between layers of foam, Kevlar and fireproof Nomex cloth, is Nextel, a material often used under car hoods for insulation.

But the most important aspect of these layers is the prevention of damage from space debris: "The Nextel and foam layers cause a particle to shatter as it hits, losing more and more of its energy as it penetrates deeper," wrote NASA. And with the prevalence of space debris, an orbiting hotel needs

to have the best protection available.

Nicholas L. Johnson, NASA's chief scientist for orbital debris at the Johnson Space Center and author of *Artificial Space Debris*, claims there are some 17,000 objects sized at or above 5cm routinely tracked by the U.S. Space Surveillance Network, not including objects larger than 1cm numbering in the hundreds of thousands. The population of objects larger than 1mm reaches into the tens or hundreds of millions. (See related article in this issue on space junk.)

"The fact that the first Genesis spacecraft has remained inflated nearly two years after its launch in July 2006 confirms, at least in part, the ability of the vehicle to withstand the routine small particle impacts, which occur on a daily basis," said Johnson. The region of space selected for space hotel development was chosen because of the low debris accumulation, Johnson continued; but irregardless, all human habitations should have a solid defense

against the stray meteoroid.

While debris protection is obviously one of the most pressing concerns in space hotel development, it certainly is not the only limitation. The transportation of cargo and guests to and from the hotel poses a particularly pressing obstacle. Bigelow Aerospace has not made any recent announcements, but in a February 2008 press release, they announced negotiations with Lockheed Martin: "I don't think anyone could deny the excellent record and pedigree of the Atlas V401 as a quality choice to be upgraded to carry human passengers," Robert Bigelow said in the release.

The price tag? An April 2007 Wired Science article reported that a four-week stay on Sundancer would cost \$15 million, and the hotel will be open for business by 2012, as stated by Bigelow in a symposium.

## Galactic Suite

One company focusing on exclusively developing a space hotel is the Barcelona-based company Galactic Suite, set to open December 2012. The company also has not specifically named a transportation company. However, Marc Zaballa, the chief architect for Galactic Suite, said many projects are underway to develop private spaceflight vehicles.

"Galactic Suite has decided to monitor the progress of vehicle developers and to negotiate directly with suitable candidates," he said. According to the Galactic Suite website ([www.galacticsuite.com](http://www.galacticsuite.com)), a space vehicle will remain docked at the hotel while there are guests on board, probably to alleviate any fears. This unique concern for customer comfort is the focal point of the hotel's design and basis for the pre-flight retreat on a private island that lasts several weeks.

"Galactic Suite has developed an integrated



**A NASA diagram of the original TransHab design. Credit: NASA**

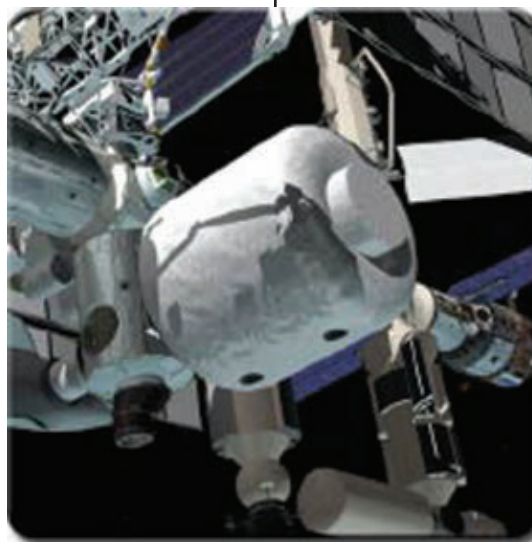
project proposal including ground, launch and space elements with [an] emphasis on the end-user experience," Zaballa said. "The company is therefore focusing on every action in each of these segments of the mission to understand the needs, dreams and feelings of the space tourist and offer him the ideal environment, both physical and psychological, wherein to maximize this unique experience."

For Galactic Suite, it is more of an "experience" than just a stay in a hotel, a mission even Barron Hilton could have agreed with. Take, for example, the molecule-like structure of the hotel which is designed to grow and develop in a seemingly natural manner.

"The general configuration of the orbital hotel,

Galactic Suite SpaceResort, is inspired by the growth of biological species that group together in close radial arrays," Zaballa explained. "The concept for the space resort is that of a small mountain refuge, not growing more than five modules, [in that it] provides better views towards the Earth for all the suites."

According to Zaballa, the island training, transportation to and from the resort, and four to six day orbit would cost 3 million euros, or roughly \$4.8 million.



**The original TransHab design as it was intended originally, as ISS crew quarters. Credit: NASA**





Cross section of the TransHab. Credit: NASA

bathing conditions, food preparation and even the eventual demise of such a large satellite. According to Johnson, “reentry plans must be made for all large objects in low altitude orbits.” He suggested that the current standard for such a spacecraft is “de-orbiting over uninhabited regions of the Pacific Ocean,” in a fashion similar to the recent engagement of the USA-193 spacecraft.

## Alternatives to Orbiting Space Hotels

Even in 1967, Hilton saw the necessary progression of humans to space: “Perhaps we’d better learn to walk before we run, so let’s begin with the Orbiter Hilton,” he said in his speech. But just because orbiting hotels are on the forefront of space development, doesn’t mean other locations aren’t being considered.

Take, for example, Project Constellation, NASA’s new program aimed at creating a lunar outpost and exploring the possibility of inhabiting other planets like Mars. Many government-funded and private organizations, such as the Google Lunar X Prize, have recognized the utility of the Moon and are tapping into this resource.

One company, MoonEstates, already is selling lunar property. According to their website ([www.moonestates.com](http://www.moonestates.com)), owner Francis Williams has found a loophole in the UN Outer Space Treaty that prevents a nation, but not an individual, from owning the Moon. On this premise, MoonEstates is selling one and ten acre plots of lunar, Martian and Venusian land. Director Angela Young estimated some two million plots of celestial land have been sold globally by MoonEstates.

Galactic Suite also has considered the possibility of alternative locations but claims “further steps [in] that direction—Moon, Mars—should be backed by previous experience where technologies, but also the society, will get prepared for other options,” Zaballa said.

As we are four years away from the scheduled opening of Sundancer and the Galactic Suite SpaceResort, we can assume that orbiting hotels will pave the way for space habitation. It appears space hotels are no longer just the stuff of dreams or futuristic movies.

## Orbiting Space Hotel Limitations

While there are many hurdles on the path to inhabiting orbital space, Zaballa suggested that there is, at least, a demand for the industry. “Studies carried on by Futron predict an estimated demand of some 4000 customers a year for orbital space tourism by 2025,” he said. Futron is a decision management company specializing in the aerospace industry.

Other foreseen obstacles, such as space debris, have been addressed by both companies. Galactic Suite has assessed the risk of space debris and micro-meteoroid collision and determined the threat is low. “Tracking stations on Earth provide data of the space debris that will allow maneuvering the hotel to avoid the impact,” he continued. As for funding, Galactic Suite cannot reveal the details just yet, but an August 2007 Reuters article reported talks with private investors from the United States, Japan and the United Arab Emirates.

Also, there are the legal issues that space hotel pioneers must consider. But international space regulations are currently in their infancy. This has caused the early space hotel companies to contribute actively in current talks. Galactic Suites specifically has participated in “current UN Outer Space Treaties and legal considerations affecting licensing, national sovereignty, risk management and environmental impact,” Zaballa said.

Other limitations in the development of orbiting space hotels include toilet operations, sleeping and



Katie Kline earned a Bachelor’s in psychology and in English from West Virginia University where she developed an interest in the space community through astronomy writing. She currently focuses on public affairs, freelance science writing and graphic design.

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# XCOR Aerospace:

By Nancy Atkinson

Artist's conception of  
XCOR's Lynx in flight.  
Credit: XCOR Aerospace



“If

you're going on the ride of your life, would you rather be up front like a co-pilot or in back like cargo?" asked Doug Graham, spokesman for XCOR Aerospace in California, the latest company to throw their hat into the space tourism/personal spaceflight ring. A few months ago, XCOR unveiled plans for their suborbital vehicle, called the Lynx and touted two major

selling points: a lower price for a ride to space than the competition, and an extremely personal "personal spaceflight" experience. The Lynx has just two seats; one for the pilot and one for a passenger.

"What a life-changing experience it will be," said XCOR test pilot, and former space shuttle commander, Col. Rick Searfoss, "to come



# Economy Class Space Tourism for a First Class Company

screaming off the Mojave Desert, home of the most amazing flight test projects the world has ever seen, and climb vertically through the same airspace where humans first went supersonic, all the way to the edge of space and beyond. And the best part of it all is that you'll ride right up front."

Everyone at XCOR knew the company would have to offer something unique in order



**Pilot Rick Searfoss in the cockpit of the EZ Rocket.**  
Credit: XCOR

to compete with their neighbors at the Mojave Spaceport, Virgin Galactic. "Everybody knows the target to aim at is Virgin," said Graham. "They have a brilliant design, their vehicle will go higher than our Lynx, and passengers will be able to float around in the cabin. But on the other hand, theirs will probably cost passengers twice as much to fly and you don't get that immediate, sitting up front, fighter pilot experience."

Graham said the market will decide what people want, whether it's economy and a one-on-one, pilot-to-co-pilot experience, or a longer, higher ride with the ability to leave your seat. "Since we never figured we'd be first on the market, we designed ours to have very low operating costs so that the people selling the tickets will have the

**XCOR President Jeff Greason and Pilot Rick Searfoss check out the EZ Rocket**  
Credit: XCOR





**Top left: EZ Rocket in flight. Credit: XCOR**



room to price the tickets aggressively.”

XCOR’s price per ticket for the first flights has been estimated at \$100,000. While not exactly cheap, it is half of Virgin’s \$200,000 price tag and extremely competitive with Rocketplane’s price of \$250,000 per passenger. XCOR won’t sell tickets themselves directly to consumers, and is not naming a price for its ride. Instead, the company will offer wholesale packages to adventure travel companies, which will set the price for customers.

2010 is XCOR’s target for their first test flights of the Lynx. The flight plan has the Lynx taking off horizontally like an airplane from the Mojave spaceport runway, but quickly going vertical and shooting up to 61 kilometers (37 miles) above the Earth, and coasting at apogee for over 4 minutes of a microgravity environment and a spectacular view of our planet. Then the vehicle heads into re-entry, putting passengers through a maximum of 4 G’s at pullout, then gliding and circling back to the runway where it all started. The flight lasts 30 minutes.

And if XCOR can stick to their schedule in having the Lynx ready to go in two years, who knows, said Graham, they might even be the first to provide paying passengers the ride of their life.

### **The XCOR Way of Doing Business**

XCOR Aerospace has been around for almost ten years. Their plan has always been to take incremental steps of first building rocket engines and pumps they knew would work reliably and efficiently, and then moving on to build a vehicle. “We’ve always taken baby steps,” said Graham. “The first rocket engine we built was designed to show people you can make an engine that can be turned on and off, lots of times, reliably. Because without that, the rest of it doesn’t happen.”

Then XCOR decided they needed to prove that airplanes could be flown with these engines. “So we built the EZ-Rocket which was, ironically enough a Burt Rutan [of SpaceShipOne fame] Long EZ kit plane that had its engine blow up,” said Graham, “so we got it and put two 400 lb

**XCOR President  
and CEO Jeff  
Greason**



thrust rocket engines on it and set a point to point distance record for a rocket propelled aircraft. Then the next step was we needed to have a new pump for the engine, which was a key part of our technology."

XCOR has designed several different engines of various sizes, from 15 to 7,500 lbs of thrust, using a combination of either methane, alcohol or kerosene combined with liquid oxygen (LOX). In 2005 they won a contract along with ATK to build a 7,500 lbf LOX/methane engine for NASA's Crew Exploration Vehicle (CEV). Other spaceflight entities use XCOR-built engines, too, for various purposes. "We have a 50 lb thrust class engine that can be used for reaction control, the things that keep your spacecraft oriented correctly," said Graham. "Today most people use hypergolic engines, the ones that mix two chemicals and they immediately ignite. One of the big advantages to that is they are simple. You pump it into the chamber and, boom, it goes. But you can't turn them off. Ours can, and ours are non toxic."

"We've said all along that this company is in the business of developing and

producing safe, reliable and reusable rocket engines, rocket propulsion systems, and rocket powered vehicles," Graham continued.

XCOR has also developed a vehicle to be used in the Rocket Racing League. Their Rocket Racer comes from an evolution in the design of the EZ-Rocket, and is based on an airframe created by Velocity of Sebastian, Florida. The airframe has been modified to carry XCOR's XR-4K14 engine, a 1,500 lb thrust rocket engine, which burns LOX and kerosene. Searfoss will be flying the Rocket Racer at the first Rocket Racing League demonstration at the airshow in Oshkosh, Wisconsin on July 28- August 3, 2008.

Again, their work is incremental. "The lessons we learn from the Rocket Racer will be used on the Lynx," said Graham. Four of those same

**Searfoss ready to pilot the Rocket Racer.**  
**Credit: XCOR**



**41k4 engine (used on both the Lynx and Rocket Racer.**  
**Credit: XCOR**



4K14 engines will be used on the Lynx.

The Lynx is the first vehicle where XCOR has designed the entire vehicle, from the engines to the airframe. "At first we wanted to concentrate on the engine and propulsion system parts, so we used existing airframes," said Graham, "the idea being that you're biting off enough with the technology, so you just have to work on getting the engines right and let someone else do the work of building a good airframe."

Flying the Lynx, said Searfoss, will be a unique experience. Searfoss has flown three space



shuttle missions in addition to flying over 50 different types of aircraft. While normal operations for the space shuttle call for computer control during the entire ascent, and also during reentry until just before landing, the Lynx will be “hand flown” for the entire flight.

“The Lynx will be hands on from ignition to wheel stop,” said Searfoss in an email response to questions about his experiences with XCOR. “The Lynx will be unique with respect to performance from any other aircraft I’ve ever flown. However, from a crew factors viewpoint with a very dynamic flight environment, I’m glad our design will allow for side-by-side seating like the F-111 Aardvark attack aircraft I flew several years ago.”

XCOR CEO Jeff Greason believes the Lynx’s design will provide for reliability and low operating costs. “We have designed this vehicle to operate much like a commercial aircraft. Its liquid fuel engines will provide the enhanced safety, durability, reliability and maintainability that keep operating costs low,” he said. “These engines will also minimize the impact of these flights on the environment. They are fully reusable, burn cleanly, and release fewer particulates than solid fuel or hybrid rocket motors.”

Obviously, the Lynx is smaller than the six-passenger SpaceShipTwo being built by Virgin Galactic, and the four-passenger Rocketplane XP.

“The reason we chose a small vehicle is so we can get a lot of these things down and worked out right with a minimum of technological challenges,” said Graham, “because the bigger it is vastly multiplies how much fuel and power you need to generate to get it up to space. In many respects the Lynx Mark 1 will give us the lessons we need to build the bigger Mark 2, which will help us build a larger and more capable suborbital vehicle and eventually an orbital vehicle.”

The Mark 1 is, of course the first version of the Lynx, and Mark 2, will be an improved version, working out any possible kinks, but on the outside, probably won’t change very much. “They might be the same size, maybe we’ll have to tweak the aerodynamics,” said Graham. “We may add an additional engine, more advanced composites in construction to give it a little more thermal protection, cut the weight so it can go faster and higher, and boost the performance. We’ll just see how everything goes.”

In returning to comparing the Lynx to the rest

of the personal spaceflight field, Graham said, “On the face of it, comparing ours to Virgin, they have a pilot and co-pilot and four passengers. But we don’t have a mother ship that we also have to maintain in addition to the rocketship, so we don’t have that maintenance cost. The other advantage we have is with a liquid fueled ship, you just gas them up and go, where as with hybrid solid fuel, you have to replace the solid fuel part of it with every flight. That means you have to put wrenches on it, and every flight is a maiden flight for that particular engine. That’s why we think we’ll have very competitive operating costs.”

Graham said Rocketplane, Virgin and even Arianespace’s vehicles are more similar to each other than they are to the Lynx. “They are multi-passenger vehicles,” he said. “The engines planned for Rocketplane and Arianespace are almost identical. Those have about a twenty-flight life span. We don’t know exactly how long ours will last, but it will be a lot longer than twenty flights.”

But XCOR believes there will be enough room in the space tourism market for people who want different experiences at different price levels. “The market will decide,” Graham said. “We hope that Virgin or the others may eventually buy some of ours and fly them.”

And if the market demands a multi-passenger vehicle, XCOR will eventually go in that direction. “That’s one of the advantages of building small,” said Graham, “it’s usually easier to go bigger. If there’s a market for a larger suborbital, we’ll build it, using the lessons we’ve learned with the Mark 1 and Mark 2. If it turns out that it’s better to start moving forward for the fully orbital, we’ll do that. It could be there will be a market for both.”

With more commercial spaceflight companies in the mix, will that mean competitive, or even lower prices for consumers?

“I would suspect much like iPhones and flat screen TVs, the first series of flights will command the most money,” said Graham. “You’d have a downward pressure of the prices even if it was just two companies, but more will accelerate that process.”

Greason agreed. “I don’t think it will ever be dirt cheap,” he said, “but I wouldn’t be surprised over several generations of vehicle development to see it come down to the price of a cruise.”

# Rocket Racing League Press Event Greet New York

by David Bullock

**T**he Rocket Racing League (RRL) hosted a press conference for the major space and mainstream media outlets at New York City's Yale Club on April 14<sup>th</sup>, 2008. RRL is a NewSpace organization that bills itself as a "new entertainment sports league that combines the exhilaration of racing with the power of rocket engines." RRL hopes to be a NewSpace version of the Indy 500 or Formula One.

Representatives of the organization spoke at the event, including Rocket Racing League CEO Granger Whitelaw, X PRIZE Chairman and CEO Peter Diamandis and Armadillo Aerospace founder John Carmack. The event outlined parts of the business plan for the Rocket Racing League, and intended to let the New York media get to know more about the upcoming self-described "NASCAR of the skies."

At the event, actor Timothy Hutton, who says he is in business with Whitelaw in the areas of film production and real estate, had described the Rocket Racing League as "Ferraris in the sky. These are race cars with wings. Very agile... I've seen firsthand the avionics and I've never seen anything like it on a car or a plane."

While each of the individual teams comes from different commercial space companies, each will try to raise its own funding and sponsorships. The event, however is owned by the Rocket Racing League. There are six teams of pilots and crafts so far. Pilots have worked for either private enterprise, military or both. Planes previously flown by these pilots include an E2-Hawkeye, F-18 Hornet and T-2s.

The Rocket Racing League pilots include Jim Bridenstine, Bryan Schwartz, Todd White, Paul Novacek, Rick Searfoss and Dave Morris. Each of these pilots run a team whose names include: Unlimited Air Racing Team, Sante Fe Racing Team, Rocket Star Racing, Brindenstine Rocket Racing, and Xtreme Rocket Racing.

Those at home can play with the Rocket Racers on a computer as The Rocket Racing League offers a virtual reality game, in which a simulated computer aircraft can fly along with the real-life racers on screen.

Why participate in the Rocket Racing League? The answer, according to rocket racer Bryan Schwartz is simple for him and for those who even partake on the computer, "To be competitive with the future of space exploration."

For more information on The Rocket Racing League go to: <http://www.rocketracingleague.com/>



**Jim Brindenstine from team Brindenstine Rocket Racing, Rocket Racing League CEO Granger Whitelaw, and actor Timothy Hutton stand before a poster touting the league at New York's Yale Club. Photo Credit: David Bullock**



## XCOR's Reputation

Over the years XCOR has gained a reputation of building solid, reliable products while running their business in a fiscally sound way and never promising more than they could deliver.

Derek Webber, the Washington DC director of Spaceport Associates, an organization that helps commercial space companies with such things as business planning, government regulations, and legal matters, expressed the respect that XCOR has earned among its peers. "We at Spaceport Associates are firm believers in the viability of the space tourism business, and have long regarded the management of XCOR Aerospace with a great deal of respect, and feel confident that they will continue their steady building block approach to space tourism until they achieve success," Webber said in an email. "The company will be successful because they have realistic plans, and each stage of their growth pulls in its own revenue contribution. They make quiet, steady progress, and are definitely heading into space."

Webber said their market data makes clear that customers are out there awaiting their own opportunity to view Earth from space, and XCOR's offering could well be one of the first to make this possible for more people, and not just millionaires.

XCOR's vision and their way of doing business is what drew Searfoss to the company. "I first connected with XCOR when they were preparing to do their first flight of the EZ Rocket several years ago when they only had 6 or 7 employees," he said. "I saw a little news item on the internet, researched it some more, liked what I saw, called them up and said, 'Hey you don't know me, but I used to fly spaceships and I'd love to meet you guys and learn more about what you do.'"

Searfoss stopped in at XCOR one day, and they fired up a few engines for him. He was instantly hooked. When he left NASA to start his



**Searfoss during NASA space shuttle mission STS-90**  
**Credit: NASA**

own consulting and speaking business, he initially served on XCOR's board, and eventually moved into a test pilot role.

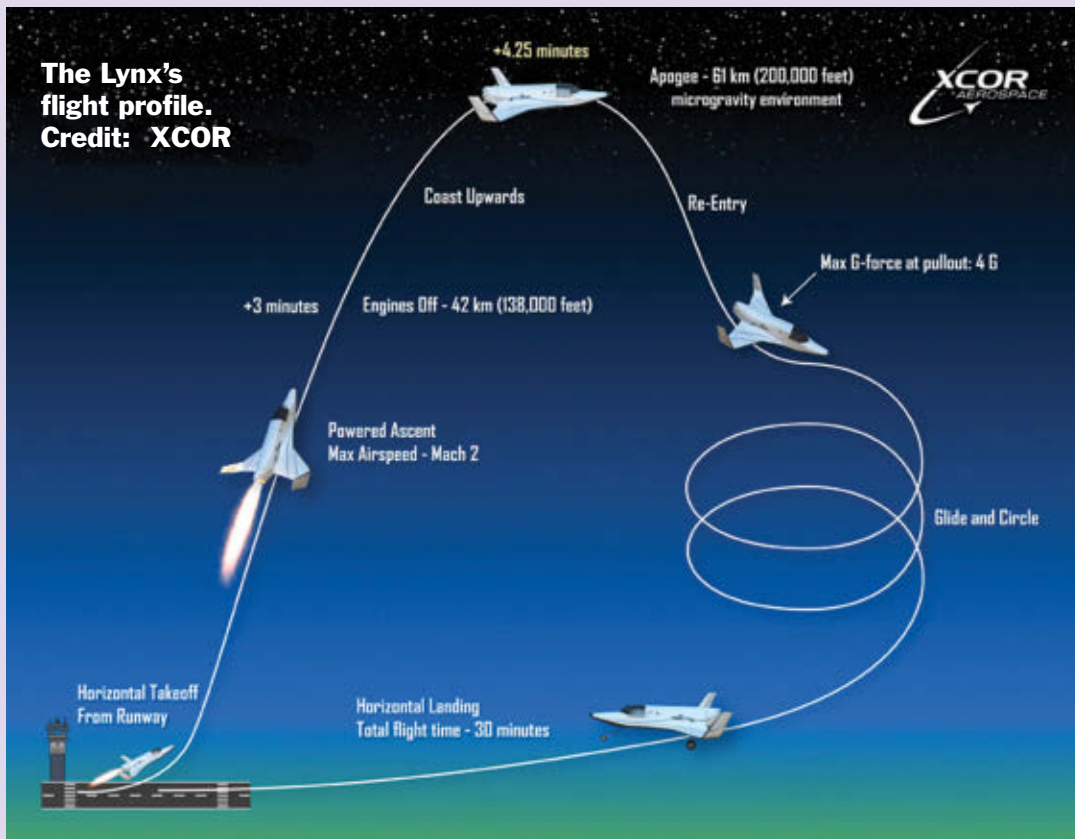
Searfoss said his goals coincide exactly with XCOR's. "We intend to open up access to space with steady, incremental technical

developments along a path that includes winged, piloted, recoverable vehicles," he said. "Additionally, given that I've had the great privilege of living and working in space for 39 days on three missions, I feel a compulsion to share that experience with others either through my corporate speaking (see [www.astronautspeaker.com](http://www.astronautspeaker.com)) or activities with XCOR to develop the capability for more people in the future to enjoy what I've enjoyed."

When asked if he thought it is taking too long for space tourism to become a reality, Searfoss disagreed. "I, and other technical experts who really understand how hard this business is, never thought that space tourism was right around the corner," he said. "Unfortunately there's excessive hype, even a few snake oil salesmen in this exciting business who say some overly optimistic things and tend to set expectations too high. I personally have gotten pretty fed up with some of the hypemeisters out there and am now very careful to steer clear of those types and only affiliate with the solid technical experts who have realistic, achievable business plans, like XCOR. Difficulties boil down to essentially two very broad categories: physics and business plans to capitalize the effort to work within physical and engineering realities to develop real capabilities."

Although XCOR's projected lower fares for consumers have been called "economy class" by the media, Searfoss says he doesn't really care for that term. "Of course my philosophy is that the only true first class seat in any flying vehicle is one with controls in front of it!" Searfoss said.

**The Lynx's  
flight profile.  
Credit: XCOR**



"I consider Lynx more the "right stuff" class," he continued. "Regardless of the price, it will be a different experience to ride in back with several other passengers and look out a dinky porthole compared to sitting right up front in what is essentially a crew position, with a great view and all the displays right in front of you. Nothing "economy" about that! Now if we can offer it at a price point below others due to reduced operations costs from a more efficient design of the overall system configuration and approach, so much the better!"

### Additional Services

XCOR also foresees a market for carrying experiments; taking out the passenger seat out to place an experiment rack, bringing research to space that might otherwise use sounding rockets. And there might even be a market for the daredevils out there.

"I personally believe you're going to see some

people who will look at the Lynx and say, 'I want to skydive out of that thing,'" said Graham. He said they already had a few people approach them about the possibility. The Lynx's canopy has the ability to be opened and shut again during flight. The "space divers" would need a pressure suit and of course, a parachute. Such a jump would definitely set a new free-fall record, another adventure of a lifetime.

Another option that might be available with opening the spacecraft during flight might be a little more somber. "I could see someone taking their loved ones ashes up to space and scattering them," said Graham. XCOR is hoping to offer that option.

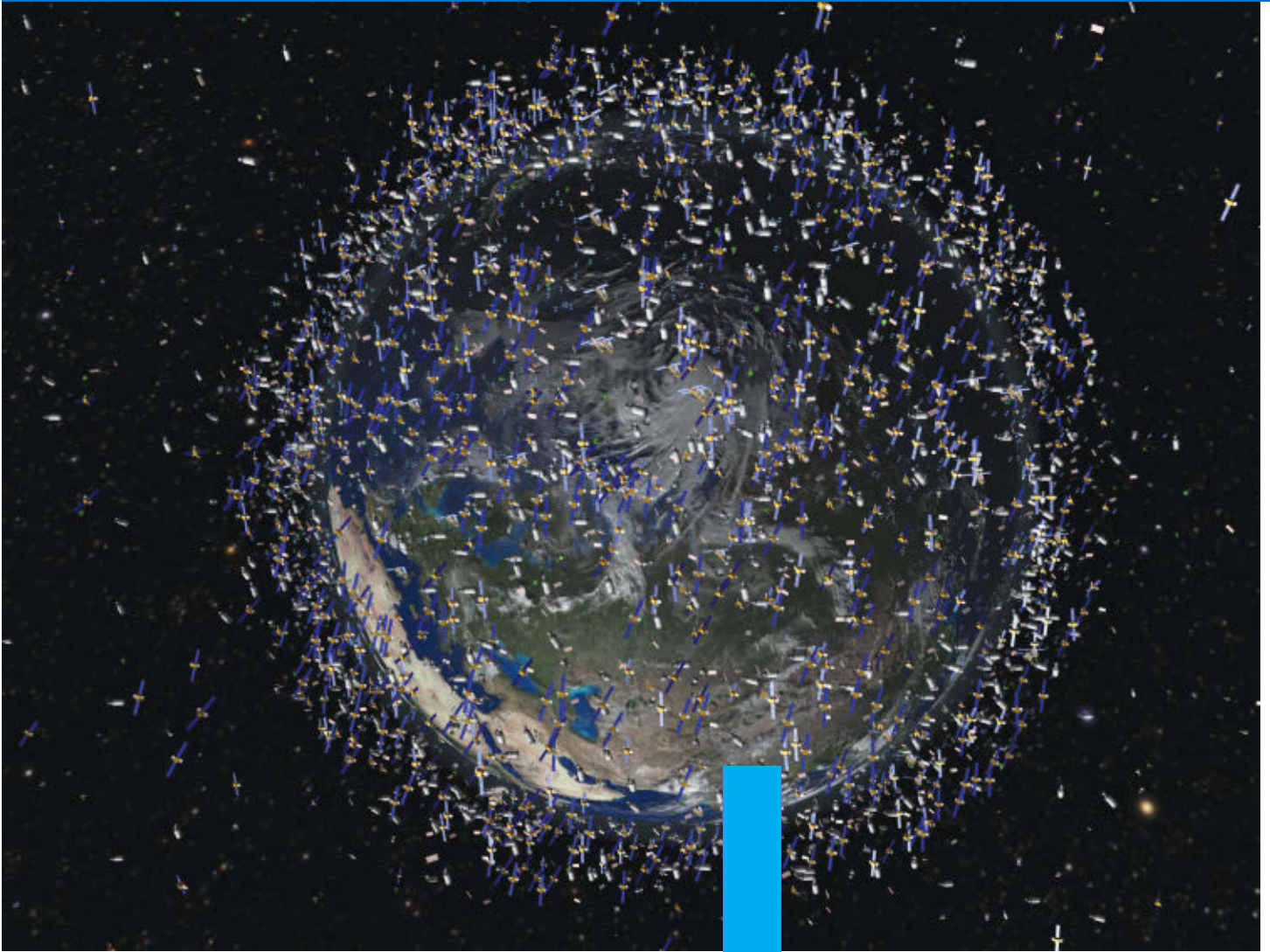
Just like everything at XCOR Aerospace, the sky is the limit.





# Space Junk

By Michael Ricciardi



**Human made orbital debris is becoming a growing problem for future space missions.**

In 1996, an upper stage of a Pegasus rocket launched two years earlier, exploded—generating a cloud of some 300,000 debris fragments. This incident holds the record for the most debris generated by the destruction of a space craft while in orbit. The resulting fragments—ranging in size from a few millimeters to well over a meter—doubled the risk of collision with the multi-billion dollar Hubble Space

# The Forgotten Legacy of the Space Race

Telescope, which shared a close orbital band with the rocket stage.

“Space junk”—more prosaically called “orbital debris”—is our legacy of 50 years of space competition and exploration, beginning with the launch of Sputnik I by the Soviets in 1957. The primary contributors to space junk accumulation are launch vehicles, “post mission disposals” (single purpose craft or sections,) explosions (of fuel tanks or reactor cores, and collisions.

Most earth-bound folks are reminded of the existence of such debris only during fleeting moments of fiery, atmospheric break-ups, or, as happened this past March, 2008, on rare occasions when the military chooses to shoot down a dysfunctional satellite. This “shoot down” in low Earth orbit (LEO) occurred because it was believed to pose a hazard to earth dwellers due to its unspent hydrazine fuel, should it reenter the Earth’s atmosphere (although later reports suggested its destruction was due to its possessing “sensitive” technology). There was also the occasion in 2005 when a Chinese made CZ-4 missile exploded after hitting a Thor rocket stage in LEO—a rocket that was launched in the 1960’s.

Much orbiting junk eventually ‘decays’ and often disintegrates from intense heating as it enters the atmosphere, although the time taken for this to happen can be many decades—it depends on the object’s altitude, speed, and ‘drag’ (its friction with the atmosphere). Occasionally (more often than we might suppose), a small or sizable piece of junk passes through the atmosphere mostly intact and makes it to Earth. Since the Earth is 75% ocean/water, these tend to fall harmlessly in the sea. But not always; there have been a good many examples of large pieces of space debris falling on dry land—if rather remote lands. This especially true of launches from Russia’s Baikonur Cosmodrome

launch site in Kazakhstan. Rarely, animals or people are hurt, or property damaged.

“Orbital debris is a problem that is slowly creeping up on us,” warned Dr. William Ailor, director of the Center for Orbital and Reentry Debris Studies at The Aerospace Corporation. “For almost 50 years, humans have been lofting objects into space, and unfortunately the population of orbiting objects has continued to grow. Most of the objects now orbiting Earth are debris – dead satellites, fragments of exploded stages, and the like – and some of these will remain in orbit for hundreds of thousands

of years. Maneuvers by operational satellites to avoid an object predicted to come unacceptably close are becoming more common, and even though collisions of tracked objects are rare (we’ve had only three since the beginning of the space age),

## FACTOID:

**To date, the only reported collision of two tracked objects took place on July 24, 1996. In this incident, a French Cerise satellite was hit by a large fragment of an Ariane H-10 rocket stage and a boom on the spacecraft was broken off, although the craft was still able to function.**

models predict that collisions will become more of an issue in the future.”

## What’s the Real Risk?

The real, persistent problem comes from space junk possessing an orbital speed and altitude band that may place it on a collision course with other pieces of debris, or more critically, operational spacecraft. When this happens there ➔



is the potential for a 'catastrophic' collision – a near, to complete, breakup – which generates even more dangerous debris in the process. Sometimes, a collision is 'non-catastrophic,' resulting in a non critical hole or dent in the spacecraft.

A 2006 article from the Associated Press, entitled 'Space Debris a Growing Problem', cited 9,000 pieces of space debris larger than 10 cm (four inches). Other subsequent reports have cited a figure of 13,000 objects. The variance in debris estimates may stem from differing assessments of the debris population, that is, the inclusion of different size ranges. Currently, orbital debris greater than 10 cm (4 inches) is tracked by the U.S. Space Surveillance Network. Space Lifestyle Magazine recently contacted NASA's Chief Scientist for Orbital

Debris, Nicholas L. Johnson, and asked him for a more precise estimate. "The number of known orbital debris 10 cm or larger is on the order of 17,000," stated Johnson. "The number of assessed debris 1 cm or larger is on the order of several hundreds of thousands. The number of debris 1 mm or larger is clearly many millions."

Scientists recently calculated that on average, the speed of a typical piece of space junk is about 8 km per second. This is nearly 30,000 mph. Most junk is less than 4 inches/10cm in size and is nearly impossible to track. Even a pea-size piece of metal debris, traveling at faster-than-a-bullet speed, can critically damage a spacecraft, even destroy it if it penetrates a fuel cell or propellant tank, and certainly can cause lethal injury if it strikes an unfortunate astronaut who happened to be doing repairs on a solar panel at the time. Such a pea-size piece of junk has the impact equivalent of a 400 lb. safe traveling at 60 mph. Significant damage would result, at the very least. A larger piece – say, the size of a golf ball – would possess an impact equivalent to more than a dozen sticks of dynamite, and would be lethal for anything in its path.

But space scientists like Johnson generally have a less alarmist, view of the problem. "Most spacecraft can be shielded against the effects of collisions with debris 1 cm or smaller," explained Johnson, "although many spacecraft are vulnerable to debris as small as a few millimeters. Collision avoidance maneuvers are an option for the 10 cm and larger population. Therefore, the inherent risk to spacecraft could generally be confined to the 1-10 cm size regime. Future improvements in space surveillance and in shielding technologies might close that gap further."

The difficulty there, of course, is tracking objects less than a few centimeters in size. Such fragments are virtually invisible to our current tracking technologies.

Quite recently, astronauts doing repairs on the International Space Station Alpha lost a tool or two to space, and there is an image circulating on the Web of an unidentified, 'ribbon-like' piece of debris believed to be shed from a Russian

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**Dr. William Ailor is the Director of the Orbital Debris Project at The Aerospace Corporation.**



Progress cargo vehicle. Fortunately, the majority of debris is located at higher altitudes than what the ISS currently occupies [it orbits at roughly 250 miles,] but this simple accident or others like it could potentially pose a significant hazard to the ISS in the future. However, Johnson downplays any serious risk to the ISS. "The International Space Station is the most heavily shielded spacecraft ever flown," asserted Johnson. "Most of its critical components can withstand impacts from debris as large as 1 cm. The ISS also follows a collision avoidance process for larger [tracked] objects, and to date has conducted several collision avoidance maneuvers." Regarding these recent repair accidents and their future hazard potential, Johnson elaborated: "Objects released, intentionally or unintentionally, from ISS normally have orbital lifetimes of about 4-6 weeks or less. Within a few hours or days, they have dropped below the orbit of ISS and no longer pose a collision threat to ISS."

#### **Where Exactly in Space is Space Junk Located?**

A large percentage of the human made satellite population (note: 'satellite' is a general term for any orbital object) are found in LEO (low Earth orbit), which is defined, roughly, as between 200 and 2000 kilometers (between 124 miles to 1260 miles). But much debris—such as old lunar mission rocket stages—is found much further out into space. The LEO 'satellite population' includes both operational spacecraft and debris such as derelict rocket bodies. However, only 700 or so of these tracked objects are operational craft such as weather and GPS satellites. Currently, the observable pieces of actual 'space junk' total over 5500 tons and the total estimated weight increases by 2 – 5% annually.

Johnson co-authored a Science Magazine article, 'Risk in Space from Orbiting Debris', (Jan. 20, 2006), and reported 60% of all catastrophic collisions (i.e., near to complete break ups) occur in the 900 – 1000 km range. This is a matter of concern given that this range is dominated by communication, weather, and navigation satellites. Debris density is greatest in the 600 km – 1100 km range, with a secondary surge

in density in the 1300 km – 1600 km range. This latter altitude band hosts much of the smaller debris population—debris that must pass through lower altitudes in its slow process of orbital decay. In its interview, SLM asked Johnson what accounted for this split distribution. "Those regions are more densely populated due both to the repeated insertion of new missions (e.g., Earth observation and communications [i.e., satellites]) during the past 50 years and the later fragmentation of spacecraft and launch vehicle upper stages which supported those missions."

When we consider how much our day to day lives depend on these satellites functioning properly and reliably, one thus gets a better sense of why every year that passes brings more warnings about space junk and the need to do something about it. Some in the private space sector, such as The Aerospace



**Nicholas L. Johnson is the head of the Orbital Debris Program Office at NASA's Johnson Space Center.**



Corporation, have taken up the challenge.

"The Aerospace Corporation's interest has been to understand the effect of orbital debris on the operations of spacecraft."

stated Dr. Ailor. "For example, we have developed models that predict the likelihood of a collision between two approaching objects and have also developed techniques for minimizing the propellant required to move a satellite to avoid a collision." According to one model, the LEGEND (the LEO to GEO Environmental Debris) model the total number of objects above 10 cm remains constant, that is, new collision fragments equal decayed fragments (GEO refers to 'geosynchronous' orbit: 35,785 km altitude). However, the model predicts that after 2055, the number of collision fragments will start to exceed the number of decayed fragments, forcing the total satellite populations to increase. Some space junk observers and critics have suggested that the recent 'shoot down' by the U.S. Navy of the defunct spy satellite may have added to the problem. However, this view was not shared by space industry insiders. "The kinetic engagement of USA-193 was undertaken to prevent a potential hazard to people on Earth," asserted Johnson. "The engagement was specifically designed to minimize the amount of debris left in Earth orbit. As of 20 April only 21 [pieces of] debris from this event were known to still be in

**"Postmission disposal will slow down the growth of future debris populations. However, this mitigation measure will be insufficient to constrain the Earth satellite population. Only remediation of the near-Earth environment—the removal of existing large objects from orbit—can prevent future problems for research in and commercialization of space."**

**— J.-C. Liou and N. L. Johnson,  
Science Magazine, report, January 2, 2006**

Earth orbit. All debris will reenter by this summer." According to NASA assessments, that mission, as well as a Chinese anti-satellite test in January of 2007, does

not significantly alter previous environmental projections.

### **The Impact of Space Debris on Future Space Missions and Travel**

Most of us who anticipate a permanent, growing space presence (inclusive of a Moon base and even a Mars base), and a well-established space-based economy, assume that this reality will be well underway by mid-century. Some space observers have suggested that if the problem of space junk is not effectively dealt with well before then, we could find our space missions caught in the 'Kessler Effect' (named after the science fiction writer who first posited the scenario) in which the space around Earth becomes so riddled with junk that launchings are almost impossible: vehicles that entered space would quickly be destroyed.

Dr. Ailor offered his take on this scenario: "Some years ago, Don Kessler predicted that the population of orbiting objects would reach a point where the number of collisions would increase, creating more debris, which would lead to more collisions, etc. Recent NASA simulations show the number of collisions among objects in low

Earth orbits increasing and predict that collisions will become 'the most important debris generation mechanism in the future.' Aerospace does not conduct long-term studies of the evolution of the debris population, but we are

**ANIMATION:** An animated film of the Distribution of Space Objects from 1957 through 2000 based on The European Space Agency (ESA) DISCOS database (Database and Information System Characterising Objects in Space) is a catalogue of Earth-orbiting objects and debris. The animation can be found at:  
[http://www.esa.int/esaCP/SEMHDJXJD1E\\_FeatureWeek\\_0.html](http://www.esa.int/esaCP/SEMHDJXJD1E_FeatureWeek_0.html)

certainly following these types of studies closely.”

Like most scientists confronted with the more dire sounding scenarios, Johnson’s view of this effect is matter-of-fact. “The so-called Kessler Effect,” said Johnson, “only relates to the net growth of the debris population due to accidental collisions.” SLM noted that the in the 2006 Science article, Johnson and his co-author J. C. Liou describe the orbital environment as “unstable,” but then later state that “the risk is small”. These statements would seem to be in conflict, and so, SLM asked for some clarification. “There is no conflict,” explained Johnson. “Although the orbital debris population will grow unless some remediation action is adopted, the rate of growth will be modest over the next century or two. Average hazardous collision risks will remain small over this period.”

So, although the Kessler Effect may be a literary exaggeration, failure to remediate the space junk problem will very likely have some economic impact on future space flights and missions—including, of course, private space missions, which, for the first time since the dawn of the space race, hold real promise and achievement potential. The worst case economic impact scenario goes like this: to protect against space debris, launch vehicles and space craft will need to be built with more shielding. This will add to the cost of construction and the weight of the craft and this, in turn, will mean more fuel expenditure, and again, more cost. The result of this cost inflation, in theory, is the making of space flight too expensive to pursue — both for government and private space endeavors. So, regarding Johnson’s earlier statement about

“new shielding technologies,” these would have to be of type that confers additional resistance [to puncturing] while only minimally adding to over-all spacecraft weight, and—if involving any new metal alloy—the cost of manufacturing.

Ailor added, “We also are concerned about how small debris and micrometeoroids can affect [functional] satellite operations. For example, we look at the vulnerability

of sensors and critical components to an impact of a very small, high velocity object. Aerospace has also been active in national and international efforts to develop techniques that minimize the creation of new debris. For example, we are working with ISO, the International Organization for Standardization, to develop an international standard for disposal of satellites operating in geosynchronous orbits. We are also interested in hazards posed to people and property when debris or satellites reenter the atmosphere.”

In 2007, the major space agencies (NASA, JAXA, ESA, the umbrella IADC, and the U.S. DOD and DOT), under the auspices of the UN, agreed to a ‘25 year rule’ regarding “postmission disposal.” The rule mandates that the orbital lifetime of any debris left in space by current or future missions (rocket stages, cargo vehicles, spent fuel tanks, etc.) be equal to or less than 25 years. This will go far towards not adding to the problem in the

long-term—assuming that we can achieve this engineering goal—but even with this rule strictly enforced, without further remediation, the total amount of space debris will still increase.

And there is one other factor potentially at play here: lawsuits. For example, a damaging collision between a communication satellite

## **FACTOIDS:**

**The International Space Station has dodged a large tracked object six times since it has been in orbit.**

**The oldest debris still on orbit is the second US satellite, the Vanguard I, launched on 1958, March, the 17th, which worked only for 6 years.**

**In 1965, during the first American space walk, the Gemini 4 astronaut Edward White, lost a glove. For a month, the glove stayed on orbit with a speed of 28,000 km / h, becoming the most dangerous garment in history.**

**More than 200 objects, most of them rubbish bags, were released by the Mir space station during its first 10 years of operation.**





**Explosions of satellites and rocket bodies.**  
Credit: ESA

need to deposit or redeploy any captured junk, then return to the targeted, higher altitudes. This activity would require great amounts of energy [to reach junk at different altitudes]. Any such orbital debris remediation craft would need a reliable, potent energy source. Current manned spacecraft cannot reach the targeted orbital regimes above 600 km where most of the space junk orbits, and are vastly more costly than robotic spacecraft. But robotic devices (even if using the newest ion engine technology) require significant energy and control subsystems.

Of course, the private sector is actively investigating solutions to the problem. “The Aerospace Corporation has examined the use of tethers to remove debris from geostationary orbits (GEO),” explained Ailor. “This concept would involve launching a satellite to an orbit near GEO, deploying a long tether above and below the satellite, and attaching debris objects to the ends of the tether. The tether would then be extended or contracted to move the object to a disposal

orbit. Once the debris is released, the tether vehicle would repeat the process with other objects.”

Many space industry engineers assert that only deorbiting of satellites at end-of-life can effectively keep low Earth orbit clean. Recent successful tests of solar electric propulsion (permitting a low cost energy source for even high altitude targeting) now make this feasible. This process, however, would take several months. During such time, there is always a small risk of collision. This possibility supports arguments for reorbiting an aging satellite above LEO rather than deorbiting it. Given this strategy, and a fine-tuned collision avoidance system and minimal thrusting power, virtually all risk of collision can be excluded. Still, a “reorbiting system” has yet to be built and tested.

No single strategy is going to solve the problem. And, given its vested interest in low-risk access to space, SLM asked Dr. Ailor what he thought the role of the private space sector might

Clean Spacecraft Operations  
Explosions: 36

2112

Business As Usual  
Explosions: 130

● Satellites ● Mission-related objects ● Explosion Fragments ● First Explosion

Simulation of the GEO environment with mitigation measures (top) and without (bottom)-2012 (image incorrectly says 2112). Credit: ESA

be here. "The private space industry has several roles in debris mitigation and remediation. First, industry can develop satellites and launch vehicles that shed as little debris as possible during launch, deployment, operations, and after disposal. As an example of what has already been done, on-orbit explosions of stages and spacecraft have been substantially reduced by capabilities that enable venting of gasses and propellants at end of life."

"Second, industry can explore and develop cost-effective techniques for removing dead satellites from operational orbits. For example, space tugs have been proposed that would grab a dead satellite and move it to a disposal orbit. Perhaps a market will develop for such services. Finally, industry can assist in the development of new international standards capturing best practices for minimize the creation of new debris."

Even with workable technology and cost-benefit improvements, an effective junk remediation

strategy with surely cost billions over many years. Public support and understanding, political will (money), and innovative space engineering are the main keys for progress here. The financial burden could be shouldered internationally (though the US and Russia are the primary contributors) and paid for through a space tourism tax added to the cost of a private space flight ticket, just like the airlines.

The International Academy of Astronautics is currently reviewing a wide range of near-Earth space environment remediation concepts. Its report will be completed and released in 2009.

An official Orbital Debris Program Office was established at Johnson Space Center in 1979. It remains the leading such organization in the U.S. The work encompasses all aspects of orbital debris measurements, modeling, and mitigation within NASA, the US Government, and the international community.



## ***The Future of the United States Civil Space Program***

**By Eligar Sadeh**

**Eisenhower Center or Space and Defence Studies**

**United States Air Force Academy**

**T**he United States is at a crossroads in civil space with NASA efforts directed at: (1) retiring the Space Shuttle by 2010; (2) completing the International Space Station; (3) and addressing the issue of the time gap between retirement of the Shuttle and the Constellation program that is slated to replace the Shuttle and support the United States Space Exploration Policy.

Budgetary resources are a policy challenge for civil space programs and especially for the United States Space Exploration Policy. This implies that there are trade-offs that need to be made between human and robotic exploration of space, and other space and Earth sciences, as well as aeronautic activities carried out by NASA. There are also various political pressures, from Congress and the space science communities in particular, to reprioritize funding for specific programs in space and Earth sciences. A challenge for civil space and the Space Exploration Policy is how to successfully transition from the Space Shuttle to the Constellation program within an environment of limited budgetary resources, while maintaining the current and planned programs and projects in space and Earth sciences, and utilizing the International Space Station once it is fully assembled.

The key policy choice for the United States Government is to either support the current Space Exploration Policy that calls for a political commitment to human and robotic exploration beyond Earth orbit as the guiding goal of the civil space program or to depart from the Policy and emphasize space and Earth sciences and human operations in Earth orbit.

Support for the Space Exploration Policy establishes a strategic vision for human spaceflight and human and robotic space exploration. This policy is important as it addresses why the United States should risk human lives for spaceflight. It

taps into the desire to move beyond low Earth orbit. Along this journey, the United States will learn much about international cooperation, innovations, and scientific discoveries and applications. Successful implementation of the Space Exploration Policy rests on renewed efforts to strengthen cooperation between civil space and commercial space, and sustaining the commitment to “remake” NASA organizationally so that the Agency can better manage within budget limits to get the most out of the Space Exploration Policy. Terminating the Space Shuttle program in 2010 or 2011 is an absolute necessity to free up funds required to support the goals of the Space Exploration Policy.

A departure from the Space Exploration Policy emphasizes and prioritizes NASA’s space science and Earth science enterprises, and leads to a political commitment to human operations in Earth orbit that includes support for utilization of the International Space Station. This commitment to human operations can be met by transitioning from the Space Shuttle to a low Earth orbit only version of Constellation. Such a version of Constellation facilitates reprioritization of funding for specific programs in space and Earth sciences. Concomitantly, a departure from the Space Exploration Policy leaves the United States without any strategic guidance for civil space exploration beyond Earth orbit, and the role of humans in that exploration.

*Dr. Eligar Sadeh is the Founder and President of Astroconsulting International that provides specialized assessment and educational services to advance the development and exploration of space. Sadeh has more than twenty-five years of experience in the space community and currently serves as Associate Director of the Eisenhower Center for Space and Defense Studies at the United States Air Force Academy. From 2001 to 2006, Sadeh was an Assistant Professor of Space Studies in the School of Aerospace Sciences at the University of North Dakota. This is the first installment to a three part ‘op-ed’ series on space policy challenges facing a new American Administration in 2009.*

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The future of civil space and the Space Exploration Policy is linked to the issue of United States civil space leadership. During the Bush Administration, United States Government leadership in space has eroded. The United States Government cannot be a leader if no one will follow. Today, the United States is not seen as a good partner in space.

The position of the United States in world affairs is influenced by leadership in space. Given the many issues and challenges the space community faces, leadership is by no means assured. In order to identify and meet the challenges in civil space, United States Government space leadership is indispensable. Leadership requires that the United States develop a strategic vision for space that is supported by strong executive leadership, and effective interagency and government-industry partnerships. Space is an international drawing card that engenders national prestige, prevents conflict, and fosters international

cooperation.

Advancing space leadership through multilateral international engagement and soft power facilitates a means to address the challenges facing the United States civil space programs. For example, civil space exploration benefits from lending political support to the multilateral Global Space Exploration Strategy developed by NASA. This strategy, if implemented, helps to advance the United States Space Exploration Policy. Any successful implementation necessitates a renewed commitment to space diplomacy and strategic communications with soft power ends. Space leadership is exhibited through soft power by partnering with other states to not only advance civil human space exploration beyond low-Earth orbit, but also to address other global space-related civil challenges, like orbital debris proliferation and potentially hazardous Near Earth Objects.



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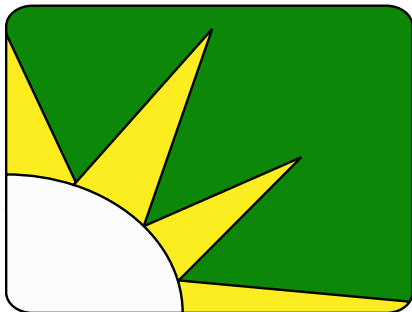
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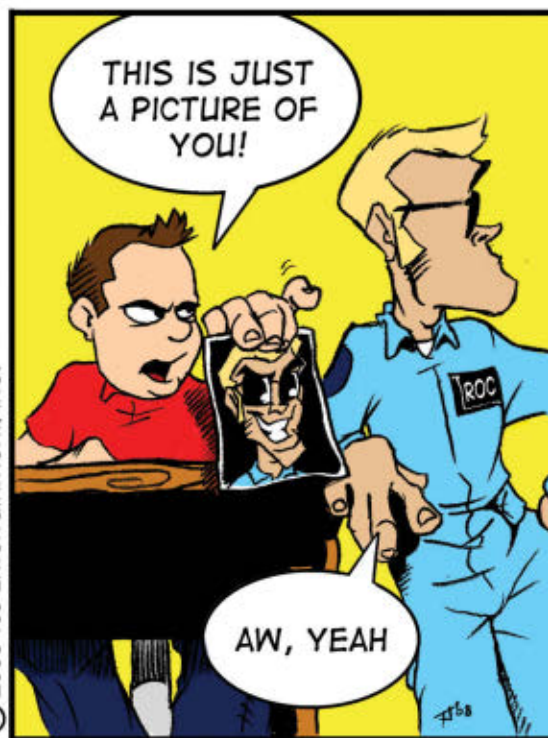
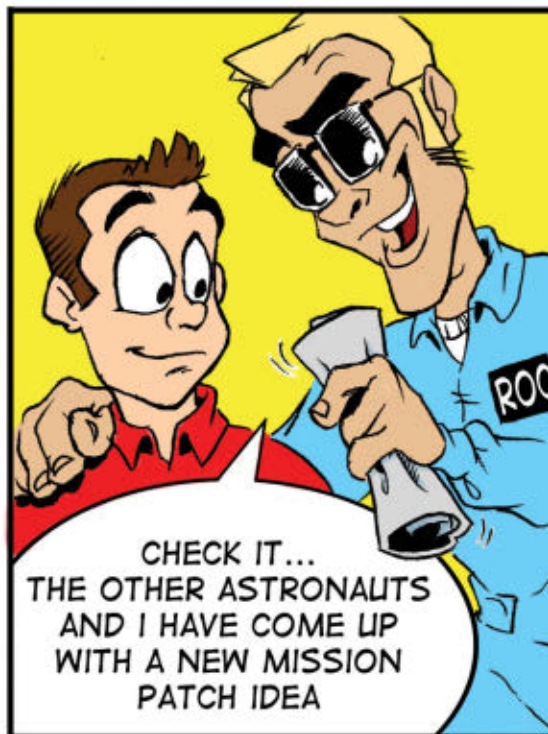
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## Klyde Morris by Wes Oleszewski



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