THE MARS QUARTERLY

PUBLISHED QUARTERLY (EARTH TIME) BY THE MARS SOCIETY

VOLUME 1, ISSUE 4 - FALL 2009

· Extravehicular Activity Research - BioSuit
Dava Newman

· Hubble Service Mission
John Grunsfeld

· Lavatubes on Mars:
Penny Boston

· The Habitability of the Phoenix Landing Site:
Carol Stoker, et al

A Cold Dry Cradle

Part 2 of a Novella by Gregory Benford and Elisabeth Malartre

In This Issue

Failure IS an Option
By Chris Carberry.......................................3

Readers' Forum: GOING TO MARS
By Raymond Burke.....................................4

BOOK REVIEW: The Big God Network
By J.C. McGowan
Review by J. Emilio Rondeau.....................5

Lavatubes on Mars: Science, Habitat, and Resources
By Penny Boston.......................................6

Mars Society Launches TEMPO Balloon
By Tom Hill...8

The Upcoming Season at MDRS
By Artemis Westenberg.............................9

Batteries Recharged!
By Keith Keplinger....................................10

FMARS - A Key Strategic Asset
By Joseph E. Palaia, IV 13

The Habitability of the Phoenix Landing Site:
A Comparative Assessment 14

Interview with Professor Dava Newman, MIT
By Susan Holden Martin 16

Interview with John Grunsfeld
By Chris Carberry.....................................18

A Cold Dry Cradle, Part II
By Gregory Benford & Elisabeth Malartre .24

On the Cover: Steven Hobbs lives in Australia and combines photography and computer graphic talents in his artworks.
www.StevenHobbsPhoto.com.au

From the Flight Deck

It is my pleasure to introduce you to our newest editors:

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On behalf of the staff of *The Mars Quarterly* and The Mars Society, I would like to thank everyone who responded to our call for editorial assistance. The response was overwhelming and all candidates were highly qualified. It was a difficult task to choose from among them. Please join me in welcoming our newest editors.

We are currently in need of experienced professionals who can assist us in our advertising department. If you would like to join the team, please let us know.

On to Mars!

Susan Holden Martin, Editor-in-Chief
tmq-editor@marssociety.org

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A Note to Readers

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Failure IS an Option - But it doesn't need to be...

By Chris Carberry

We could fail! We may not get humans to Mars in the next decade or two, or even in our lifetime. If we allow others to make decisions without our strong and consistent input, we could absolutely fail in our cause to see humans on Mars in the near future. What I mean by the near future is the 2020s. Regardless what some people in Washington, D.C. and elsewhere say - that humans to Mars in the short-term is impossible - they are wrong. They are either misinformed, have other agendas, or do not have faith that great deeds are still possible.

While the recently released preliminary report of the of U.S. Human Space Flight Plans Committee (The Augustine Committee) does state that Mars should be an ultimate goal for human space flight, it appears to promote the concept of technology development without purposeful objectives and without a schedule that would require any effort to achieve its goals. We need a stronger, better defined plan to truly put the United States back into the business of exploration rather than "testing the water" indefinitely. Keep in mind that this report is just recommendations to the Obama Administration. President Obama doesn't have to accept any of these recommendations. In addition, we are not alone in our reservations about this report. Several members of Congress and other prominent individuals have been quite critical of Augustine's preliminary report. However, if the administration doesn't hear any strong opinions from the public on the subject, they may be more inclined to go with Augustine's recommendations.

We live in complicated times. The worldwide economy is still struggling, and the United States government is spending colossal sums of money in an effort to restore faith in our nation's ability to succeed. Sadly, they fail to see that a rapidly developed human mission to Mars could stimulate the economy dramatically by spending only an extreme fraction what has already been spend on stimulus efforts. It is up to us as an organization and as individuals to make sure the Mars message is heard by our elected officials, the press, and the general public. Our message is a much stronger and positive message than most concepts circulating around Washington, D.C. It proposes an optimistic future for the United States and the world. We can win this battle. We just need to make our voices heard.

We can also lead by example. That is what The Mars Society does. That is what we want to do more effectively in the future. Our projects and political efforts can and do make the difference. These projects are moving ahead well and we expect the next couple of years to be highly productive for The Mars Society - but we need your help.

What can you do?

1. Contact your elected officials and say that you support a human mission to Mars at a vastly accelerated schedule than is now planned.
2. Become a Mars Society volunteer. We have a lot of important projects and could use your help.
3. Contribute to the Mars Society. Our ongoing and targeted efforts require a substantial amount of money in order to be successful. We can't achieve our goals without your financial support.
4. If you know anyone who might want to support our organization and projects, let us know!
5. Ask your friends to join.

We look forward to hearing from you!

Chris Carberry can be reached at:
Carberry@MarsSociety.org

NightSky - Photo by Babak Tafreshi/TheWorldAtNight

TWAN Director Receives Lennart Nilsson Award *- Babak Tafreshi (Iran) of The World at Night shares the 2009 Lennart Nilsson Award with NASA's Cassini Imaging Director Carolyn Porco. http://www.twanight.org/newTWAN/news.asp?newsID=6040*

Readers' Forum

GOING TO MARS

by Raymond Burke

We are in danger; danger of not realising our dreams.

I had attended the 4th European Mars Conference at the Open University in the UK in 2004, and was inspired and impressed by the varied presentations and visionary goals. Since then, the whole experience and the story of reaching the Martian Grail has been further impressed upon me by two books I have recently read.

The first book, *The Arctic Grail* by Pierre Berton (1988), chronicles the explorations of the British Navy in the eighteenth century, highlighting the intransigence of the Admiralty in its attempts to conquer the Northwest Passage. The nationalistic approach, the non-adoption of native survival customs, the ill-preparedness for the cold, scurvy, and overland travel, even after almost a century of documented successes in those areas by seasoned Arctic explorers, was wholly negligent. Some might think that that was a sign of the times. That is true; but NASA is a sign of our times. And things are not looking good.

Going to Mars continues our long and proud heritage of human exploration. It is indeed a worthy goal for mankind.

NASA reminds me of the old Admiralty. Obstinate in its approaches to space travel and not heeding advice and warnings from experienced scientists, technicians and senior astronauts. NASA has rekindled the complacent culture of the Admiralty, both organisations suffering loss of life and folly after folly. I am reminded of the Challenger and Columbia shuttle disasters, which surely rank with the Franklin Expedition. With failed robotic Mars expeditions, the cancelled orbital space plane programme, the rejinked[1] Space Exploration Initiative and the lustreless International Space Station, NASA has failed to recapture the glory days of its moon shots, just as the Arctic expeditions were used merely to employ sailors and to glorify the Empire after Napoleon's defeat. The parallels are striking. I can only hope that in a century's time, people do not look back at our time and wonder with dismay, what went wrong?

The second book is Friedrich Nietzsche's *Thus Spake Zarathustra* (2003 translation). In it, the character Zarathustra muses: "Mankind still has no goal... if the goal of mankind is still lacking, is not also mankind itself still lacking?" Well, to me the answer must be a resounding "Yes!"

You may be thinking that mankind has goals! Alleviating poverty, eliminating diseases, increasing education, cleaning air, land and sea, and forestalling starvation, etc, are all goals of mankind are they not? Well, no. They are not goals, they are rights. Everyone has the right to be free of poverty and disease, to be educated, to have clean food, water and air, etc. Going to Mars is not a right - it has to be striven for; attained. Going to Mars continues our long and proud heritage of human exploration. It is indeed a worthy goal for mankind.

How can we achieve this? We would need a collaborative Mars programme. In an ideal world, NASA, ESA, the Russians, Japanese, Chinese and other space-faring nations would establish a policy derived from all of the individual national pursuits. We would learn from each other and from our past mistakes so that one overall Mars programme would be instituted. We would need to create a balance between public, corporate and private initiative, sustained effort, financing, and continued support for decades.

But that is in an ideal world. In reality, each nation is pursuing its own agenda, like the British, and later, the American and Scandinavian efforts to discover the Northwest Passage and the North Pole. Each nation has the same goal, but achieving it alone with diminishing funds and support, will be next to impossible, unless there is a radical shake-up of the space establishment. The goals of exploration, whether to the ends of the Earth or Mars, mean different things to different people, but in the end, it can only benefit mankind. It is ironic that the Mars Society, dedicated to the exploration and colonisation of Mars, has its Flashline Mars Arctic Research Station (FMARS) in the high Arctic on Devon Island. What would the Admiralty of old have made of that? And now NASA has announced plans to return to the moon. Let us hope that the resurgence of the old NASA "can-do" spirit has taught them lessons about the past and makes them keen to set a new goal for all mankind.

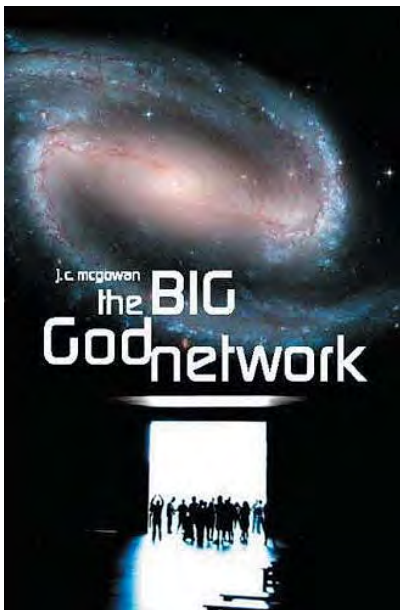
Is Mars too far or too expensive a mission? Tell that to Columbus, or the Pilgrims, or to Neil Armstrong. Why do we have costly Olympics or other world sporting events or fly around the world on holidays? They, among other entertainment and adventures, may benefit and enrich human life, but they are costly pursuits. In all honesty, Mars would not benefit the public for some time, perhaps not for a generation. But who does not save for their children's further education or wedding in a generation's time, with no immediate benefits? Who does not invest in mortgages, pensions, insurance or other financial plans? They are risk investments that mature or bear fruit in a generation's time. Going to Mars is the same; a small investment now will bring future

continued on page 32

BOOK REVIEW: The Big God Network

by J.C. McGowan
Review by J. Emilio Rondeau

Twenty years from now, humans have not yet visited other planets and SETI's radio telescopes have failed to pick up a coherent signal from another world. Yet an appreciation of the cosmos has grown greatly in popular culture. Unmanned space probes are common, and the Net and satellite TV offer channels with live video feeds from space cams on Mars, Titan, and the sub-surface oceans of Europa. Many religions mix spirituality with cosmology and believe that life throughout the Universe is sacred. This is part of the backdrop to the recently published novel The Big God Network by J.C. McGowan, which mixes near-future science fiction with wry political satire and a healthy dose of Carl Sagan-esque "cosmic awe."



Sally Simkin, a principal character in the book, believes in UFOs and would have much to discuss with the late astronomer Fred Hoyle, a proponent of the "panspermia" hypothesis. She is a member of Offworld, a group that believes that life came to Earth via comets or meteors. In addition, Offworlders believe that "interventions" by extraterrestrials helped guide Earth's evolution. Yet Offworld is not a wacky UFO cult along the lines of Heaven's Gate or the Raelians. Rather, it is a global religion with nearly unlimited resources that is pouring billions of dollars into a top-secret project called the Channel, which seeks to surpass SETI. The two-way "smart" Channel seeks interaction with extraterrestrials; it transmits radio waves laden with artificial intelligence into space and is ready to decipher and interact with AI-encoded alien transmissions sent our way.

A side benefit, or danger, of the Channel is that its powerful AI (artificial intelligence) renders the most secure Earthly information systems vulnerable, and threatens the balance of power among the new nations of "post-America" (the United States having fragmented into a liberal West Coast, a theocratic heartland and other new countries). Dark forces covet the Channel for political ends and net journalist Franz Sampaio seeks to keep it out of their hands. The action sprawls across California, Bali, Tokyo, and exotic virtual worlds (people now spend much of their time in cyberspace).

The Big God Network is funny, political and visionary. Loaded with diverse cultural references, the novel references ideas familiar to readers of scientist-authors like Michio Kaku. It is downright rhapsodic about the universe. As the character Arwin reflects, "We aren't alone, ultimately. All the life in the universe originated in a singularity, spouses and siblings and neighbors emanated from the galactic womb, and every man carries the birth of the universe in his bones, the atoms of stars in his blood, and billions of years in his stride. And after we die, we will leave a progeny of matter scattered through this world, in the flora and fauna, its rocks and its rain, and molecules drifting into space, there to be absorbed into new worlds, emerging universes. The matter of all time is what our ashes shall ultimately be, while in the night sky shines a firmament of our far-flung, long-lost cousins."

Reviewer J. Emilio Rondeau is a journalist and filmmaker in Rio de Janeiro who spent twenty years in Los Angeles covering film, music and culture for Brazil's TV Globo and various international publications.

Author J.C. McGowan is an American writer of diverse interests who now lives in Rio de Janeiro. As Chris McGowan, he is also the author of the music guide "The Brazilian Sound: Samba, Bossa Nova and the Popular Music of Brazil" (Temple University Press, third edition, 2009) and "Entertainment in the Cyber Zone: Exploring the Interactive Universe of Multimedia" (Random House, 1995). He blogs for the Huffington Post and has written about culture, the arts, politics, and the environment for the Los Angeles Times, Billboard, Los Angeles magazine, and Musician, among other publications.

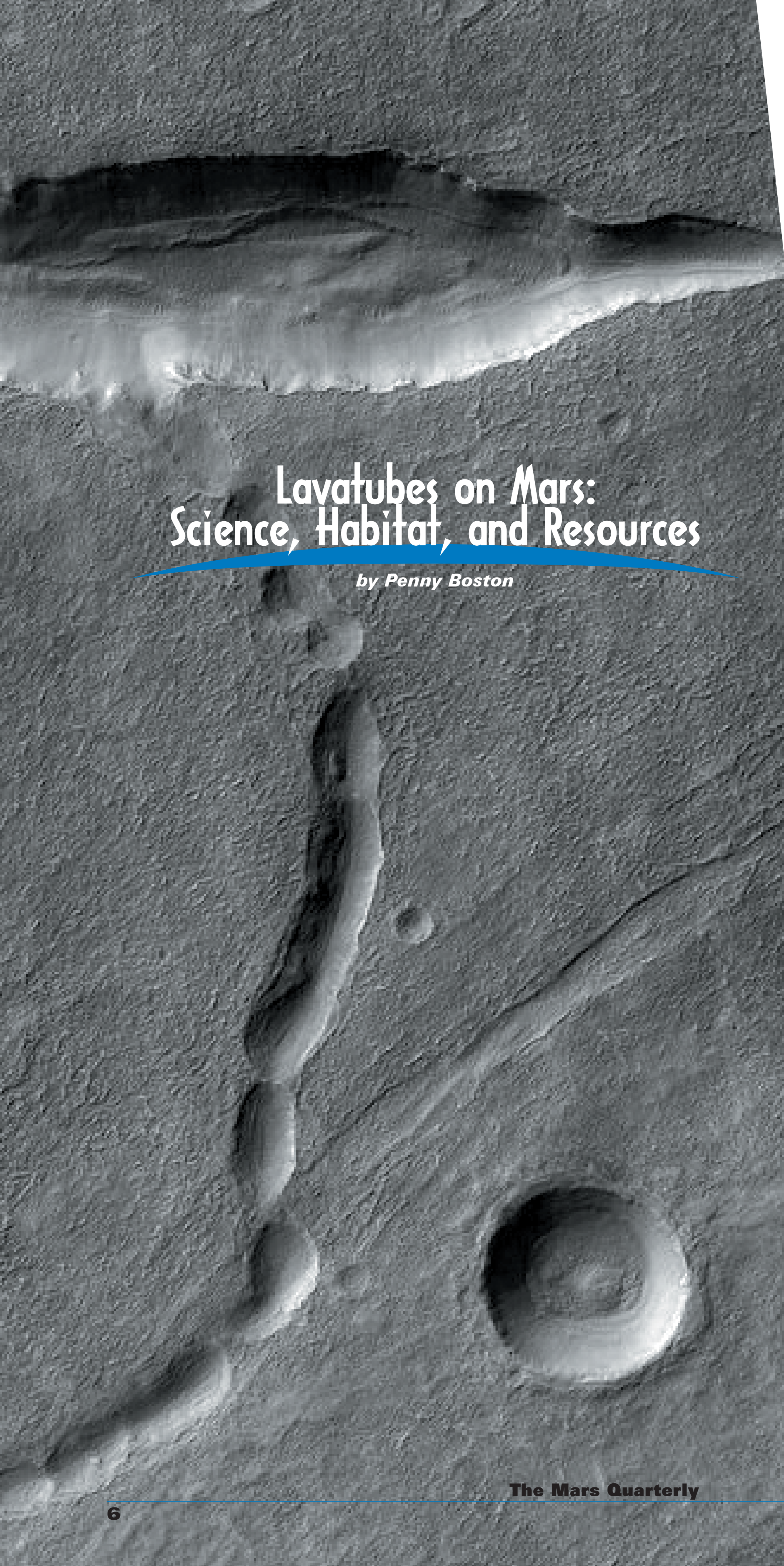
About the book:

"The Big God Network" by J.C. McGowan (Xlibris, 2008)
ISBN: 978-1-4257-6937-6

Big God Network Amazon page:
http://www.amazon.com/exec/obidos/ASIN/1425769373

Big God Network Facebook group:
http://www.facebook.com/group.php?gid=67854007436

Big God Network's MySpace page (with reviews):
http://www.myspace.com/biggodnetwork



Lavatubes on Mars: Science, Habitat, and Resources

by Penny Boston

During the Apollo era, scientists recognized that the lunar terrain strongly resembled volcanic regions on Earth, including open channels (rilles) and closed tubes that are the byproduct of lava flows. When eruptions cease and these tubes drain and cool, they are known as lavatubes or pyroducts. These are actually caves and many of them on Earth are easily accessible to human entry. Several times in the 1980's and early 1990's, people have speculated about the potential for such structures on Mars. During the latest era of Martian missions, starting with Pathfinder in 1997, the evidence for lavatubes has continually increased, showing a large number of apparent tubes. These appear much larger than their Earth counterparts. Typically tubes on Mars can run for a hundred kilometers or more with entrance diameters on the order of 100 meters and only a few tubes reach 30 m in diameter. The longest tube known on Earth, Kazumura in Hawaii, is only about 61 km (38 miles). The gargantuan sizes of these structures may be due to the lower gravity on Mars allowing lava to flow farther or chemical differences in the makeup of the lavas themselves. Whatever the reason, Mars appears to be lavatube-rich. The strongest evidence so far, has been offered by Glen Cushing and his team at the US Geological Survey in Flagstaff, Arizona. They have documented a series of lavatube entrances in Martian imaging data from the MRO (Mars Reconnaissance Orbiter) HiRise camera system from a number of different angles and new data is in the works to further bolster their case.

So, the tubes appear to be there… they appear to be very numerous… and they appear to be extremely big! What does this mean for us as advocates of Mars science, exploration, and human habitation? With all the truly compelling sites on Mars that have been championed as the "best" sites for future Mars missions, why have we chosen to focus on caves? Is it just because we are looking for a new twist on the old theme of planetary exploration? No, we have championed this idea because caves provide both unique scientific targets and critical practical human support functions.

What does this mean for us as advocates of Mars science, exploration, and human habitation?

Science

The geology of the tubes will obviously be a major focus of future studies but from the perspective of an astrobiologist, my focus is on their potential as habitat, past or present. We have long argued that any present Martian life is more likely to be similar to Earth's subsurface microbiological biosphere than anything currently found on Earth's surface. As early as 1992, I published a paper suggesting this with colleagues Chris McKay at NASA Ames and Mikhail Ivanov, a Russian friend and colleague. Besides drilling (a very technically challenging activity on Mars), natural cavities like lavatubes or other caves present a potential way to get into the subsurface to study any lifeforms there, the subsurface gas and fluid chemistry and geology, and to assess the status of potential resources like water ice. We have been actively studying Earth caves for more than fifteen years in pursuit of exotic and amazing microbial life partly to demonstrate the potential for extraterrestrial caves to yield similar secrets. We know that on our planet, some microorganisms make their living by using inorganic materials in the bedrock itself. They often leave telltale mineral traces of their presence. Similar traces of life, known as biosignatures, might be identifiable from the walls of Martian lavatubes and other caves.

Besides the possibility of living organisms in Martian caves, traces of ancient life will likely have been better preserved in the subsurface. As we know, the present Martian surface environment is extremely cold, dry, chemically active, and high in both ultraviolet and ionizing radiation. Indeed, even organic materials do not appear to survive on the surface. Caves offer natural time capsules for biological materials, geochemical traces of past life, and past climate indicators here on Earth. We anticipate that on Mars, caves may also be similarly valuable.

Human Habitation

Natural subsurface cavities present the most mission effective habitat alternative for future human missions in the high-radiation and thermally challenging environments of Mars and Earth's Moon. Because rock is a good attenuator of ionizing radiation and the subsurface protects from strong ultraviolet radiation, the potentially "free real estate" that extraterrestrial caves represent could provide an enormous advantage in reducing payload mass. Requiring only the materials necessary for modification rather than construction, the time to prepare a habitat for human occupants could be significantly reduced compared to building from scratch. In addition, tubes and other caves could offer easier and safer subsurface access for drilling deep, and may provide extractable minerals, gases, and ices.

Between 2000 and 2006, our team worked on a series of several NASA-funded feasibility studies of the concept of cave utilization on Mars and the Moon. We developed a menu of critical enabling technologies necessary to implement the idea of subsurface extraterrestrial habitat and science. These technologies included inflatable cave liners that could be foamed in place after inflation, modular air locks that could be fitted to complex cave entrances also with flexible inflatable units, and many others. We designed and implemented simple prototypes of some of these technologies and conducted a "Mouse Mission to Inner Space" (MOMIS) to test some of them with mice as substitute speleonauts. We further designed and built components for a "Human Mission to Inner Space" (HUMIS) which awaits field testing. We developed the concept of a complete, integrated subsurface habitat system including a spectrum of missions from both robotic precursors to human expeditionary missions and ultimately colonization. Humanity's future may well be on Mars, or perhaps it may actually be IN Mars!

Relevant web links:

NASA Institute for Advanced Studies Reports on the Karst Information Portal (KIP)
http://www.lib.usf.edu/karst-test/docs/NIAC_Cave_I.pdf

http://www.lib.usf.edu/karst-test/docs/NIAC_Cave_II.pdf

http://www.lib.usf.edu/karst-test/docs/Microbot_NIAC_II.pdf

Overview of the NIAC work
http://www.highmars.org/niac/

Images of the lavatubes and other caves we study on Earth by photographer Dr. Kenneth Ingham
http://photos.i-pi.com/Caves/

http://www.caveslime.org/

For kids K-12, Journey into Caves website:
http://www.caveslime.org/kids/cavejourney/

Mars Society Launches TEMPO Balloon

By Tom Hill, TEMPO^3 Project Manager

Balloon launch: The TEMPO craft and its gondola are hauled into the Colorado sky while Mars Society President Bob Zubrin (center) and TEMPO Project Lead Tom Hill (right) watch.
Photo credit: Eric Knight

As an interim step in preparation for the Tethered Experiment for Mars inter-Planetary Operations CubeSat (TEMPO-Cubed) orbital mission, the Mars Society Steering Committee approved a high-altitude balloon flight in February of 2009. Balloon flights have the advantage of being relatively low-tech, and have the potential to return data along with excellent pictures and video of Earth and their payloads.

After several months of development using a home-made structure and off-the-shelf electronics, a group of Mars enthusiasts took to the plains of Colorado on September 26th to fly the experiment. The mission was designed to fly to approximately 100,000 feet in 2 hours, then use model rocket engines to 'spin up' the TEMPO portion of the craft, so it could drop away and generate artificial gravity for a few seconds before air resistance impacted the flight. Both flight segments would be recovered using GPS tracking data and short-range beacons.

Unfortunately, a design flaw in the connection between the balloon and the payload cut the flight short. The connection broke about 25 minutes into the flight, but the attached parachute brought the hardware down in very good condition. Current plans are to fly the mission again in March, applying lessons learned from the September flight.

Meanwhile, efforts move forward in developing the orbital mission for TEMPO. Talks continue for a flight opportunity, and we hope to make an announcement with more details soon.

The TEMPO project wishes to thank Eric Knight, Rod Lane, Don Skinner, and the Stratofox team (http://www.stratofox.org/events/tempo3-20090926/) who helped in final assembly, tackled some last-minute technical problems and made the payload recovery possible.

The Upcoming Season at MDRS

By Artemis Westenberg, Mission Director

This season, MDRS (Mars Desert Research Station) will host the three winning experiments of the Florida high school students that Space Florida, together with Kennedy Space Center and the Florida Department of Education, organised with the Mars Society. 46 teams with more than 300 students have registered to compete for this Mars Experiment Design Competition that gives high school and middle school students a chance to hand in experiments on geology/biology field studies, mission operations and human factors. A Hab crew will conduct the experiments and transmit data via 'live' camera and Internet blogs. With cooperation from NASA-KSC and their Digital Learning Network (DLN), NASA personnel will transmit special interactive programs to the three winning school entrants.

This season will also see the continuation of the Food Study of Dr. Kim Binsted, the Extremophile Search Project for Reactive Surfaces Ltd., the Environmental Contamination Study of Dr. Penny Boston, and the Spaceward Bound program of Dr. Chris McKay. Many more experiments and field research projects will be brought in by the 12 crews that will visit the Hab. Media visits will show the Mars analogue experience to their audiences.

On 14 November, the MDRS season will begin and run for five months. Dr. Carol Stoker's crew will start with her drilling on the Moon/Mars project, and a fully Belgian crew, to celebrate the stay of the Belgian astronaut Frank de Winne at the ISS, will complete the season. As is the same in every season, a group of volunteers will start up the Hab in the weeks before the first crew arrives.

Thanks to sponsors, new flags will fly over MDRS sponsored by Kazi Blaszczak. New linoleum will cover the upstairs floor thanks to the donation of Ronnie LaJoie. And two new, well second-hand ATVs will transport the crews because of a donation by Gary Fisher.

Steve McDaniel has taken care of the costs of a needed spectrometer. The season as such will run on fees paid by each crew member who participates at MDRS.

We are looking at a financially healthy Hab season with potential for growth and more upgrades. On our wish list is a garage for the ATVs fashioned onto the hillock opposite the Hab, a better workbench for the crew engineers, and a new 33-foot growing dome for the fresh food supply.

Follow the Hab crews at http://desert.marssociety.org/MDRS/ and http://www.hablife.org


On 14 November, the MDRS season will begin and run for five months.

Batteries Recharged!

The annual "once-in-a-lifetime" gathering of The Mars Society puts Mars back on the top of the pile.

Text and photos by Keith Keplinger, Keplinger Designs

"Cap and Trade." Health Care. Unemployment. Obama's birth certificate. The news is full of things that tug at us, and the things that we hold near and dear tend to get buried in the pile. So it was with great hope of getting priorities rearranged that I headed off to the University of Maryland, College Park for the 12th annual gathering of The Mars Society. Sara Spector, TMS Secretary and Mom-in-Law, was to join me on the trek, but situations changed that prevented her from making the trip. Another long drive ahead.

Thursday dawned bright and full of hope as I left Fredericksburg and headed up I-95 for DC. A simple hour's drive. Nope, more like 2 ½ hours - You can have DC traffic! I arrived at the UMD campus, got checked in, arranged for parking (thanks for the ticket!) and was ready for The Mars Blitz! About 60 brave souls gathered and were divided into 14 groups. Group 11 consisted of myself (group leader), Brian Mikkelson, Matthew Haslam and Jurgen Herholz. A bus ride, two Metro trains, and a four-block walk, and we were ready! Gus Scheerbaum did a great job of setting up the appointments with the 14 groups, so that the group members got to see senators and representatives (or their aides) from the group's home states.

Group 11's first meeting was with Rep. Betty McCollum's aide, Chris Kelly. Since Brian is originally from Minnesota, he took the lead in the discussion, as each group member explained the talking points and our own experiences and dreams for Mars. Mr. Kelly thanked us for our time and we presented him with his package of TMS materials. A brisk walk across the Capitol's lawn afforded us a few photo opportunities, then our next appointment. Next up was Senator Debbie Stabenow's aide, Trevor Clarke. Matt made the presentation to the Michigan Senator's aide, as Matt is from Michigan. Another good meeting and discussion ensued. Finally, we had a meeting with North Dakota Senator Byron Dorgan's aide Frannie Wellings. Ms. Wellings' schedule was rather tight, and she requested that we keep our presentation to the allotted 15 minutes, so we arrived a few minutes early to make sure that we could maximize our time. While waiting in her office, I had the opportunity to "preach" the Mars sermon to the Senator's junior aides who were in his

Martians invade Washington DC!
Well, not quite, but The Mars Society did spend Thursday afternoon lobbying many senators and congressmen.

lobby with us. The aides were fascinated at the prospect of landing humans on Mars within 10 years - never miss an opportunity to spread the word about Mars! Brian once again lead the discussions, as he is currently attending college in North Dakota, and we had an interesting Q/A discussion and left the TMS materials. Back across the Capitol lawn, all of the teams gathered for a quick photo with the Capitol in the background and it was back on the Metro to get back to UMD for the evening's programs. Everyone had great stories to tell of their meetings and the feeling was that we had accomplished our mission well.

Thursday evening began with a welcome reception sponsored by Aerojet and a few well-deserved frosty cold beverages. The highpoint of the evening was the screening of "Roving Mars" the IMAX movie by director George Butler of the saga of Steve Squyres and the Mars Exploration Rovers. Mr. Butler preceded the screening with anecdotes of the making of the movie, and Mr. Squyres followed the movie with his observations and an update of the Rovers' continued progress. For a mission that was scheduled to last 90 sols, the Mars Rovers passed the 1982 sols mark the evening of the presentation and are still making exciting discoveries. Talk about the

Steven Squyres (Principal Investigator) and George Butler (Film Director) discussed the film "Roving Mars" and the ongoing mission of the Mars Rovers.

little Energizer™ bunnies! You can purchase "Roving Mars" through Amazon.com. My copy should be here soon!

Friday began with a packed list of exciting Plenary Session speakers. Dr. Jim Garvin/NASA Goddard spoke on "Mars - The Past 10 years and the Future"; Dr. Mario Livio/Space Telescope Science Institute discussed the "Top Ten" Hubble Telescope discoveries; Dr. John Mather/NASA Senior Astrophysicist/Nobel Prize Winner presented information on Exo Planets and the search for new ones; and Dr. Louis Friedman/Executive Director rounded out the morning with information from The Planetary Society.

A quick salad from the student center, and it was back for the panel discussion of "Exploration: An Historical Perspective" with Roger Launius/Curator, National Air & Space Museum; Andrew Chaikin/Author, Theodore Swanson/NASA Goddard; and Robert Zubrin/The Mars Society. Where we've been, how we got there, and where we want to go - a lively discussion! Track sessions included Jurgen Herholz on Mars Society/Germany's Archimedes project, as well as sessions on Mars settlements, philosophy, mission design, and advocacy - something for everyone!

Jurgen Herholtz (The Mars Society/Germany) gave a very informative presentation on the Archimedes project.

Friday night continued with the Town Hall meeting, where TMS members were encouraged to ask questions of Dr. Zubrin and Chris Carberry/TMS Executive Director. The evening's presentation was a panel discussion moderated by Miles O'Brien/Former CNN news anchor, and included William Klanke/Publisher, Space News; Robert Asman/Producer, NBC News; Jeff Foust/Space Today, The Space Review; and AR Hogan/UMD master's student. Included in this presentation was a special remembrance of legendary newsman Walter Cronkite. The evening drew to a close with a special screening of "Marsdreamers" a soon to be released movie by the eminent Swiss documentarian, Richard Dindo, which featured several TMS members on the big screen!

Saturday was another opportunity to "plug in and charge up" with the first session on Mars Science, moderated by Dr. Jim Garvin/NASA Goddard and featuring Dr. Paul Mahaffy/NASA/Goddard/PI on SAM-MSL; and Dr. Brent Bos/NASA Goddard. Next up was Dr. Chris McKay with a presentation on Mars Sample Return, Lunar Base and NEO as steps to Human Exploration of Mars. A lively Q/A session followed his presentation. Joe Cassady/Aerojet gave an interesting presentation on "One Way Mission to Mars".

Following lunch, it was time for the "Art of Space" discussion panel, moderated by Michael Carroll/Artist (2009 TMS Convention poster) and featuring Andrew Chaikin/Author, Steven Hobbs/Artist-Photographer, George Butler/Director "Roving Mars", Emil de Cou/Assistant Conductor, National Symphony Orchestra, James Dean/Founder NASA Art Program, Bert Ulrich/Curator, NASA Art Program, and myself, Advertising Creative Director. An inspiring display of works of art that have challenged mankind for over 50 years was presented, as well as discussions of how film and music all inspire us to reach for Mars.

Unfortunately, after the Arts presentation, it was time for me to "Unplug from the Charger" and head home, as I had family and work commitments. But my "Mars Batteries" were well charged and I'm eagerly optimistic of what the rest of 2009 and the future bring for humankind's quest for Mars. Plan to get yourself recharged each year by attending The Mars Society's annual convention.

Artemis Westenberg, MDRS Mission Director and Gary Fisher, TMS Treasurer, lust over the collection of spacesuit gloves during the tour of the University of Maryland's Space Systems Lab.

After Keith left, the real fun started!

By Chris Carberry

That evening we held our annual banquet. It was a lively affair. Miles O'Brien served as Master of Ceremonies and was able to move the program along seamlessly. The crew of the FMARS 2009 season gave an impressive presentation, which included some stunning aerial videos of FMARS. Although Carolyn Porco had to back out as our dinner speaker, space artist Michael Carroll, stepped to the plate and delivered a wonderful after dinner lecture. Next up was the auction event. The two auction items that received the most attention were the original painting of our conference poster (painted by Michael Carroll), and a Robert Zubrin bobblehead doll that we had made several months ago. Artemis Westenberg is now the proud owner of the Robert Zubrin bobblehead. The auction was followed by the annual fundraising address by Robert Zubrin.

On Sunday, we had presentations by FMARS 2009 crew member, Joe Palaia; an update on the TEMPO3 tether satellite project by Tom Hill; and a panel of TMS authors gave tips on how to write and publish books. After a short afternoon session of track speakers, Robert Zubrin delivered his closing remarks which exhilarated the crowd, effectively "recharging the batteries" of our audience for another year!

The Space Art Panel included Michael Carroll, Andrew Chaikin, Steven Hobbs, George Butler, Emil de Cou, Jim Dean, Bert Ulrich, and Keith Keplinger.

FMARS - A Key Strategic Asset

By Joseph E. Palaia, IV - FMARS 2009 Executive Officer & Chief Engineer

The Flashline Mars Arctic Research Station (FMARS) is a key strategic asset which has to this date been underutilized. As a high profile, flagship project of The Mars Society, the station can provide, on an ongoing basis, unrivaled opportunities for showcasing the talents, acumen and determination of the society's volunteers and staff before a global audience while demonstrating through bold action that The Mars Society is capable of managing the financial, logistical and technical aspects of a complex project. Only through demonstrating such capabilities can The Mars Society hope to attract the support needed to tackle even more ambitious projects.

Photo: Kristine Ferrone

FMARS consists of an impressive and valuable set of infrastructure. The robust two-story habitat is well designed and strongly constructed, having weathered nearly a decade in the harsh arctic environment while remaining virtually unscathed. It contains everything needed to support and enable, on the remote Mars analog Devon Island, a crew of up to seven researchers for extended durations. But what I find most striking about FMARS is its virtually untapped potential. The 2009 crew, during a few short months of preparation, raised significant support including financial donations and sponsorships as well as key equipment and scientific experiments to deploy. In addition, their actions resulted in over two dozen news articles highlighting The Mars Society's efforts. Imagine what a dedicated group working throughout the year could accomplish!

Going forward, strong planning and proper program management are the key ingredients required to allow the project to consistently exceed expectations, expand and flourish. It is my opinion that this would result, in short order, in the fiscal self-sufficiency of the project and in much greater utilization of the station for furthering The Mars Society's objectives. This can best be accomplished through the appointment of a passionate, enthusiastic and skilled operating team, and through the empowerment of this team with professional and financial incentives linked to performance and appropriately crafted to ensure mutual success. I make it no secret that I intend in the near term to submit a proposal to The Mars Society to accomplish these ends, and look forward to vetting my approach before The Mars Society.

Photo: Stacey Cusack

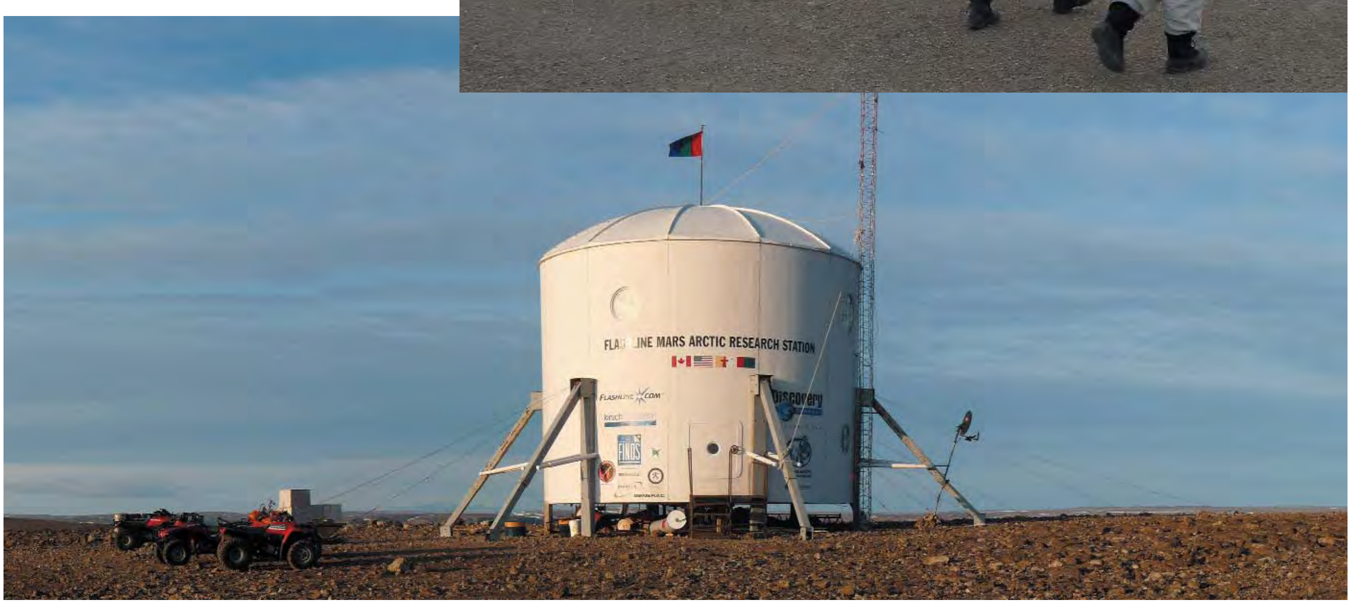


Photo: Brian Shiro

The Habitability of the Phoenix Landing Site: A Comparative Assessment

by C.R. Stoker[1], P.D. Archer, Jr.[2], D. Catling[3], B. Clark[4], J. Marshall[5], P. Smith[2], S. Young[6], and the Phoenix Science Team

Introduction: The Phoenix landing site was chosen to sample near surface ground ice in the Northern Plains discovered by the GRS experiment on Mars Odyssey [1]. One goal of that sampling was to determine whether this environment may have been habitable for life at some time in its history. The unifying theme of the Mars Exploration program, as laid out in the MEPAG roadmap, is the search for life on Mars [2]. Given our current understanding of life, the potential for habitability in a specific time and space encompasses three factors: (1) the presence of liquid water (P_{lw}), (2) the presence of a biologically available energy source (P_e), and (3) the presence of the chemical building blocks of life (e.g. C, H, N, O, P, S) in a biologically available form (P_{ch}). In addition to these factors, temperature and water activity must be high enough to support growth. Since these three factors must be simultaneously present, MEPAG further defined a Habitability Index, HI= 100 * P_{lw} P_e P_{ch} , which is the product of the probability represented by each of the three factors, and posited that a life detection mission could not be justified unless a previous mission had determined HI to have a combined probability greater than 50. Thus a quantitative evaluation of habitability is a precursor requirement for sending a mission to search for life.

Another useful guide to determine where and when life detection missions are justified is the probability that signatures of life are preserved in the environment and can be observed. We call this the Detectability Index (DI). Factors affecting DI include how long before present that habitable conditions occurred, and whether the environment is conducive to organic preservation of a record of life. This paper evaluates HI and DI at the Phoenix landing site and shows how it compares with other sites visited on Mars.

Approach: Each of the above probabilities can further be decomposed into sub-elements or observables that combine for its evaluation. Each probability is computed using the formula $P_n = \Sigma F_{ni} W_i / \Sigma W_i$ (Eq. 1), which is the normalized sum of relevant factors, weighted relative to each other by the importance of each factor, and (in some cases) the certainty associated with the observation. In equation 1, Fni are the factors identified, and Wi are their weights. In all cases, the factors are assigned a value from 0 to 1. Weights estimate the relative importance of each factor, or the uncertainty in the analysis of the factor, and are also in the range 0 to 1.

P_{lw} is comprised of two main factors: F_o, observations (chemical or morphological) that suggest liquid water; and F_{th}, theoretical models that show ice melting is possible. Observations that suggest liquid water may have occurred include 1) heterogeneous subsurface ice morphology including the presence of possible segregated ice located in a polygon trough area as compared to ice cemented soil located in the polygon center; 2) carbonate minerals were observed by both the Thermal Evolved Gas Analysis (TEGA) and Wet Chemistry Laboratory (WCL) instruments; and 3) microscopic evidence for chemical etching of soil particles is observed. However, none of these observations constitute unambiguous evidence of liquid water in the local area, so this factor is assigned a medium value.

Theoretical considerations for the presence of liquid water involve both a mechanism to emplace water at the landing site and climatic conditions that support stable or even transient liquid water. Snow was observed on Mars by the LIDAR instrument and SSI camera [3] and near surface ground ice is also an available water source. The Mars North Polar region (and the landing site) experiences periodic climate change associated with the variation in orbital parameters causing conditions that are far warmer than at present, and sufficient to cause surface melting of pure liquid water [4]. This factor is assigned a high value.

The evaluation of P_e considers the presence of energy available to biological systems. At the surface, solar energy is available and is a dominant energy source. However, the presence of strong ultraviolet radiation may result in sterlization if metabolism is not active enough to overcome high rates of organic destruction. In the subsurface, below the photic zone, metabolism is only possible if chemistry supports oxidation reduction reactions (redox pairs) for chemoautotrophy. Perchlorate salt was identified in the soil by the WCL, probably in the form of $MgClO_4$[5]. The reduction potential of perchlorate and chlorate (1.287V; 1.03V) makes these compounds ideal

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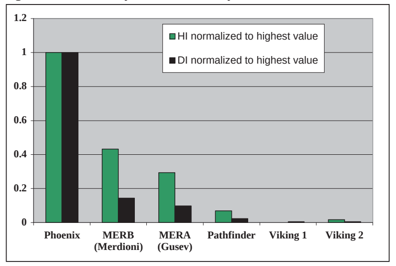
electron acceptors for microbial metabolism and they are utilized as an energy source by numerous species of microbes [6]. Perchlorate reducing bacteria grow by the oxidation of organic carbon or inorganic electron donors (H_2, H_2S, or Fe^{2+}) coupled to the reduction of perchlorate. They have can grow under a wide range of environmental conditions including in Antarctic soils, and have a broad range of metabolic capabilities including (of relevance to Mars) the oxidation of soluble and insoluble ferrous iron. Since both Sunlight and chemical energy are available in the same zone where liquid water can occur, P_e is assigned a high value.

P_{ch} is the probability of presence of chemical conditions conducive to life. Factors evaluated in P_{ch} include the presence of organic carbon, presence of soluble ions of biogenic elements, presence of other elements known to support metabolism, and the presence of non-toxic chemical conditions. CHNOPS sources. The presence of carbonate(s) and the alkaline pH means that in addition to the atmospheric reservoirs of C (as CO_2 and CO), there is an abundant source of readily available C in the soil. H is available from H_2O. There is no information on fixed nitrogen on Mars. Although some terrestrial organisms are capable of converting atmospheric N_2 to nitrate, it is energy-intensive and biochemically complex so nitrates in the soil would be a very important nutrient source. WCL ISE for nitrate detection was masked by its response to perchlorate ions. However, in Atacama Chile, where perchlorate forms in the driest terrestrial deserts, nitrate also occurs in uncommonly high abundances. The aggressive oxidants in the martian atmosphere may produce nitric acid which then can be scavenged by the soil to produce nitrates. Hence, the occurrence of perchlorates is consistent with nitrates in the soil. In addition to sources in the atmosphere (O_2, O_3, H_2O_2) and various photochemical oxidizing non-molecular forms (OH radical, O*, O-, etc.), the perchlorate salts provide a storehouse of relatively readily

Figure 1. Habiltability and Detectability index, normalized to 1.



available oxidizing power. No measurements of P content are available for Phoenix samples but phosphorus-containing minerals are abundant in all MER samples, including strong enrichments in Ca phosphates in some suites of materials in the Columbia Hills. Martian meteorites contain phosphates extractable using mildly acidic solutions (pH 5 or lower). It is inferred that P is as abundant in martian soils as in terrestrial soils, although the alkaline pH implies from limited solubility of most plausible minerals that P will be present at trace but sufficient quantities for metabolism. No sulfates were detected in Phoenix samples, but sulfate has been identified in many locations on Mars. Because of global dust storms, it is anticipated that some fraction of globalized dustcontaining S is present in the topmost polar soils at least. All sulfates of major cations except $CaSO_4$ are highly soluble, and should provide trace quantities which are as bioavailable as most terrestrial non-oceanic environments.

Finally, the measured pH of 8.3 is only slightly alkaline, comparable to most semiarid soils, and ideal for a broad range of organisms. The WCL has also measured ions of Potassium, Calcium, and Magnesium, recognized nutrients for microbial growth, that are in the normal range for terrestrial soils. Based on these considerations, P_{ch} is assigned a high value.

Results: An evaluation of Equation 1 shows that the HI for the Phoenix site is higher than for any other landing site previously visited. Figure 1 shows how the landing sites compare, with all sites normalized to the highest HI. Since many of the factors in the calculation are uncertain, the absolute value of the HI is similarly uncertain, but the general conclusion is that the Phoenix landing site is the most habitable.

The conclusion is even stronger that the Phoenix site has the highest value of DI. The presence of organics at the Phoenix landing site is still an open issue [7], but organics were not found at the Viking site, and were not looked for at the other sites. So, organic preservation at all sites is not a distinguishing characteristic. Therefore, the comparitive value of DI scales based on whether conditions allowing liquid water occurred in modern or ancient times. We assign a value to this factor of 1/t where t=1 for modern, t=2 for Amazonian, and t=3 for Hesperian or Noachian. Thus, DI is correspondingly lower for the other landing sites where habitable conditions occurred during ancient times.

In summary, Phoenix landed at a location on Mars with a higher potential for detecting life than any site previously visited and sampled icy material that periodically may be capable of sustaining modern biological activity. The payload selected provided key information about the potential habitability of this environ-ment and the data suggest habitable conditions have occurred in modern times.

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NASA/JPL-Caltech/Cornell University

Interview with Professor Dava Newman, MIT

By Susan Holden Martin

Martin: Tell us a bit about yourself and how you became interested in the development of the BioSuit.

Newman: I've been working on the Biosuit for about 10 years. It stems from the last two decades of my work on the current NASA spacesuits. My specialty is trying to quantify astronaut performance and looking at designs that enable exploration. The current suit, EMU, is quite capable especially for a microgravity operation such as fixing the Hubble Space Telescope, but there is a huge lack of mobility. So we set our sights to come up with an advanced design for the Moon and Mars. The current capabilities just aren't sufficient at all.

Initially we were able to get funding from the NASA Institute for Advanced Concepts at Nyack. It has gone away now, but it was really a wonderful offshoot organization. It was set up outside of Atlanta, Georgia, and offered a small funding level. The great thing about the Nyack mission was that they wanted an idea that could not be attained within 10 years. So we had to give them a 10 to 40 year time horizon, and that just was fantastic. So the idea to do a completely revolutionary Biosuit design was a good fit. But the technology -- we really had to push the envelope -- maybe we couldn't do it in next few years, but it would take about 10 years to have all the concepts that relate to the materials, and enough understanding of how we could use mechanical counter pressure. That is the fundamental idea behind the Biosuit -- applying pressure directly to the skin of the astronaut -- rather than putting [the astronaut] in a gas pressurized balloon, which is all conventional spacesuits, both NASA and the Russian suit.

Martin: What would you say has been the most exciting aspect of suit development to date?

Newman: We now have [the Biosuit] trademarked and patented, and so really I would say design and patterning of the suit were our biggest breakthroughs.

Martin: Any surprises or setbacks during suit development?

Newman: First let me give credit and mention a couple of important facts. Our work is based on a review of the literature and background of Paul Webb, who had space activity suit that used mechanical counter pressure back in 70s. He is an advisor to us today. Another important person is Dr. Iberol, who looked at gas pressurized, but really how to increase mobility. Both of their contributions are really fundamental to my work. They both had great ideas well before their time; both gentlemen were working in late 60s and 70s, obviously thinking at that time of lunar suits in the Apollo era. I looked at our work as taking their ideas and contributing and enhancing them. So their fundamental ideas are what we used initially to start on, then fast forward to today and what we have accomplished with our prototype and mockups. We have the MIT Engineering team, the designers are Trottier and Associates, and then we go to Italy to have the mockups fabricated with Dainese. So the teaming has been really important between MIT Trottier Associates and Dainese. The work has been a lot of fun as well -- not too surprising, but we put together a really great team of engineers, industrial designers and architects to at least get us to where we are at today.

More challenging has been the lack of funding in last few years, we had Phase I and II funding from Nyack between 2000-2006, but no continued funding from NASA in past three years. So now I am doing it on my own with discretionary funds. It is just a reality that nothing is receiving NASA funding right now. The flip side is that I am starting up with the National Science Foundation, using some of my own designs and patterns on a really exciting project to take some of the suit patterns and to apply them to try to help kids with cerebral palsy walk. So one day perhaps we will make a spacesuit for Moon or Mars astronauts, but we will feel really good if we can also have the 1g applications and some really exciting biomedical applications that I am pursuing right now too. These are more down to earth applications if you will, and so that's going well.

Martin: Have you tested the suit in analog environments, and if so how has that contributed to suit development?

Newman: We do vacuum chamber testing with the prototype lower legs of the suit in the lab. That is the most rigorous testing we do. We don't have a full suit; the pictures you see are mockups. NASA has a big vacuum chamber, but we haven't gone in that. We don't have breathing air in the helmet, so we haven't done full body vacuum chamber testing. We have teamed up with some of the folks and colleagues who have gone up to Haughton Mars, but that hasn't been with a whole pressure suit.

We have an information technology system that is part of my spacesuit research. On any future lunar suit, we need to make a lot of enhancements to the information [available to the explorer]. We need to improve visual displays, as well as voice displays. We have an effort called Mission Planner, now "Sextant" which has terrain mapping. So imagine you're the explorer, you're in a suit, and let's say to the left of [the helmet] screen you want your vitals -- heart rate, oxygen consumption, and maybe you only have 40% left because you are out being a geologist from six different way points. So obviously you don't want your vision obscured. Then we envision on the right side of the helmet we have the capability to show you a 3D topographical map of where you are at, and then we plot the six way points on there. We can give a real rich dataset; we calculate the metabolics, how long it will take to get there, and we also do route planning. You can go over a steep ridge, but that's going to cost lot of energy, so if you take a longer path, we plot the slopes, we do the calculations of distance/time and metabolic costs. Right now we have two new elements we are working on. We're adding a scientific weight, and trying to get that in real time. So maybe I send my rover out the night before to the six way points and get good pictures, and I decide I'm still going. While I'm there, as scientists typically do, I decide I'm finding such good data that I want to spend more time, so in real time we can replan the mission to see if I am still going to get to my six way points. That's what I call mission planning -- it's a 3D topographical map if they want it, and it's very rich in helping execute the actual path, the slopes, and the metabolic costs.

Martin: What aspects of suit technology are you currently working on?

Newman: We are working on calculations of moon and sun illumination angles, which are a critically important. This was a big problem for the Apollo astronauts. When it is bright, it is very bright. They literally almost fell into Cone Crater when they were there with Apollo 13, and of course when it's dark, it's black, really black. Not a good time for exploration. So we are doing calculations for sun illumination so that we can present that to the explorer, and even preplanning -- what might it look like, what to watch out for. Those are the simulations and the preplanning part of the mission.

Martin: What is the projected cost of BioSuit development looking forward to production for a manned mission to the Moon or Mars? Have you been affected by the downturn in the economy in terms of the funding of further research?

Newman: In terms of cost, it is best not to use numbers. I would say the cost of research and development would be 1 or 2 orders of magnitude less than a current flight capable suit. What do I think it would take to get the Biosuit to be a qualified flight system? At MIT we could do it in the next 3 to 5 years, but we would need really significant research funding at the level of $1-2 million per year. Which is still orders of magnitude less than current NASA suits. But I approach it from the research side. At MIT we won't field space qualified suits -- that's NASA's job, or NASA with industry contractors. We do the research and development and hand it off to NASA and industry folks; we are not in business of making flight systems.

Martin: What aspects of Biosuit technology will be most useful to future humans on Mars?

Newman: This whole 3D mapping exercise is now actually much easier right now for us to do on Mars because we have much better resolution images so we have put together 3D topographical maps, and we can do [our mission planning] better from Mars right now than from the Moon. In terms of the technology, I see humans and rovers and robots all working completely in unison and it is very essential that we have all these precursor missions because it's expensive and we should only send humans to Mars when they are really very valued-added. Personally I think there is a huge value-added; I think we will have a much better chance to look for evidence of past life. Astronauts will need to be in very flexible mobile spacesuits. They will be riding rovers, and I'm sure there will be pressurized and unpressurized rovers; and if [they] have a lot of robotic assistance, all the better. When we do this mission planning we purposely say "Ok, we're going to send two rovers up in this direction, and maybe one astronaut will go with one rover," because when we get to Mars we will definitely be in this state, which will be a seamless operation between robots, rovers, and people.

Martin: What challenges are ahead for continued research at MIT?

Newman: It is all tied in to what NASA is going to do, maybe some commercial opportunities, of course those are going to be very short -- maybe low Earth orbit, or just up and down. I'm hoping the commercial efforts will be very successful because it would be a shot in the arm to space [programs] all over the world.

In terms of the report of the Augustine Commission, the good news is that Mars is in the picture, but the bad news is that it looks like it's a long way away. But I think that Charlie Bolden needs to have a chance to put his vision on it. We're all in same boat — about exploration — whether to the Moon or Mars, and hopefully both. In terms of our research at MIT, we are trying to push the limits to make sure we have the best possible designs and engineering solutions. We think the Biosuit, and a very mobile spacesuit, is part of an overall EVA system that could really enhance operations.

Dava J. Newman, is a Professor of Aeronautics and Astronautics and Engineering Systems at MIT, and the Director of the Technology and Policy Program. Contact: Room 33-307; Phone: (617) 258-8799; or via email at: dnewman@mit.edu. For more information: http://mvl.mit.edu/EVA/biosuit/index.html.

Photo Credit: Professor Dava Newman, MIT: Inventor, Science and Engineering

Guillermo Trotti, A.I.A., Trotti and Associates, Inc. (Cambridge, MA): Design

Dainese (Vicenza, Italy): Fabrication

Douglas Sonders: Photography

Interview with John Grunsfeld

By Chris Carberry

Based on his recent first-hand experience in orbit at the Hubble Space Telescope, astronomer, physicist, and astronaut Dr. John Grunsfeld (Ph.D. in Physics, 1988), describes what humans could do in space that robots could not. In his opinion, the original planned robotic mission would have yielded poorer results than the mission that Dr. Grunsfeld actually flew. He credits the Mars Society and other advocacy groups for their part in convincing NASA to risk a human crew for this mission to rescue "The People's Telescope."
- Kenneth Katz,
Contributing Editor

Carberry: The mission was a long time in coming. From your perspective a few years ago, did you think it was ever going to take place? And what role did groups in the advocacy community - like The Mars Society - have in resurrecting the mission?

Grunsfeld: I think the role of advocacy was huge. When NASA Administrator Sean O'Keefe made the decision that it was too risky to use people to go to Hubble - Hubble being a non-station (ISS) flight - in the aftermath of the tragic loss of Columbia and in the context of the findings of the Columbia Accident Investigation Board, I think the public response - the advocacy community response -the Congressional response - the press response - and to a lesser extent, the White House response - was swift and clear. The reality was [that]- it was true that it is riskier - but how much riskier? That's a quantitative question and it is somewhere around ten percent riskier.

At the time, from where Administrator Sean O'Keefe stood, it did not look like we could mount the mission with the depth of defense that we eventually had. And by that I mean it wasn't clear that we could launch a second orbiter in case we got into trouble. It wasn't clear that we could have any kind of extended-stay capability in orbit. We hadn't developed any of the tile repair or leading edge repair techniques, nor inspection techniques that allowed us to stand alone to make sure the orbiter was safe to come in. We didn't have that capability; so it would have been substantially more risky. In fact it would have been like Russian roulette - not knowing the condition of the thermal protection system.

Folks know that we went up and repaired Hubble, but what they generally don't know is that we spent almost two full days inspecting the outside of the orbiter for damage - both before we worked on Hubble - just after liftoff - and after we deployed Hubble - to make sure we were safe to come home. There were a number of folks who were critical in putting the mission back on. The Space Telescope Science Institute - Steve Beckwith, then the Director, was an advocate. John [Bacall], representing the science community has been a staunch defender of Hubble throughout the program, but particularly when the servicing mission was cancelled. The various space societies would lobby Congress and the White House. Even school children in Australia sent postcards and letters to the White House and NASA saying, "Please put the Hubble mission back on." They even collected pennies to help pay for it. It was quite broad.

> **NASA did a great job of getting back on its feet after Columbia - doing the right thing and making the program a lot safer.**

At the same time, I was part of a group that started the Hubble Robotic Servicing Mission led by the GSFC and the Hubble team. The thought was, if we can't use the Shuttle to service Hubble, then how we can service Hubble? So, we invented the Hubble Robotic Servicing Mission in order to find at least a minimal mission so that we could extend Hubble's life at least another five years. Given the knowledge in 2004, the Hubble project crystal ball said that Hubble would end its life in 2007 or 2008 because of battery lifetime and gyro lifetime shortly after that. So the clock was ticking, and I think if we had been forced to mount the Hubble mission by 2007, we wouldn't have made it. The huge credit in all of this goes to the hard-working folks in the Shuttle program - the technicians, the engineers, the planners - being able to develop what we believe is robust tile and leading edge repair and orbiter boom sensor system that has the camera and sensors on the end of it - which allows you to inspect. And the procedures - we were able to put together a plan that had two Space Shuttles on the pad, ready to go at the same time. That was really a tour de force of folks working incredibly hard. We needed the tile repair and the leading edge repair for all flights. NASA did a great job of getting back on its feet after Columbia - doing the right thing and making the program a lot safer. People often ask me what I think about riding the Shuttle when the chance of dying is something like one- in- sixty-five- or- seventy. This was Shuttle flight number five for me, and I am convinced it was the safest Shuttle flight I have ever been on. The previous ones, we just thought were safer than they actually were. We've come a long way.

The Mars Society members Robert Zubrin, Chris Carberry, Blake Ortner, and David Schuman in front of the clock at the STS-125 launch.

Carberry: Of course, some things have changed since you were planning a robotic mission. There were additional failures on Hubble. Do you think a robotic mission would have been possible for the mission that actually took place or was the human element essential for mission success? Do you think the human element bolstered the argument for human spaceflight as a whole?

Grunsfeld: That's a good question. The robotic mission we had originally planned for Hubble was just to do three things - 1) bring up batteries, 2) bring up gyros, and 3) extend the Hubble through those means. At the same time, we needed a plan to put up a de-orbit capability, which we still have to do. There was a hope to replace the wide-field camera 2 with wide-field camera 3, because that's an externally mounted instrument. That's when it started to become more complicated. Even so, I think if we had found a clever way to get gyros mounted without having to open the doors, and if we could have put the batteries on the bottom in parallel with the current batteries, that would have been better than nothing at all. We wouldn't have done it the same way as eventually we did it with our crew on STS-125. The software complexities, the vision systems, and overcoming the problems that we had are beyond what we can do in space with robots.

Carberry: Were there any points in time when you didn't think you were going to be able to accomplish all the mission objectives when you were up there?

Grunsfeld: There were points, but let me finish the robotic point. On planet Earth we have robots doing surgery on real-life human beings. Robots is a tough term. When we say robots, we must include mechanical effectors of human hands and mind. We have surgeons that are using these robots -that could be remote -to do surgery on people; that's very effective, and much better than having figures and scalpels actually controlled by humans. So the potential is there to do very complex repairs and operations on spacecraft from remote locations with robots, even with the [latency] problems. For the mission we did - STS-125, Drew and I got out of the hatch and our first major task was removing wide-field camera 2 and a simple stuck bolt that involved trying a bunch of different things to get it unstuck. Eventually, it took elbow grease, and the risk was the torque in which this bolt released was very close to the torque in which the mechanism would break. So we inched into it. If we had had a robot driving that same bolt I think we would have had the same result. It would have involved the ground trying it and increasing the torque slowly until it released. I think it will be many years before we can get a robot to do other things though, like the Space Telescope Imaging Spectrograph repair which involved the tiny screws and pulling out a card, and certainly the Advanced Camera-For- Surveys Repair - which rank by far as the most complex EVA we've ever done in space would be tough for a robot. There were so many little problems during that task -- and just the raw complexity of the task - that I think it will be many years before we can get a robot to do that. Then there are just simple things: opening and closing the Hubble doors really requires a level of coordination and using the senses - touch and feel. Trying to train a robot to coordinate what it's sensing and what it's seeing along with the knowledge of how to open and close things. You'd need an incredibly immersive virtual reality environment to have feedback to a human operating such a robot. I don't think we're quite there yet.

The really great thing about sending our crew up there is that we were able to accomplish so much more, to the point where Hubble is really like a brand-new telescope. It is the first time we have had five state-of-the-art instruments operating: the Wide-Field Camera 3, the Cosmic Origins

Spectrograph, the Space Telescope Imaging Spectrograph, the Advanced Camera for Surveys, and the Near Infrared Camera and Multi-Object Spectrometer are all back to life. Plus the new gyros and the new batteries. We have a new scientific instrument command and data handling computer. Combined with previous missions, we've put in a new spacecraft computer; a new power system; and a new transmitter. We even dressed up the outside of the telescope to have better thermal protection. I think after 19 years in orbit, we've gotten Hubble to its ultimate capability. Not that in five yours we couldn't put in new detectors that would be even better, but Hubble now has the best discovery capabilities that it has ever had. In 2009, there is no way that we could have even done a small fraction of that using robotics. The Hubble robotics were really about a rescue mission to maintain a minimal capability. What our crew did was the complete makeover.

Carberry: What are your expectations for Hubble over the next ten years?

Grunsfeld: I think our warranty is three years.

Carberry: Okay, what are your expectations for the next three years?

Grunsfeld: Our expectation for strictly mission success is three years. I think everybody is convinced - barring any odd failure - we've certainly bought five years of life. One of the things that we did in 2004 was to challenge the operations team at NASA Goddard Space Flight Center and the operations team at the STSI to find ways to extend Hubble's lifetime so that we didn't have this looming 2007 or 2008 death- by- battery failure. The folks really rallied. They went to the manufacturers of the batteries. They did extensive testing at the Marshall Space Flight Center in the battery lab. They learned how to operate the batteries more efficiently. Between 2004 and 2009 the batteries didn't lose any capacity. One of the battery cells actually gained capacity. Sort of like doing a deep cycle on your battery to regain capacity. These are nickel hydrogen batteries and it is phenomenal that they lasted 19 years; orbiting the Earth every 96 minutes - they get cycled and charged back up - that's a lot of cycles. It's remarkable that they were able to maintain about half their capacity. If those lasted 19 years and it was only three years that they were operated super-efficiently, I think the batteries could easily last another 19 years or more.

The gyroscopes are a little more problematic. We have six gyroscopes. We need two to operate as an observatory. There is software that would allow us to operate on one [but] our observing efficiency would go down a lot. Prior to the decision not to go to Hubble, we thought we needed three gyros. With this life extension program, we built and tested the software to operate on two. It has been very successful. So, in theory, using two gyros at a time and assuming that they last another three years in pairs, that's nine years. My guess is that they will last longer than that. The gyros probably have a ten year lifetime. We put in a new Fine Guidance Sensor. We'll probably lose one in the next few years just because of mechanical wear - that's Fine Guidance Sensor 3. Strangely, FGS1 has been in since the launch and is still going strong. Almost all of the other systems are dual redundant. If we have a failure, we can switch over. I'm hopeful -very hopeful - that we can get ten productive years.

Carberry: If it is still functioning and productive when the James Webb Space Telescope is launched, do you think they would still run Hubble or retire Hubble - or run them both at the same time?

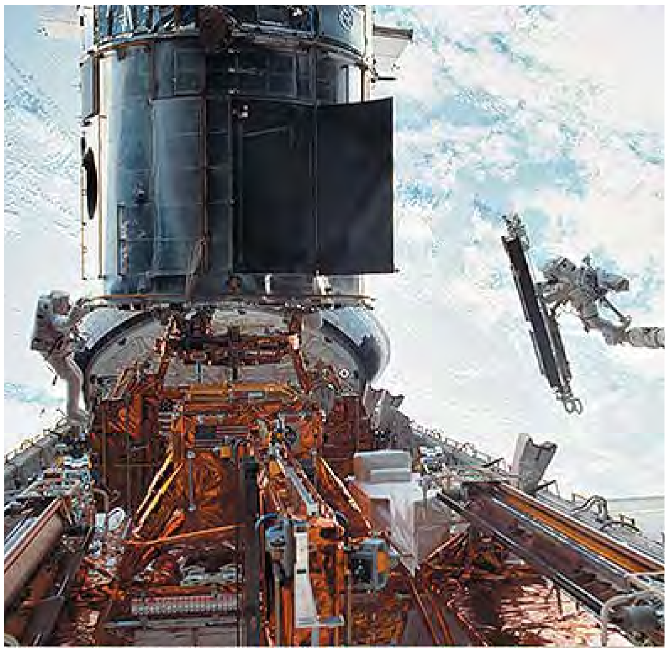
Grunsfeld: You hit what I think is a very exciting point. It didn't disappoint me at all when we shifted from the original launch date of April 2008 to August, September, October, then we slipped all the way to May of 2009, because it increases the possibility that we have overlap between Hubble and the James Webb Telescope. The James Webb Space Telescope is an infrared telescope - near infrared and far infrared - and it is going to give us amazing insights into an earlier universe than Hubble can see, because of the Redshift, due to the expansion of the universe. It will also be able to peer through a lot of cosmic dust into the center of objects that in the optical, Hubble can't penetrate. But the amazing thing is that if you look at the combination of the two, we get coverage from the ultraviolet, to the optical, to the near infrared with Hubble; and then picking in the deeper infrared all the way to the far infrared with the JWST. We cover an amazing range of wavelengths which we've learned is the most powerful way to understand the physics of what these astronomical objects are - to have wide wavelength coverage. Almost all observations these days are based on a combination of, say, Hubble in the optical and Chandra in the X-Ray, or Hubble and Spitzer in the infrared and optical - or Hubble in orbit and a large telescope like the Gemini Observatory on the ground doing spectroscopy. Well, now we have the capability of doing infrared and optical spectroscopy from the ground and also ultraviolet spectroscopy on Hubble. With the JWSP we'll be able to look much further into the infrared and much deeper into the universe.

We believe that we are in the golden age of astronomy now with all these great tools, but I think it is just the beginning of the golden age. There are many new capabilities coming online. What I think is truly phenomenal is the potential of having an operating Hubble Space Telescope, a James Webb Space Telescope, along with the tremendous ground observatories that we have - including one that is called the Atacama Large Millimeter Array (ALMA) that will have better resolution than Hubble on sub-millimeter observations. So we'll be able to put this all together. We'll really start getting a much more detailed understanding of how the universe works. I think it is a very exciting time to be in astronomy or going into astronomy and that includes new observations in our own solar system. We're still at the very beginning of our exploration of the solar system.

Carberry: Well, hopefully these prospects do inspire a new generation of astronomers - who may not have gone into astronomy otherwise.

Grunsfeld: It is very much like the exploration of Mars. We've known for a century that there is water on Mars. We've seen the polar caps. We've known that there was both CO_2 ice and water ice. All this hoopla about water discoveries on Mars - why is that such a big deal if we've known about water on Mars for so long? The Mars Express and the ESA spacecraft that have helped map Mars, have shown there is not just trace water, but extensive water, and it extends quite far south from the poles. Then of course, there were the amazing discoveries from Spirit and Opportunity that showed that water was not a footnote to Mars but was a major factor in shaping the surface and the mineralogy of Mars - and what Mars is made out of. To top it all off, there was the phenomena of the Phoenix lander landing on top of a big ice cube. To me, all of our dreams about going to Mars and having access to something as critical as water is huge. I've often said that discovering subsurface water there might be as easy as pounding a steel pipe into the surface and turning on a heater and watching water flow out. So the dream is a reality now. Once you have water - and Bob Zubrin has been a big advocate of this - once you have water, the in situ resource utilization is totally achievable. It is a lot easier to split water through electrolysis using either nuclear or solar [power] than it is to try to create methane from CO_2, via the Sabatier process. We know how to do both and we should be able to do both. But water of course is critical for life - and whether there is life on Mars now, we don't know; but if we go there, we will certainly need that water.

In the planetary field, the discoveries we've been making on Mars just make the need to continue to go there and explore that much more compelling. At the same time, there is this little spacecraft called Kepler that in five years is just going to change our world - change our world-view of the universe. It is already beginning to do that. Though



we haven't yet, we're on the cusp of being able to discover an Earth-like planet around a neighboring star, using Kepler or ground- based telescopes, or other instruments in the future. Then using these other telescopes, like ALMA and Hubble and Spitzer, to characterize that planet, we may find that it has life. We may be able to find another life-bearing, rocky planet around a nearby star within the next 15 years.

Carberry: Shifting a little bit to policy, although I know you probably can't comment much on the Augustine Committee, but in the broader context, do you think that an Apollo-like program is still possible in the current political environment - and possible at NASA in general?

Grunsfeld: NASA Administrator Charlie Bolden has set the bar for commentary by saying we have just got Augustine and we now have to digest it. I can say that the Augustine Committee (full name) has come out with its preliminary report and there were some good things in the report and there is nothing in there that surprises me at all; we look forward to the full report. The Committee said very clearly that we should continue the space exploration program and its goal should be to extend us beyond low Earth orbit - a program in addition to the really great things that NASA does for planet Earth, for aeronautics, and certainly for space science. But what we really are about is our human exploration program, and we should go out and explore. The preliminary report also said we need more resources in order to begin meeting this goal in a timely fashion. The goal of extending human exploration beyond low Earth orbit and the need for more resources to accomplish that are two really important points. But another point is how humans do well when they have a high performance challenge that is goal-oriented and the goal is well defined; if we just say that we're going to go out and explore and not articulate where we're going to go, it is hard to implement any sort of program, so having a destination is important. We're much more successful when we say we're going to leave LEO or that we want to explore NEOs because they are fundamentally interesting and also a huge potential threat, or even that we're going to visit the Moon, if that helps.

Someday Earth is going to get hit by something big and we're not going to like it but what are we going to do about it? Dinosaurs didn't do anything about it and look what happened to them. But we get to choose. We have a space program and we want to explore Mars because Mars, of all the planets in our solar system, has life most similar to what we know -

microbial life. Certainly the moons of Jupiter and Saturn also hold a tremendous amount of intrigue for exploration, because life there may be quite different from what we know - more into the extremophile - or far into the extremophile existence. So I think we should go explore those, too, probably first with robots, but send people there someday. As for the Jovian moons, they may be a little too harsh from Jovian radiation, so maybe we send robots. But that doesn't rule out exploring them some day. Mars is the most obvious and compelling destination. As to giving NASA all of those options, I think Augustine would agree that they examined options to try and the range of options we ought to be thinking about, without being prescriptive and saying these are the only five options, or these are the only options. I think what he [Augustine] wanted to convey is that we have the current Shuttle derived plans, and we could look at EELV based options. I think he was very supportive of heavy lifting, whether it was Ares V or another variant. He was also very supportive of the opportunities that commercial space transportation to LEO may offer if it is successful.

Carberry: That was my next question. What do you think the role of the private sector will or could be?

Grunsfeld: Since I got involved in the policy arena as Chief Scientist of NASA, I've said I think it is a wonderful dream that someday NASA can purchase trips to LEO the way we buy airline tickets now. Routinely flying space tourists to LEO will bring such robustness to the system, but will only occur when the systems engineering and reliability engineering are so good that the degree of safety allows us to trust riding on the rockets. That can only benefit NASA.

The work we've been doing with SpaceX and Orbital is exactly the right answer to getting cargo to ISS. There could be a service as reliable as the US Postal Service, FedEx, or UPS - where you pay some money and the next thing you know your package arrives at a destination. If someone is willing to do the engineering and provide the service for getting cargo to ISS, then we should take advantage of that. Then we can use our NASA resources to build rovers to drive on the Moon and build new spacecraft systems to enable us to get to Mars, and do the really hard work that is exclusive to the US government, and that can be done in collaboration with our international partners. I also have a dream that commercial companies develop a LEO commercial capability that is affordable. Then I can take my family into space, an experience I would love to share with them. That will only be possible with a really robust industry.

I will also add that being an astronaut for 17 years and knowing the complexities of the rockets, of the systems, of the software, of the environmental factors, and of the space environment itself, I know that it is a very unforgiving business. It is very challenging. So I think any company that wants to develop human space flight or build rockets has a very steep road ahead, and I think it is wonderful that we have people who can be challenged in that way and who are rising to the challenge.

Carberry: Risk versus Reward?

Grunsfeld: I think the drive to explore is encoded in human DNA. You only have to look at babies trying to understand their world to confirm this. It is that drive for exploration that has made us so successful on this planet. We've explored most of terrestrial planet Earth, in some way or another. We've explored, by some measures, about ten percent of the oceans; there is still a lot of unexplored ocean, although we think we have a pretty good understanding of many facets of the ocean. We've explored only a tiny bit of space - even with all of our wonderful telescopes that have allowed us to look back within 700 million years of the beginning of the universe. As far as exploring space in the way pioneers in this country explored the American west, we have barely scratched the surface. People have taken huge risks exploring this planet. They have done that in part due to that fundamental drive to explore, but also for the perceived rewards.

As we press out into space exploration, I've made a personal decision and a decision on behalf of my family to only take risks for things that I really believe are important. In spaceflight, I feel that I have done that. Nothing characterizes this commitment more than taking the risk to go to space and enable great science. Doing the servicing mission to HST is enabling great science, and is something else I really believe in because I think it will have lasting impact on humanity.

I think for humans to push out beyond LEO, to explore the Moon again, and especially to push on beyond that - to Mars - and to see if we can live there, is definitely worth risking human lives. I think we have been phenomenally lucky that we've only lost the Apollo 1 crew, and the Challenger and Columbia crew. Tragic as it is, when you look at the risks we took back in the Apollo program, it could have been much worse. I just hope that the public and our policymakers have the stomach to weather through what may be future losses of life as we push out. It is going to be hard because the farther out we go, the riskier it is going to get. The reality of this risk is the same for the commercial providers. I hope that if SpaceX or Orbital or Virgin Galactic or one of these other companies develops a privately run human space flight capability, and if there is loss of life, that they persevere and learn from the experience and make their systems more robust.

Imagine if there had been a news reporter helicopter circling over Donner Pass when those folks were struggling for their lives and eventually succumbed. There may have been criticisms, and discussions about how we shouldn't push ahead and explore the Oregon Trail and suffer this way. If the exploration of that time in our past had been under the microscope of the instant media that we have today, people might have been turned away from exploration by that constant microscope.

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THE MARS SOCIETY

THE MARS SOCIETY is a 501(c)3 tax-exempt non-profit organization with headquarters in Colorado, USA, committed to furthering the goal of the exploration and settlement of the Red Planet, via broad public outreach to instill the vision of pioneering Mars, support of ever more aggressive government funded Mars exploration programs around the world, and conducting Mars exploration on a private basis.

A Cold Dry Cradle, Part II

by Gregory Benford & Elisabeth Malartre

Gregory Benford is currently working on a novel that entwines both SETI and the Mars life we envisioned in Cold Dry Cradle (and then expanded into The Martian Race). It explores what such an ancient lifeform would think about...

Despite Marc's best efforts, dinner was not a culinary success. Marc was the foodie among them, forever trying out new combinations of the limited range of kitchen stores. But they had long ago exhausted the narrow potential of the kitchen stores for new tastes, and now everything they ate was too familiar to the tongue, though Marc kept trying. He had even brought along spices as part of his personal mass allowance. Some of his infamous attempts had produced stomach-rumbling distress. The microwaved frozen vegetables especially resisted creativity. Still, the food was much better than the freeze-dried horrors of NASA days...or so some said.

Still, the food was much better than the freeze-dried horrors of NASA days... or so some said.

They took turns in the tiny galley. On the outbound voyage Ann bowed to the public's expectation and dutifully did her time, but the others agreed that the results were definitely substandard, and she was relieved of cooking. Instead, she did extra cleanup.

That didn't bother Ann, a dedicated non-foodie, who believed that eating was a somewhat irksome necessity. She went through school with a minimally equipped kitchen. Throwing a box of macaroni and cheese into boiling water stretched her limits. Piotr joked that he sure as Hell hadn't married her for her cooking. She actually liked good food, but wasn't interested in taking the time to produce it.

"So what did you two do while we were gone?" Ann asked later over very slightly grainy pudding. The chocolate color disguised any visible traces of Martian dust, but the tongue found its sting.

Marc licked his spoon carefully. "Well, we drilled another core. Found something ...interesting."

"Where were you working?" asked Piotr.

"We took the runabouts back to the mouth of the big canyon in Long Ridge-- you know, where we saw the fog a couple of months back on that early morning trip." The base sported two open dune buggies that the crew used for short sprints of less than 10 klicks roundtrip. By taking both buggies, it was possible to haul the drilling gear.

Ann shivered, remembering the biting cold that morning she and Marc had seen the fog, suit heaters cranked to the max, looking like quilted penguins. Their picture now graced the cover of the Lands' End catalogue, wearing the parkas and leggings now called Marswear©, of course. It was the latest rage in macho-type clothes, and the underwriting helped pay for the mission.

As they'd prepared to leave the rover she'd grabbed her tea cosy and worn it like a knit ski cap. That was only the first time she'd used it as extra insulation.

Marc continued, "We were down about thirty meters, going pretty slow through some resistant stuff, then all of a sudden the drill started to cut down real fast. I stopped it then so we wouldn't lose the tip. But when we pulled out the drill stem and core, it was smoking."

"Uh-oh," said Ann, automatically sympathetic.

"That's what it looked like, anyway, but it wasn't hot, wasn't even warm." He smiled, looking at Ann and Piotr slyly.

"So how could it be smok-- oh, wait, it was water vapor!" shouted Ann. "You found water!"

Marc grinned. "Yep. The drill tip was really wet, and making cloud like mad." It was so cold and dry on Mars that water on the surface never passed through a liquid stage, but sublimed directly from frozen to vapor. The team had concentrated their efforts to drill for water in places where early morning fogs hinted at subsurface moisture.

"So, the deepest core is always the wettest. Makes sense. There really must be frozen oceans down there," said Ann.

"What does Earth think?" asked Piotr.

"Well, with all the data from the other cores, first indications are that it's probably good enough."

"Good enough for the government, as they say," said Raoul with uncharacteristic levity. Raoul Molina, the compact and muscular fourth crew member, was the top mechanic on the team, and ritually cynical about governments. He even disliked the fact that NASA had separately contracted with the Consortium to supply some geological data.

"Too bad we're not working for the government, eh?" shot back Marc.

Ann looked over at him, surprised. The brief exchange left much unsaid, but all understood the shorthand. Tensions were definitely building as the launch date approached. No one wanted to be the cause of a delayed return. The search for subsurface water had gone slowly, disappointing some of the mission backers, and raising the specter that the team would be asked to stay longer to complete the mapping.

After dinner it was time for their regular video transmission to Earth. They pulled Consortium logo shirts over their waffle weave longjohns and prepared to look presentable. In fact, they wore as little as possible when in the hab-- loose clothing didn't aggravate the skin abrasions and frostbite spots they suffered in the suits. They kept the heat cranked up to compensate, but then nobody had to pay the electric bill, Marc pointed out. Competition was keen for creams and ointments for their dry skin rashes.

"My turn, I think," said Marc.

Ann smiled. "Janet on the other end tonight, then?" Janet Burton was a former test pilot who had trained with them, and clearly had hoped to make the trip. The Consortium had made a careful selection: individual talents balanced with strategic redundancy. The crew of four had to cover all the basics: mission technical, scientific and medical. They fit together like an intricately cut jigsaw puzzle.

In the end it had come down to a choice between Janet and Piotr, and Ann was relieved at the final decision. She didn't know if she could have left Piotr behind so soon after their marriage, even for a trip to Mars.

For the thousandth time she wondered if that had figured in the crew choice. Adding a woman had inevitably made for tensions, but on the other hand, it also gave half the possible Earth audience somebody to identify with. And the Consortium could be subtle.

"Let's play up the water angle, not the ankle," Piotr said.

"Drama plays better than science," Ann said.

"So we must educate, yes?" Piotr jabbed his chin at Marc.

But Marc wasn't listening. The brief description of Piotr's accident had been squirted to Earth earlier, and he was downloading the reply. Due to the time delay of six minutes each way, normal back and forth conversations were not possible, and communications were more like an exchange of verbal letters. At times the round-trip delay was only a matter of four minutes, sometimes forty. Nonetheless, Earth and Mars teams agreed on a download at a specified time to preserve the semblance of a conversation. They did a short video sequence at the same time. It was great theater, but the Consortium also had a team of doctors scrutinize the footage.

At the short delay times Marc and Janet tended to handle the bulk of the communications. And there was a little spark in the transmissions.

The crew gathered around the screen to watch the latest video from Earth. It was Janet, all right, gesturing with a red Mars Bar. Waiting for a successful landing, Mars, Inc., the candy manufacturer, had agreed to become a mission underwriter, releasing a special commemorative wrapper-- a red number featuring the four of them against a Martian backdrop. They had taken about twenty shots of each crew member holding up a standard Mars Bar before a scenic backdrop. They each got five thousand dollars per shot, with the Mars Bar people paying ten thousand dollars per pound to ship a box of the bars out for the photo shoot. It would have been irritating after a while, except that they came to relish the damned things, keeping one for exterior shots, where it quickly got peroxide-contaminated, and eating the rest as desserts. The cold sopped up calories and the zest of sugar was like a drug to Ann. She was quite sure she would never eat another, Earthside, even if she did get an endorsement contract out of the deal.

Ann had dubbed the resulting red-wrapped candy the Ego Bar, unwilling to honor it with the name of a planet and an ancient god, and the team adopted the name. There had been some talk early on about producing another wrapper with Mars life pictured, but microbes weren't exciting enough, and the manufacturer had just decided to stick with the Ego Bar.

Somehow, the commercialism of it all still grated on her. But she had signed on with eyes open, all the same. She had known that market-minded execs ran the Consortium, but going in had thought that meant something like, If we do this, people will like it. Soon enough she learned that even exploring Mars was seen by the execs as If we do this, we'll maximize our global audience share and/or optimize near-term profitability. Such were the thoughts and motivations on Earth. Still, Mars the raw and unknown survived, unsullied and deadly.

#

The spirit of getting to Mars on private capital was to shuck away all excess. No diversionary moon base. No big space station to assemble a dreadnought fleet. No fleet at all--just missions launched from Earth, then propelled outward by the upper stage of the same booster rocket that launched them. They had then landed on Mars after a long gliding journey, as the Apollo shots had.

Still, Mars the raw and unknown survived, unsullied and deadly.

But the true trick was getting to Mars without squandering anybody's entire Gross National Product. When President Bush called in 1989 for a manned mission to Mars on the 50th anniversary of the 1969 Apollo landing, he got the estimated bill from NASA: 450 billion dollars.

The sticker shock killed Bush's initiatives in Congress. The price was high because everyone in NASA and their parasite companies tacked every conceivable extra onto the mission.

When evidence for ancient fossil microbes had turned up in 1996 and later, public interest returned. Soon enough, even Congress-creatures realized that the key to Mars was living off the land. Don't lug giant canisters of rocket fuel to Mars, just to burn it bringing the crew back to Earth. No fluids like water hauled along for an eighteen month mission. Instead, get the basic chemicals from the Martian atmosphere.

The Mars Consortium had begun by sending an unmanned lander, the Earth Return Vehicle. It carried a small nuclear reactor for power, an automated chemical processor, the rovers, and the Return Vehicle, unfueled.

Using the nuclear reactor power, it started its compressors. They sucked in the thin Martian carbon dioxide and combined it with a store of hydrogen hauled from Earth. This made methane and water. The chemical plant was compact, laboring for half a year to separate the methane into the rocket fuel tanks and clean some of the water for later human use. The rest of the water got broken into oxygen and hydrogen, and the oxygen was reserved for later combination with the methane in the combustion chambers of the Return Vehicle.

All this was simple chemistry: hauling to Mars only hydrogen as a feed stock for the process, the ship made eighteen times as much rocket fuel as the mass of hydrogen it brought. Taking all that fuel to Mars would have cost billions, plus assembly of the mission in orbit. By going slim and smart, the Consortium saved all that. Had the early European explorers tried to carry all their food, water and fodder to the New World, few could have gone.

Bush's 450 billion dollar program showed that a NASA-run program could easily turn into an enormous government pork farm.

Slightly over a year after the first launch, the refueled Return Vehicle awaited the crew. They had launched on a big Saturn-style booster rocket, the contribution of the Russian partner, Energiya. Their closed-loop life support system had recycled the air and water.

As their upper stage burned out, it pulled away on a tether cable about 300 meters long. A small rocket fired on the habitation drum, setting it to revolving with the upper stage as its counter-weight. At two revolutions a minute, the hab drum had a centrifugal gravity of 0.38 Earth's, to get them used to Mars.

At the end of six months gliding along a curving trajectory close to the minimum-energy orbit, the hab cut the cable. Rather than firing its rocket right away, it used an aeroshell--a cone-shaped buffer--to brake itself as it swung around the planet. They targeted on the radio beacon set up for them and landed right beside the fueled Return Vehicle.

All this was risky; their loss of precious water on the way out had come close to doing them in. Making exploration super-safe was not only hugely expensive, it was impossible. Further, it was anti-dramatic: the public audience was thrilled all the more if lives truly were at stake.

Risks were both obvious--a blowup at launch, as with the Challenger shuttle--and subtle, as with radiation dosage. The voyage exposed them to the solar particle wind and to cosmic rays. They could shelter from solar storms, which were infrequent, but the rest of their exposure amounted to about a five percent increased probability to having a fatal cancer within their life span.

Further, Mars itself could do them in. Storms could collapse their habitat or blow over their return rocket. Dust could clog the pumps at the crucial blast off.

But the 1970s Viking landers had been designed to last ninety days, yet one held out for four years against cold, wind and dust, and the other lasted six.

Multiple backup systems are the key to safety--but the more backups, the higher the cost. Bush's 450 billion dollar program showed that a NASA-run program could easily turn into an enormous government pork farm.

So a radical idea arose: the advanced nations could get this adventure on the cheap by simply offering a prize of 30 billion dollars to the first successfully returned, manned expedition.

This mechanism European governments had used for risky explorations centuries ago. The advantages are that the government puts out not a dime until the job is done, and only rewards success; investors lose if their schemes fail. Also, if astronauts died, it was on somebody else's head, not an embarrassment to a whole government.

So the Mars Consortium of Boeing, Microsoft, Lockheed and the Russian Energiya took the plunge. They originally wanted to use the name Mars, Inc., but discovered that a candy manufacturer had long ago beaten them to it. A Japanese partner bowed out, finally contributing only the smart-toilet, now dubbed the Marsbidet. At ten thousand dollars to fly a pound to Mars, disposables were impossible. This went right down to writing paper--erasable slates served better, and could be digitally saved, even sent Earthside--and toilet items. Nobody had figured out how to recycle toothpaste, but toilet paper was dispensable. The smart toilet combined a bidet arrangement of water jets with a small blow-dryer. Since its inclusion on the mission it was the hottest piece of plumbing on two planets.

A second mission attempt was being made by Airbus Interspatiale, formed from the French Nationale Industrielle Aerospatiale, British Aerospace, the Spanish Construcciones Aeronauticas S.A. and Daimler-Benz Aerospace. The Airbus group had a more cautious method; their fully fueled Return Booster had arrived in Mars orbit four months before. The Airbus crew had launched fifty days later. They could win only if the Consortium's Return Vehicle failed at launch. The whole world was watching the race... which made the Consortium's nightly "Hello, Earth" show rake in the dollars.

#

They all snorted when the usual question came in from Janet. She looked embarrassed, but what could she do? "And how are you feeling, with Airbus getting nearer and your own launch--"

Marc started before Janet was finished. "We'll wave to them as we head home."

Everybody laughed, but there was a forced quality to it.

After the usual updating on Ann's foray, Janet wished Piotr a speedy recovery, transmitted some bland medical advice and then turned to quasi-technical details about the upcoming liftoff test. Piotr's accident was one more mishap to be overcome. Janet didn't fail to mention the obvious: the broken ankle meant their Captain would be less effective if anything went wrong with the liftoff of the Return Vehicle. What should have been a routine test in this part of the mission was looming as a potential crisis.

On arrival they had discovered that the Return Vehicle was damaged. A failure in the aerobraking maneuver made the Return Vehicle come in a shade too fast, crushing fuel pipes and valves around the thruster. None of the diagnostics had detected this, since the lines were not pressured. In some instances the damage went beyond mere repair and Raoul had been forced to refashion and build from scratch several of the more delicate parts. Working with the Earthside engineers, he had been steadily making repairs.

In this he drew upon not only his technical training, but his family's tradition of Mexican make-do. His father and uncle ran a prosperous garage in Tecate, just below the US border. He'd grown up in greasy t-shirts with a wrench in his hand. Coming from a country with a chronic shortage of hard goods meant that "recycle and reuse" was not just a slogan but a necessity. Raoul was good at creative reuse, making novel pieces fit, but never before had he worked under this kind of pressure. Their return, and quite possibly their lives, depended on his repairs.

They ended the transmission on an edgy note. It was thirteen days and counting to launch.

#

There was plenty of grunt labor to get ready for the liftoff test. Gear they had used on the repairs, supplies dumped months ago while in a hurry, scrap parts--all had to be hauled away from the Return Vehicle. The big job was taking out parts of the chem factory that they wouldn't need on the long glide back to Earth. Every kilogram extra they carried made their fuel margin that slimmer, and it wasn't that fat to begin with.

Ann didn't mind the heavy labor. The low gravity helped but the laws of inertia still governed. Man-handling gear into the unpressured rovers to stow it for the next expedition at least gave her a chance to think; simple jobs didn't absorb all her concentration. That was when all her frustrations surfaced and she decided to do some pushing of her own.

#

After the usual heavy-carbo lunch she found Marc in the hab's geology lab, packing a core for transport.

"So what do we do now?" she asked. "Just you and me?"

Their last, long expedition in the rover was out--that much was clear. Safety protocols demanded two in the rover, and both mechanics, Raoul and Piotr, had to be working on the Return Vehicle. Marc was the backup pilot, so he would be needed to help Piotr, at least through the liftoff trial.

"You're going to tell me, right?" He grinned.

"I'm not going to sit around twiddling my thumbs on my last two weeks on Mars."

Marc said crisply, "You can't go out for a week by yourself, Ann."

"I know. Come with me, Marc. There's just enough time left for a vent trip."

The extensive Return Vehicle repairs had cut into all their schedules. For the week-long rover trips, mission protocol decreed that one of the pair be a mechanic-- Raoul or Piotr. When the two of them were tied up doing Return Vehicle repairs, Ann and Marc were restricted to day trips in the rover. Marc had filled his time setting off lots of small seismic blasts, and was surprised to discover extensive subterranean caverns several hundreds of meters down. So far they hadn't found a way into any of them, and Ann knew Marc was itching to get down there.

Marc looked doubtful. "You did that already. I thought we agreed it was a bust. No life or fossils."

"Yes, but we picked a vent that was outgassing remnants of atmosphere--it had oxygen in the mix."

"So? We were looking in the most likely place for life."

"For Earth life, and ancient Mars life, but not modern Mars life. Oxygen is most likely poisonous to the organisms we're looking for."

Marc frowned, distracted by his chore. "Why so?"

"About 4 billion years ago, Earth's atmosphere was a byproduct of the early photosynthetic microbes... precursors of plants. They succeeded by learning how to make their own food, and by poisoning the competition, the anaerobes, with their wastes."

"Oxygen?"

"Right!" Ann nodded vigorously, caught up in her vision. "On Earth, anaerobes went underground or underwater to get away from the poisonous oxygen atmosphere. Here on Mars, oxygen-using forms would have been eliminated when the planet lost its atmosphere. Maybe it's their descendants under the soil, living off the peroxides. But the anaerobes only had to fight the cold and drought. They must have followed the heat and gone underground."

"Where d'you want to look?"

"The big vent about 55 klicks to the north is the closest."

Marc said, "We could maybe manage a few days in the rover, no more."

"Good enough. I'll start packing."

"Not so fast. We've all got to agree."

#

Raoul shook his shaggy head. All the men were letting their hair grow out to the max, then would shear it down to stubble just before liftoff, including beards. The "Mars Bald" look, as Earthside media put it, went for Ann, too. In the cramped hab of the return vehicle, shedding hair was just another irritant. If it got into their gear, especially the electronics, it could be dangerous. He gestured at the injured Piotr. "Without him, we'll take longer to complete checkout. Marc, I know it's not your job, but I'll need both you and Ann to help. I want to eyeball every valve and servo in the undercarriage."

"Okay, I can see why you need all of us for that. But once it's done--"

"Until we've done the liftoff, planning is pointless," Piotr said in a voice that reminded them all that he was, broken ankle or not, the commander. So far he had not needed to throw such weight around. Ann shot him a look and saw in his face the man who was the commander/ mechanic first and her husband second. Which was as it should be at this moment, she knew. Even if a part of her did not like such facts right now. She said slowly, "I have a quick run we could do."

Piotr called from his bunk, "For jewels, I hope."

She grimaced. Piotr was deeply marked by the bad years in Russian space science following the collapse of the Communist economy. She recalled his saying, "In those dark years, the lucky ones were driving taxicabs, and building spaceships on the side. The others just starved." Not only research suffered. Some years there had been no money, period. Faced with no salaries, staff members in some science Institutes found new ways to raise money, sometimes by selling off scientific gear, or museum collections. It was like her grandparents, who had grown up during the Great Depression; they couldn't get money far from mind. So Piotr made a fetish of following Consortium orders about possible valuable items: he scrounged every outcropping for "nuggets," "Mars jade" and anything halfway presentable. They all got a quarter of the profits, so nobody griped. Still, Piotr's weight allowance on the flight back was nearly all rocks--some, she thought, quite ugly.

> ***The biggest day-to-day irritant was not the peroxides, but the sheer penetrating cold of Mars.***

"No, for science. "

Piotr gave her a satirical scowl.

"Your vent idea." Raoul eyed her skeptically.

"There are three thermal vents within a hundred kilometers. I want to try the closest one, to the north."

"We've studied their outgassing, the whole area around them," Marc said. The Consortium wanted information on water and oxygen; they could use it on later expeditions, or sell the maps to anyone coming afterward.

Raoul shook his head, scowling. "We've already got one injury. And we've looked in one vent already. Crawling down more holes isn't in the mission profile."

"True, but irrelevant," she said evenly. Raoul was the tough one, she saw. Piotr would support her automatically, though grumpily, if she could fit her plan into mission guidelines. Marc, as a geologist, had a bias toward anything that would give him more data and samples.

"It's too damned dangerous!" Raoul suddenly said.

"True," Marc said. "We could use our seismic sensors to feel if there are signs of a venting about to occur, though, and--"

"Nonsense," Raoul waved away this point. "Have you ever measured a venting?"

"Well, no, but it cannot differ greatly from the usual signs on Earth--"

"We do not know enough to say that."

She had to admit that Raoul was right in principle; Mars had plenty of nasty tricks. It certainly had shown them enough already, from the pesky peroxides getting in everywhere--even her underwear!--to the alarming way seals on the chem factory kept getting eaten away by mysterious agents, probably a collaboration between the peroxide dust and the extreme temperature cycles of day and night. "But our remote sensing showed that venting events are pretty rare, a few times a year."

"Those were the big outgassings, no?"

"Well, yes. But even so, they are low density. It's not like a volcano on Earth."

"Low density, but hot. Our pressure suits do not provide good enough insulation. I believe we all agree on that."

This provoked rueful nods. The biggest day-to-day irritant was not the peroxides, but the sheer penetrating cold of Mars. Raoul's style was to hedgehog on the technicals, then leap to a grand conclusion. She got ahead of him by not responding to the insulation problem at all, but going to her real point. "The vents must be key to the biology."

"We have done enough on biology," Raoul said adamantly. "Look--"

"No," he cut her off with a chop of his hand, the practical mechanic's hand with grime under the fingernails. "Enough."

And they all had to agree. In Raoul's set jaw she saw the end of her dreams.

#

The liftoff test came after two days of hard labor.

They had been burning methane with oxygen in the rovers for over 500 days, but that was with carbon dioxide to keep the reaction heat down, acting like an inert buffer much as nitrogen did in the air of Earth. But the Return Vehicle boosters would burn at far higher temperature. The many engineering tests said the system would withstand that, but those were all done in comfortable labs on Earth. And they did not use a system that had ruptured on landing and that Raoul had labored month after month to repair.

A warning call from Raoul made her crouch down. They had decided that this test liftoff, just to see if anything blew a pipe, would have only Raoul and Piotr aboard. Piotr could run the subsystems fine from his couch. She and Marc took shelter a few hundred meters away, ready to help if something horrible happened. The stubby Return Vehicle stood with its chem systems detached and gear dragged away, looking a bit naked against pink soil as thoroughly trod as Central Park in Manhattan, and with more litter.

She and Marc had nothing to do but pace to discharge all their adrenaline. The damned cold came through her boots as always and she stamped them to keep the circulation going. Even the best of insulation couldn't keep the cold from penbetrating through the soles of the boots. It was early morning, so they would have a full day of sunlight to make repairs. She seldom came out this early into the biting hard cold left over from the night. Quickly enough they had learned the pains of even standing in shadow, much less of Martian night--skin stuck to boot tabs, frostbite straight through the insulation. Raoul's limp resulted from severely frostbitten toes after hours of making repairs in the shadow of the Return Vehicle.

She closed her eyes, trying to relax. They were about to land on Mars for the second and last time; think of it that way. Such odd ways of taking each moment, relieving it of its obvious heart-thudding qualities, had sustained her through the launch from Earth and their aerobraking. Months of tedious mission protocols and psychological seminars had given her such oblique skills.

"Ready," she heard Raoul through the suit com. "Starting the pumps."

Piotr responded with pressure readings, flow rates. She saw a thin fog form beneath the rocket nozzle, like the vapors that sometimes leaked from the soil as the sun first struck it.

More cross-talk between the pilots. Their close camaraderie had been so intensive the past few days that she and Marc felt like invisible non-entities, mere "field science" witnesses to the unblinking concentration of the "mission techs," as the terminology went. Then Raoul said, almost in a whisper, "Let's lift."

A fog blossomed at the Return Vehicle base. No gantry here, nothing to restrain it: the conical ship teetered a bit, then rose.

"Nice throttling!" Marc called.

"Wheeeee!" Ann cheered.

The ship rose twenty meters, hung--then started falling. A big plume rushed out the side of the ship. Crump! came to her through the thin atmosphere. A panel blew away, tumbling. The ship fell, caught itself, fell another few meters--and smacked down.

"All off!" Raoul called.

"Pressures down," Piotr answered, voice as mild as ever.

"My God, what--?"

Then she started running. Not that there was anything she could do, really.

#

At least the damage was clear. The panel had peeled off about a meter above the reaction chamber. Inside they could all see a mass of popped valves.

> *"...While Viking was licking dust into the biology experiments, an undetected Martian giraffe walked by on the other side of the lander."*

"Damn, I built those to take three times the demand load," Raoul said.

"Something surged," Piotr said. "The readout shows that."

"Still, the system should have held," Raoul insisted, face dark.

"Over pressure was probably from that double line we made," Piotr said mildly.

"Ummm." Raoul bit his lip; she could see his pale face through his helmet viewer and wondered if he felt defeated. Then he nodded briskly." Probably right. We should check with the desk guys, but I'll bet you're right."

"The double line was their idea."

"Right, Piotr. We'll go back to the original design."

Somehow this buoyed them. It had to, she reflected. Either they get the system working or they wouldn't dare lift. The Airbus crew would rescue them, maybe, getting the glory and the thirty billion dollars.

"Should I contact Ground Control now, or wait until you get back to the hab?" Marc asked.

"They control nothing," Raoul said. "We're in control."

"Is damned right," Piotr said, laughing in a dry way.

"Okay." She grinned uncertainly and Marc followed suit.

"I suppose we should wait, talk to Earthside before we pull anything out and start refitting," Raoul said.

Piotr's voice crackled in the radio, his accent more noticeable "Nyet, nyet, no waiting. You do it. And Marc, tell them, the Airbus --we may need their wessel to get home."

#

She brought up the unthinkable as a way of edging her way around to her own agenda. What the hell, they were all exhausted from laboring on the repairs, and it had been three days. They were nearly done. Time to think the unthinkable again.

Ann turned to Marc. "Okay, suppose we can't get off at all. We've got months until Airbus gets here. What do you think we could do with the highest impact?"

Marc looked surprised. Nobody answered for a very long time. She could see in their faces a vast reluctance to face this issue. But they had to. Finally Marc said slowly, "Geology, maybe."

Piotr laughed sourly. "Scratch scientist, find fanatic. Geology we have plenty. A cold dry desert with red rocks and ancient water erosion. Not much better than the Viking pictures."

Raoul said reasonably, "Ann, this is an old argument. Of course the Viking landing spots were purposely picked to be flat and boring and dry. Not the best places to look for life, but the safest to land. Now we know Viking could never, anywhere on Mars, have found your microbes that retreated to their little layer when the seas and lakes dried up."

"Over a billion years ago, I estimate," Marc put in.

"We don't know that the microbe retreat model is the only one," she said.

Piotr called, "Ah, your new version of the old Sagan argument. While Viking was licking dust into the biology experiments, an undetected Martian giraffe walked by on the other side of the lander."

Ann bristled but did not show it. Sometimes she wondered if Piotr had to occasionally show that he was not just her husband, and thus an automatic ally. "I'm not really expecting earth-type animals, but I'm keeping an open mind about other possibilities."

Marc blinked. "You really think we'll find more than microbial life in a vent?"

"I certainly think we should look. We're probably never going to be here again, any of us." She looked around at them. "Right?"

This they had never discussed. In some ways the surface mission was the least risky part of the expedition, the first four-fifths in days spent but not in danger. Their coming launch was risky, and the aerobraking into Earth's atmosphere would be more tricky than their rattling deceleration in the comparatively soft Martian atmosphere. Still, the sheer wearing-down of their labors in the harsh cold dryness of Mars had sobered them all somewhat. When they returned home--or if--they would be wealthy, famous. Would they do this again?

Still, the sheer wearing-down of their labors in the harsh cold dryness of Mars had sobered them all somewhat.

"I might come back," Marc said.

"I, too," Raoul said, though without the conviction he had before.

"I am honest enough to say that I will not," Piotr said, grinning at them. "I will have a wealthy wife, remember."

They all laughed, maybe more than the joke deserved. The laughter, after a filling meal, served to remind them that they were a team, closer than any contracts could bring them. This was a highly public, commercial enterprise, of course, but none of it would work without a degree of cooperation and intuitive synchronization seldom demanded anywhere.

Ann looked at the others, their clothes emblazoned with the logos of mission sponsors, all quite soiled. Through the Consortium's endless marketing they had endorsed a staggering array of products. They were destined to be a team forever, no matter what happened in the future.

Marc said, "The metals, that's why I'm here. They'll be more important than life, in the long run."

Piotr: "I disagree. The asteroid belt is where we will go for metals. Mars is where we build a base to mine the asteroids. Going to be much cheaper to boost from here than anyplace else."

Raoul appeared from the pint-sized galley toting a bulb of coffee. "So we've just wasted our time looking for metals on Mars? Suits me. If we jettisoned all of the damned ore samples there'd even be room to breathe on the return."

Ann said, "We shouldn't be limited by what we think we know. Or what we think we're going to find. A biologist named Lovelock pointed out before the Viking landings that there was probably no life because the atmosphere was in chemical equilibrium with the surface. Spectroscopy from Earth showed plainly that there was nothing in it but boring CO2 & nitrogen."

"Good argument, you have to admit," Marc said.

"But it assumed life would use the atmosphere as its buffering chemical medium. Unlikely, because it's so thin...so, what about life that has long abandoned the atmosphere?"

"That's what we found." Marc looked puzzled. They were co-authors on the microbial Nature paper, but they all knew the major work was hers.

"Other life may have many ways of holding on deep underground. We can't reach it except through the vents."

When her news of life was beamed to Earth, the public had chewed over it, and decided that it was not all that exciting. Just a bunch of microbes, after all. The deeper issue of its relationship to Earth life had to wait until they got the samples home. Until then, the issue was the province of learned talking heads chewing over the implications. Time for that later.

They had been through all of this before, of course. In the course of two years you get to know each other's views pretty damn well, she reflected, and Raoul had his set look, jaw solid and eyes narrowed, already announcing his position.

#

The second liftoff trial was grim. Their lives were riding on the plume of scalding exhaust. She fidgeted with the microcams--Earthside wanted four viewpoints, supposedly for engineering evaluation, but mostly to sell spectacular footage, she was sure.

"Let's go," Raoul called in a husky whisper.

The vehicle rose on a column of milky steam. The methane-oxygen burn looked smooth and powerful and her heart thudded as the ship rose into the burnt-blue sky. It was throttled down nicely, standing on its spewing spire as Raoul and Piotr made it hover, then drift sideways, then back.

"All nominal," Piotr said, clipped and tight.

"Control A sixteen and B fourteen integrated," Raoul answered. "Let's set her down."

And down they came, settling on the compressed column. The ship landed within ten meters of the damp smear which marked the takeoff.

"Throttle down," came from Piotr in a matter-of-fact voice she did not believe for a minute.

Then she was running across the rocky ground, feet crunching, her cheers echoing in her helmet along with all the others, tinny over the com.

#

Celebration. Extra rations; they even ate the last Ego Bar. Joyful calls from Earth. The laconic way Piotr told the Airbus people that they would not be needing a ride home after all...

Then the next morning. Assessment.

Now they had five days until liftoff and it stretched like forever. The rush to do the second test had kept them at it sixteen hours a day, pouring their anxious energy into the other preflight procedures. After two years they functioned smoothly together, anticipating one another's needs wordlessly. The efficiency of true teamwork bore fruit: now they were ahead of schedule. Ann worked alongside them and judged their mood and dreamed her own dreams. Home! The call of it was an ache in the heart. The cool green hills of Earth...

Still, she could not let go her own itchy ideas. She lay beside Piotr in the cold darkness and thought.

Leaving Mars...

Behind her she felt the yearning of millions, of a whole civilization reaching out. Why had the issue of life here come to loom so large in the contemporary mind? It dominated all discussions and drove the whole prize-money system. Piotr and Raoul thought economic payoffs would be the key to the future of Mars, but they were engineers, bottom line men, remorselessly practical. Just the sort you wanted along when a rocket had to work, but unreliable prophets.

She suspected that the biologists were themselves to blame. Two centuries before they had started tinkering with the ideas of Adam Smith and Thomas Malthus, drawing the analogy between markets and nature red in tooth and claw. The dread specter of Mechanism had entered into Life, and would never be banished after Darwin and Wallace's triumphal march across the theological thinking of millennia. God died in the minds of the intellectuals, and grew a rather sickly pallor even among the mildly educated.

All good science, to be sure, but the biologists left humanity without angels or spirits or any important Other to talk to. Somehow our intimate connection to the animals, especially the whales and chimps and porpoises, did not fill the bill. We needed something bigger.

So in a restless, unspoken craving, the scientific class reached out -- through the space program, through the radio-listeners of the Search for Extraterrestrial Life --for evidence to staunch the wound of loneliness. That was why their discovery of microbes satisfied nobody, not even Ann. Mars had fought an epic struggle over billions of years, against the blunt forces of cold and desiccation, betrayed by inexorable laws of gravitation, chemistry and thermodynamics. Had life climbed up against such odds, done more than hold on? To Ann, survival of even bacteria in such a hellish dry cold was a miracle. But she had to admit, it left an abyss of sadness even in her. And there was still time...

#

Morning. Four days to go. Over breakfast Ann signaled to Marc, took a deep breath and made her pitch. The last few days' hectic work had pushed them hard. More than that, it had nudged them across an unseen boundary in their feelings towards the trip. Despite what Marc and Raoul had said about returning, they all realized that this was a one-time experience. Once they left it would be all over.

Raoul looked up. "The vent trip again? I thought we laid that to rest. You didn't find anything the first time."

"Absence of evidence is not evidence of absence," she shot back.

Raoul frowned, "Besides, there isn't time. We're not packed up yet."

"We're ahead of schedule," said Ann.

Piotr cut in quickly. "Under normal circumstances, yes." He gestured at his cast. "With this, I'm clumsy. It takes longer to do everything." He looked at Ann. "I need your help."

They all knew that a public admission of weakness cost him a lot, and it touched her, but she was determined not to be swayed. She refused to meet his eyes. Damn. Why did women always have to choose? He never would've asked that of a man.

In an empassioned tone, she used her Columbus argument --how could they go home when there was the chance they had only nibbled at the edges of discovery?

Marc came to her rescue. After days of grunt work, the scientist in him yearned for this last chance as much as she did. "We can do it in two days. We'll work here tomorrow morning, drive to the site and set up the pulleys by nightfall. Next day we'll explore the vent and come back. That gives us a full day to finish up here before liftoff." He looked at Piotr and Raoul. "We feel we have to do this."

Technically, the two scientists could amend mission plans if they felt it was warranted. Clearly they would do so this time.

Raoul looked pensive. "I want to go over the thruster assembly again. something might need adjustment after the burn we just did." He hurried on, "but I can do it alone."

In a flash Ann understood that Raoul wished to take responsibility for the repairs, needed to have time alone with his handiwork. He would be just as happy not to have two itchy scientists underfoot. Then he could take as much time as he liked, obsess over every detail.

There was a long moment. They skirted the edge of a rift. Finally Piotr nodded agreement. He had followed Ann's arguments carefully, hoping to be convinced. Now he snapped back into mission commander mode. "Da. All right. Two days only."

Ann's heart soared. She flashed him a brilliant smile, leaned over and, ignoring mission discipline, gave him a big kiss. Spending one final night in a hellishly cold rover would be the price, but well worth it. She was going to explore the vent at last!

Part 3 will appear in the next issue of The Mars Quarterly.

The Port Hole

by former astronaut Julie Rodriguez Jones

From her “astronomical” space art to her liturgical banners and ministerial stoles, Julie Rodriguez Jones' passion for art shines through. http://www.ArtFromTheSoul.com

Reader’s Forum
continued from page 4
benefits and security for humans. At this moment private corporations and other public/private interests are bringing costs down by investing their own time and money so that the public will not have to bear all the costs. The private industries will profit initially, but that private profit will be the guarantor of future missions and benefit the public.

Is it too dangerous to go to Mars? No, it is not. Some people cite the dangers of cosmic radiation, technical difficulties, bone mass loss, the deep isolation, food issues, etc., but in all honesty, these issues will be resolved before we go, whether from all the growing research upon Earth, on the ISS, or on future Moon missions. The only danger is not having the political will to do it and more importantly, to continue with the missions and not have a one-off, flag-planting exercise. Both the expense and danger of going to Mars will lessen significantly over the course of a few missions with the 'live off the land' philosophy. The more we discover about Mars from rovers, satellites and human missions, the more we could depend on Martian resources (oxygen, fuel, minerals, water, etc.) to survive. The real danger is in not trying.

I do not believe that humans will lack the courage to go to Mars when the time comes, but we will need to do it soon so that the fear of trying does not prevail and to secure the survival of our race. Going to Mars may be the most selfless thing that humankind can do.

[1] *Rejinked. Derivative of jink; verb: a [sudden] change of direction. Oxford English Dictionary, 2009.*