THE MARS QUARTERLY

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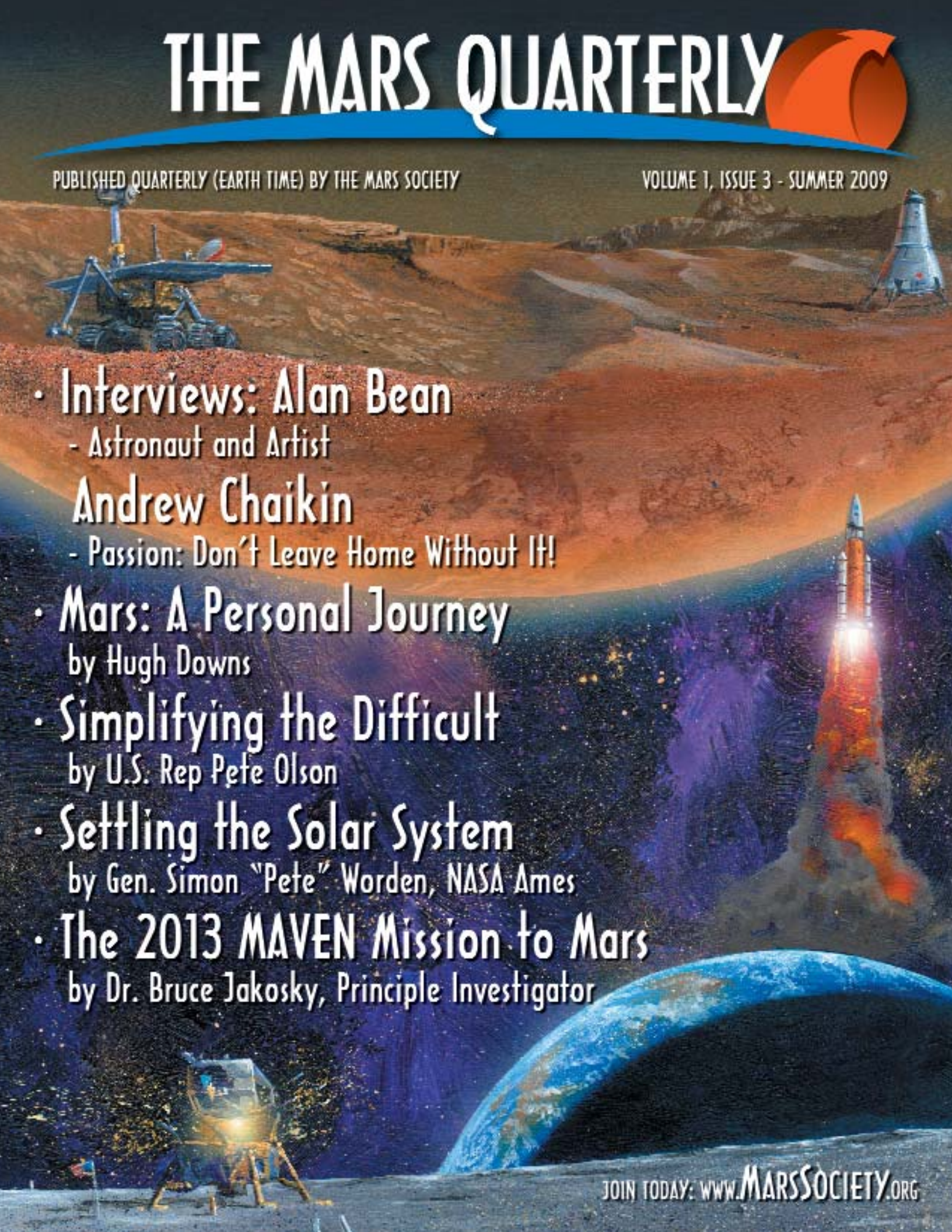

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In This Issue

On the Cover: Michael Carroll's exciting artwork, The 2009 Mars Society Convention Poster, is available for purchase at www.MarsSociety.org

From the Flight Deck

We break new ground with this issue by offering both a print and digital edition, and will expand our reach by providing a complimentary print copy to each member of the U.S. Congress during our Great 2009 Mars Blitz on July 30. History may well record this decade as pivotal in our reach for the stars. If you have not already signed up to participate in our march on Capitol Hill, please do so today.

In this issue we continue to offer our readers a blend of national and international opinion pieces, as well as articles that provide the most up-to-date information available on the status of humans to Mars. Our writers span a variety of professional affiliations, each with their own unique understanding of the urgent and compelling issues affecting the space industry.

We hope you enjoy the outstanding visual content of this issue which includes the cover by Michael Carroll, centerfold by Greg Martin, and the art of Alan Bean, Ron Miller, and of course, the humor of Theresa McCracken. We are indebted to these artists for allowing us to publish their extraordinary work.

The Mars Society offers this publication as part of its goal to provide thoughtful leadership to the Mars community. We encourage our readers and contributors to continue the dialogues and debates framed by our pages.

On to Mars!

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

IN MEMORIAM

Mike Flynn **1949 - 2009**

Air Tanker Pilot/Wildland Firefighter
Husband of Marilynn Flynn,
Tharsis Artworks

THE MARS QUARTERLY

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A Note to Readers

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The Summer of Mars

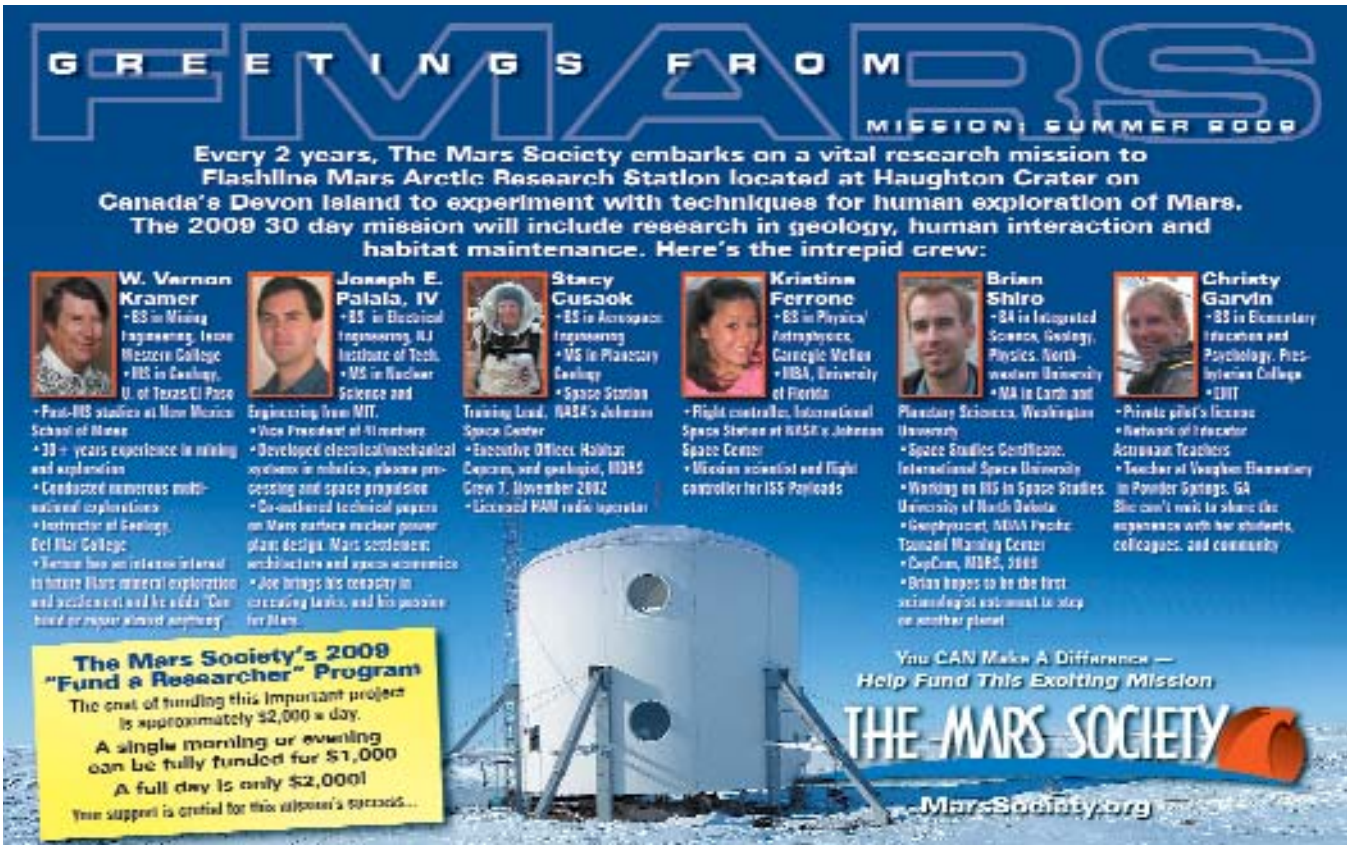
By Chris Carberry

The summer of 2009 has arrived and we have reached the pivotal moment we have been waiting for. President Obama is now in office and his administration will be making key decisions concerning the future of the space program as early as this year. The selection of Charlie Boland as NASA Administrator and Lori Garver as Deputy Administrator is certainly a good sign. In addition, the appointment of Norm Augustine to review NASA's human space flight program is reassuring as well. However, these decisions do not guarantee that the administration will decide to choose an ambitious human space program. On the contrary, if the space advocacy community does not step up and demand something bold, we could very well remain imprisoned in low earth orbit as we have been for over 35 years. As has been our tradition since our founding, The Mars Society plans to make every effort during the remainder of 2009 and beyond to rally support for human missions to Mars through meetings with Congress, the Administration and other decision-making and advisory bodies.

...The Mars Society plans to make every effort during the remainder of 2009 and beyond to rally support for human missions to Mars...

In addition to our political efforts, The Mars Society hopes to influence space policy by our example. We are in the midst of the busiest year in our history. We are conducting a mission to our Flashline Mars Arctic Research Station (FMARS); we are running reinvigorated MDRS seasons; we will be conducting a high altitude balloon drop later this year to test components of our tether gravity satellite, TEMPO^3; the University Rover Challenge just completed its third annual competition; and The Mars Society of Germany is making great strides forward with their Mars balloon project, Archimedes. In addition, we are running our annual convention and introducing the print version of The Mars Quarterly. All in all, not a bad year. If you ever wondered whether your donations and membership fees were pout to good use, look at this list. I highly doubt you will find any other space advocacy group who has been so productive in the same time period.

I hope all of you will join us at our conference at the University of Maryland and take part in our massive Mars Blitz. Although the current economic climate may seem as though it might make our goals less likely, hard times can often create opportunity. Help us create this opportunity and join us on Capitol Hill or call and write your members of Congress and President Obama. One person can make a difference - imagine what thousands of people can do!



An Interview with Alan Bean

ASTRONAUT AND ARTIST

By Chris Carberry

Carberry: First, a general question. This year is the 40th anniversary of both Apollo 11 and 12. What are your general thoughts on this anniversary year?

Bean: I just got back this last week from Oklahoma City for the 40th anniversary of Apollo 10, and then Apollo 8 and 9 in San Diego, and then Apollo 7 up in Dallas. So, with the 40th anniversary of each of these, we've gotten together and celebrated and remembered all the fun times we had.

Carberry: Did you think we'd be further along after 40 years?

Bean: What we were doing then - I didn't realize it then, but I do now - we were going as fast as and far as we could technically. We were doing the best that we could. We were building the lunar module. We were getting to the moon which was a huge giant step. So I imagined that we would keep doing that, and after we got to the moon, then we'd build little bases. I remember thinking I'd see people land on Mars in my lifetime. Now, maybe - maybe not - I'll just see them in training preparing to go. I thought that America and the world would keep moving along as fast as we could. Then when they cancelled Apollo 18-20, I began to think, maybe we won't do that. Perhaps cultures get tired of thinking about things after they've done them for a while. They get tired about thinking about space. They may say, "Well, we've already been there. Let's do some other stuff." That's what seems to happen. There were 128 years in the time between when Columbus discovered America and the Pilgrims came over. It just takes time to do these things. I've been able to be more accepting of the fact that we're not moving as fast as we could, because I think this is what countries and cultures and peoples do.

...We were going as fast as and far as we could technically. We were doing the best that we could.

Carberry: I agree that it is very easy to get into these kinds of ruts where society is unwilling to push the boundaries, but sometimes changes in governments or moods can break us free from these ruts. Do you think the change of administration could change things - start accelerating the program?

Bean: Well, what I think it should do and what I think it will do are two entirely different matters. I would like to see people start moving ahead as fast as we could - to explore - explore Mars. If you ask me, I'd say skip the moon. I don't know what we could do there differently. We could do a million things there, but I would be more interested in going directly to Mars. But I don't see us getting the money to do it. In fact, I don't see us getting the money to go back to the moon for another 50-60 years. I want us to do a lot of stuff, but I don't see it, because it is money and you're not going to - in my opinion - convince the President or Congress or the American people to spend the kind of money to do those kinds of jobs. I just think that's the way it is. We Americans in the space business imagine this ideal world. You and I are imagining this ideal world right now: that we do what we want to do and follow the ideas that we have. I'm out speaking to people several times a month and they're not interested, really. They're interested in stories about the moon, but they're not at all interested about spending any money. We're interested, the people reading your magazine are interested; the guys that I got together with this past weekend and at past events are; but we're just a small minority of the country. I don't see us going back to the moon for another 50-60 years, but what do I know. Do you see Obama coughing up any money to send us back to the moon? Do you really?

Carberry: Perhaps as a result of the stimulus plans or do you think foreign competition could motivate Obama? Do you think we should stay in the lead?

Bean: Yeah, we are in the lead. Nobody is even close to us. That's one of the problems that we've got - nobody is even in the game compared with the United States. It's just a lot of talk - China, maybe they're going to drop something, but they haven't done squat. India hasn't done anything - Russia doesn't do anything anymore. We're it. We're in first and that's one of the reasons why Americans don't want us to do anything. We're already ahead. We won the race in people's minds. Why should we spend any more money on it? We're already ahead. Don't get me wrong -- I'm on your side. I'm on the side of the readers of your magazine, but I don't see it out there and I am not going to sit here and say Obama's going to give us money, that people are going to see the errors of their ways and realize the benefits of exploration and all that. I wish they would, but I just don't see it happening.

Carberry: To shift gears away from politics, what was your first impression when you stepped onto the moon? Your paintings are bright and vibrant. Did you see something that doesn't translate in the

photographs and film?

Bean: I didn't have anything philosophical. I didn't think "this is wonderful" or "this is a small step for man . . ." that was Neil's job. I was thinking of getting on my "cuff checklist and getting down to business to do the things that I was trained to do and trying to take a few minutes to get my balance. That was on my mind - "I hope I can get my balance soon so I can do my work." "In ten minutes I've got to dig a ditch", etc. So I was mostly thinking of the prosaic part of spaceflight, which is doing the job that you've been sent there to do - make the observations - deploy the experiments - collect the appropriate rocks. That was on my mind.

Carberry: Doesn't sound like you were looking around with an artist's perspective at the time. In retrospect, was it more colorful than people perceived it - as your paintings depict, or do you take artistic license?

Bean: Well, it is what you have to do when you become an artist. I started this 28 years ago. I've been gone from NASA that long and I've been working hard every day. At first when I left, I was an astronaut that was trying to learn to paint and to transition to becoming an artist. So, if you look at my early paintings, you'll see that moon is pretty grey. In fact, if I tried the paintings that I do now, then - if I had had the skill then - I would not have accepted the colors that I use now. I would have thought "this isn't the moon" -- this isn't right. I approached it as an astronaut with a scientist's mind. The moon is grey - there isn't any color up there. The sky is black - kind of a patent leather shiny black. If a black rock gets enough light on it, it can look white, but there are no colors in it. It doesn't change to yellow or blue or violet. The shadows were grey - very dark. As the years have passed, and I've become more of an artist and I think more as an artist - as I do now - I don't think of myself as an astronaut anymore. I think of myself as an artist who was an astronaut 28 years ago. Now I am an artist. As I became more of an artist, I began to want to make things look more than what I thought would look interesting; more emotionally related to what we saw -- that was more fun to look at; more beautiful to look at. I didn't know all these things when I left NASA, even though I had studied art at night for years. So, I was involved in art, but I'd always been a pilot or something like that, but when I started to change over, I began to see things differently - not physically - but emotionally and mentally.

I went over to see Giverny, where Monet painted his water lilies and other things. As I looked at them scientifically, they were just green leaves in a dirty pond - just like everywhere else. I also went to Rouen, where he did those beautiful cathedrals. Before sunrise, I stood there in the morning - he did the morning ones there - and they're beautiful violets and greens and all these different colors. I just stood there and looked at it. It's gray granite as it is any other time of day. I kept coming back to this place at all times during the day to look. I kept saying, "why does he keep seeing all these colors?" Well, that was kind of an eye opener. He didn't see any colors different than you and me. We know that people can be color blind and not see as many colors, but nobody around sees a bunch of colors when they're not really there. It is just not a scientific fact. By the way, when I tell this story to art people - art historians -- they get pissed off, because they still believe that he looked at that gray cathedral and saw all those beautiful colors. I guarantee that my eyes at that time were as good as they get, and the cathedral was gray. That's not the job of the artist. An artist could reproduce it and he did. Some of his early

Rouen cathedrals are gray. A few of his early Givernys look just like the garden or just like the lily pond. Later on he likely said to himself, I'm going to make this more beautiful. I'm an artist, not a scientist. I'm going to make this thing more interesting to look at - more beautiful - more texture. So I'm going to make it like I think it ought to be, like I want it to be - more beautiful. That's what I do. I'm an artist now. I'm not a scientist anymore. I'm working on a painting of Neil and Buzz right now - so when I'm painting, I'm thinking "I want to make this look like Neil and Buzz, but the shadows on their suits . . . I think I'm going to make the shadows lighter blue - maybe put some greens in there - and make it more beautiful." It will still be Neil and Buzz. They'll still be two guys on the moon, but it will be more beautiful to look at. That is what art is all about. Art is about visuals. It is not a science. And I'm a different guy now.

Art is about visuals. It is not a science.

To answer your question, if you want to see what the moon looked like, look at the beautiful photographs that we took. If you get one that's neutral gray - that's it. That's how it looked up there. Beautiful, but my job as an artist is not to reproduce that, but reproduce what I liked about it. What I thought would be beautiful. Artists do not understand engineers and astronauts - I guarantee it and I have a lot of artist friends. Engineers and astronauts don't understand artists - because they're different. They think differently. They have different goals in their lives. That's the answer. I make these things as beautiful as I can think to make them. Sometimes I over do it. I've got some paintings that I'm looking at now on my wall and I over did it. I'm sorry that I did them in those colors, because if I could do them now and change the colors, they would be better. But, at that moment, in that year, that's the way I wanted them to look. Boy, they're beautiful, no doubt about it. I'm looking at one of Pete Conrad. Pete was happy guy - a wonderful guy - all the time. Never had a down day. Never complained. One of the things he did when he was feeling especially good - which was about once a week - was jump up and click his heals together. He did that on the moon in his space suit, and I painted him that way - but I've got the sky blue and the ground a kind of red violet, because those are my favorite colors. By the way, Monet painted the Rouen Cathedral in those same colors. That's where I got the idea. Those exact colors and the Rouen Cathedral - as I mentioned before - is gray. So, I'm looking at Pete's suit right now and there is a cool green, blues, some violet, red, every color of the rainbow in that guy's suit. Of course they really weren't, but I can do that . . . I'm an artist. It's a different way of thinking about things.

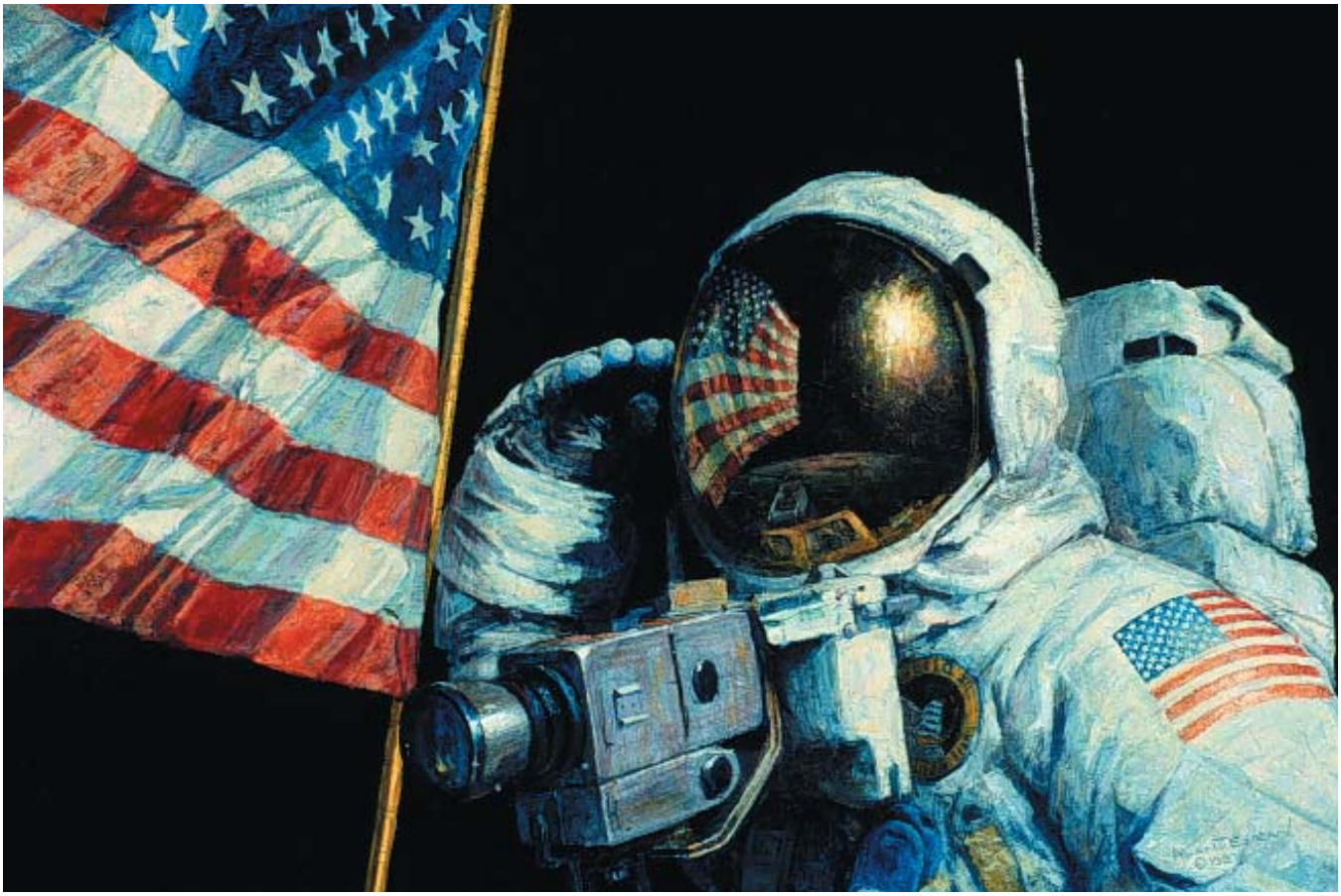
Carberry: Sounds like you're applying your emotions to the painting…

Bean: That's exactly right. This painting of Pete is like what I think about of him. It is a great picture of Pete, but it doesn't really look like he did there. Often, I'll put a warm color in the foreground - like a yellow or an orange. It's hot up there. If you paint neutral gray, it doesn't look hot - it looks kind of cool. You've got all these elements at work. Sometimes I say that I'm going to make the moon more yellow because I just want it to look warmer and then I'll be able to work in some greens and blues. It will still look like the moon, but it will look more beautiful. I wish the moon had looked like that, but it didn't, but I'm an artist - I can make it look like that. I enjoy being an artist and I enjoy doing these things, but it is not science - and it has taken me a number of years to change myself so that when I did these they seemed beautiful. I never could have done those paintings early on because I wouldn't have accepted them. My mind would have made me make the shadows gray and the moon gray/brown, and the sky black - and that is what my early paintings look like.

Carberry: Do you see a role for people with artistic training in future missions to the Moon and Mars, and elsewhere?

Bean: I think one of the things that we need to do is prioritize when we start doing things that are very risky and expensive. The exploration of Mars - one day - will be very risky and very expensive. So you've got to prioritize the type of person that you are sending there. I don't think an artist is necessary at all. I think a geologist, engineers, and scientist types are necessary, because we are trying to explore and see what we may be able to do with it. Then, when the next wave comes we will be able to decide whether or not to send artists. Don't forget, we have great photography now, great TV, much better than when we went to the moon. So all those elements can be solved without an artist, but I think eventually that artists will go there. You could look at Antarctica and say let's take a look at the people who were sent down to Antarctica in early years -- see what their background was. I'd bet their background was the same kind of background as in early Apollo and late Apollo. Then, maybe after a while, someone like an artist can go, like with the shuttle, sending a couple of teachers up. They taught them to go EVA and they did a good job. Well, I think that's the way Mars is going to be, and I think what my paintings do is celebrate this great human achievement which is Apollo. One of the greatest things that humans did -- advancing the state of the art of technology of the Earth and then its "We Come in Peace for All Mankind" and all those things - celebrate that. Then as time passed I realized that these are the first paintings of a world other than the Earth - period. Every other piece of art that you've seen - except mine - is of this Earth. Mine are of another world - and mine is of one human's view as we go to a new world.

When we go to Mars one day the site will look a little different, the

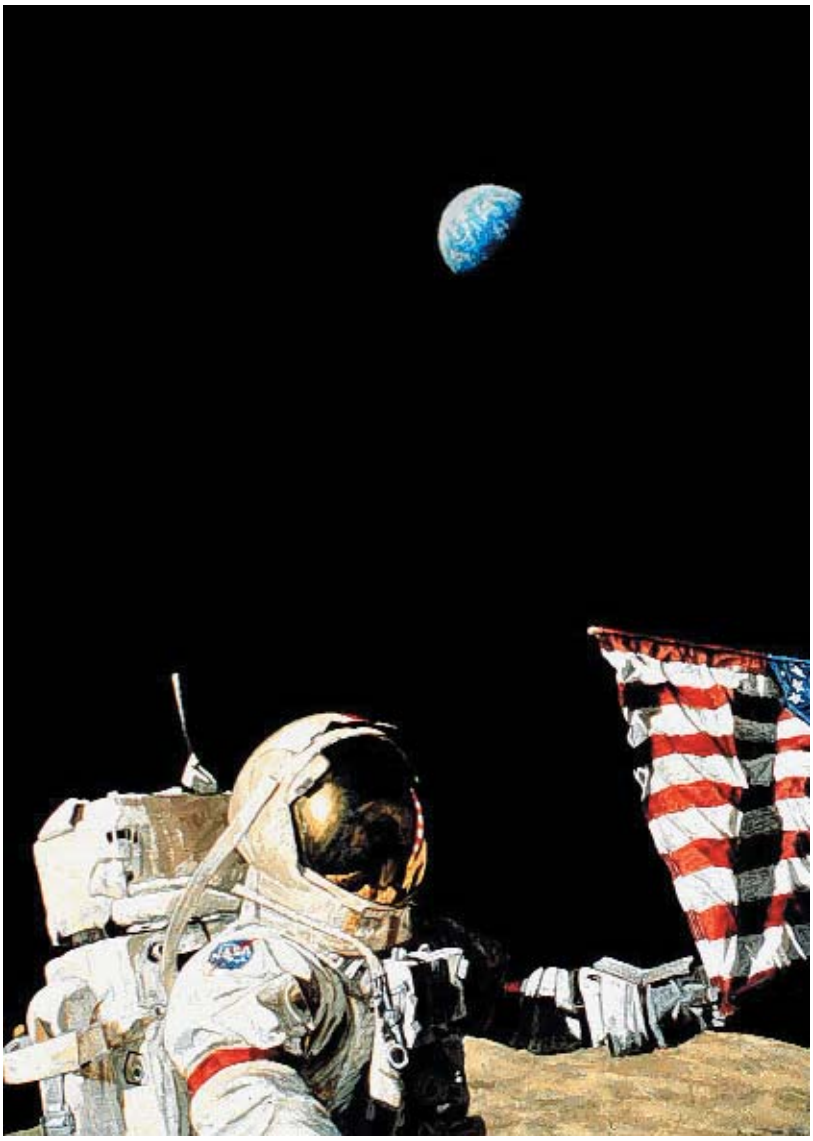


landing module will look a little different, the rover will look a little different, but the people will be doing the exact same thing that we're doing -- they'll be taking pictures, they'll be digging trenches to get information from beneath the top soil, they'll be picking up rocks. All those things that we do are things that we'll do when we go to the moons of Jupiter - or when we go out to another star. This is what humans need to do to understand where they are. Then they will come home and maybe some of them will do art. Maybe some will write a little poetry - who knows! These are paintings of what people did. You know the early West? People went out and painted the Grand Canyon and painted Yellowstone and painted the Indians, and painted cowboys later - and you look at them and it is not exactly like it really was. In Moran's Grand Canyon of Yellowstone, Yellowstone doesn't look exactly like that. The paintings are better. They're more interesting to look at. Nature is not harmonized in color. People talk about nature all the time. If you were to compose a painting to look exactly like nature, you wouldn't be considered a good artist. They'd look at it and say, "That's not very pretty. Green trees don't necessarily go with red rocks or anything like that." I know that's almost blasphemy because people go around and say how wonderful nature is. Well, nature is wonderful. We wouldn't be here without it. But, nature's job is not to create beautiful paintings, where an artist's job is. These things you don't think about when you are an engineer. You don't think about these when you're a writer. As an artist, you begin to think about these things. You paint a beautiful vista verbatim - and it sure isn't a very pretty picture - I like Monet's better. If you look at Monet and go where he was and say, "He's passed me by. He didn't paint it like it was either. He took the raw material and he made it beautiful." That's what I try to do with these paintings. I try to make the moon beautiful. I try to make the astronauts that way - make them more interesting - make it more fun to look at. Make them more memorable. It's like writing a novel. A lot of things in novels are more interesting than in real life. That's okay, that's what a novel is. A painting is more like a novel. A photogram is more like a science book or a scientific report.

Carberry: With all these wonderful Mars images coming from NASA and ESA, do you get artistically inspired by them? How do you think you would depict Mars?

Bean: Well, first of all, let's say that I was an astronaut that went to Mars. First of all, if I was just an artist, they wouldn't send me. I can't do any useful work, really. Let's say that when I got to the right age, people were going to Mars and they thought I'd be a good astronaut and sent on a Mars mission. I'd come home and I'd fly on other missions - because I would be fundamentally an astronaut - I wouldn't even realize that art was of interest to me that much. Even though I liked it, it was just a hobby. So, maybe after a number of years I would say to myself, "You know, I'm

the first artist ever to go to another world." Maybe I'll do that, because there are a lot of good young men and woman who can fly to Mars as good as I can or better. I'll leave that to them to do, since they are just as good as I am, but I'm the only one who wants to be an artist and show these adventures in art. Then I would do my first paintings and they would look just like when we look at the TV. They'd be red - the rocks would be red - kind of a reddish sky. Maybe I'd do a few that way and say, "Man, this is boring" from an artist's viewpoint - not from a scientist. Maybe if I introduce a little bit of green in here somewhere. Maybe people would still know that it's Mars, but would think that it was more beautiful. Then as the years passed and I became more an artist, I'd paint Mars just as I paint the moon today. I'd think about what the astronauts are doing and I'd think about the color and I'd ignore the red. I'd say, " Well, let's leave it a little red, but I'd really like to do a painting with a lot of violet in it - blue and violet - I like that." I think that is the way art evolves.



Carberry: I understand that you and Andy Chaikin are coming out with a children's book?

Bean: Yes, we did. We called it a children book, but I think it isn't a children's book. It is a young adult book for ten years or older. It's called Mission Control, This is Apollo. I will tell you that it is a good book, and every one of your readers should look at that book and think about buying it. It is one of the best books I've seen that talks about the space program. Half the people on Earth right now weren't alive when Apollo was taking place. It has so much information in it. The editor, is a lady by the name of Sarah November, and she put out a great book. Andy's words are great - my paintings are nice - the photographs are great - but mostly Sarah November created a great book. It's a wonderful book.

Carberry: How do you want to be remembered? As an astronaut, an artist, or something else?

Bean: Astronaut/artist would be it; I want to be a guy who did his duty. I'm doing my duty right now. I loved being an astronaut and I'd still be there if I didn't say to myself you know, there are a lot of young men and women who can fly that space shuttle, but I left that program 28 years ago to do a job that I felt needed to be done - record the great adventure of Apollo - record the first humans off this Earth - what they did - how they felt - things we laughed at - things we fussed about - and keep it, because we're gone. Think about it. I wish someone had sent artists like me along with Magellan or Lewis and Clark or with Captain Cook because we would know a lot more and would have a much better feeling about what those great adventurers were all about. I don't replace the movies, television or photographs, but I know a lot of good stories, and I can visually display them for people to remember.

Many of us are not going to be here all that much longer. I'm 77 as is everybody else, or a bit older, so we're not going to be here forever. I just hope to tell some of these great things that Neil Armstrong or Buzz, or Mike Collins, or any of these other guys did. I can't tell them all - too many stories to do in my lifetime, but I wish I could stick around and tell all that I know, because when we're gone, we're gone. I'm doing my duty. This is what I can do with my life. I get up at 5:00 a.m. I've been painting/working all day today. I do it seven days a week. I work just as hard as I did when I was an astronaut, except in a different role. I'm just doing my duty.

Readers' Forum

Call for a Global Space Revolution

by Shaun Moss

The world stands on the brink of imminent global change. The challenges currently being presented to human society by instabilities in the global climate and economy are significant, and finding solutions will assuredly occupy much of our attention over the coming decades.

However, in perfect balance, we also find ourselves at the doorstep of the greatest evolutionary leap that Earthian life has encountered since it crawled out of the oceans. We are poised to enter space - not simply as a handful of select persons or machines, but as a species.

The development and implementation of new systems for global environmental and economic management is widely understood to be of the utmost urgency, and, fortunately, steps are already being taken in this direction by great leaders and thinkers around the globe. However, what seems less apparent are the astronomical rewards for humanity that will result from our expansion into the solar system.

The potential benefits of space exploration and colonization include:

The Overview Effect

By all reports from astronauts, nothing compares with viewing the entire Earth from space. From this perspective the planet appears as a single, whole entity: a shining jewel, a living, breathing organism with no borders or other visible signs of separation between its inhabitants. It becomes more difficult to imagine that one is from any specific city or nation; rather, one sees the entire Earth as "home". From space, all people and nations are equal, bound together by the one thing we all have in common - the planet that we are all part of.

This perspective of Earth will lead to a greater unity among its peoples, an effect that will only increase as we colonize other worlds such as Luna and Mars. From space, any place on the surface of Earth is equally accessible; the differences between so-called "developed" and "developing" nations are not apparent, and indeed, from this perspective it becomes difficult to understand why such extreme variations in economic standards exist on the surface.

This profound shift in human consciousness from viewing Earth as a collection of distinct tribes to a single living world, experienced by increasing numbers of people, will automatically lead to the formation of new strategies for global environmental and economic management.

Access to Abundant Resources

Space is infinite, and contains infinite energy and material resources. By developing the necessary technologies and systems, humans can access these resources.

Once you see beyond religious, ideological or other purported reasons, conflict on Earth is almost always about natural resources such as energy, metals or land. Although limited on Earth, all of these are available in extreme abundance in space:

- Solar power, collected in an environment where the sun never stops shining and is never occluded by clouds or dust, can be efficiently and safely beamed to Earth (or anywhere else in the solar system) to provide continual, limitless and reliable energy.
- Over 400,000 asteroids have been identified in our solar system, with more being discovered all the time; the estimated total is over 1 million. Many of these orbit near Earth, and many are composed of almost pure metal, while others are plentiful sources of carbon or water. Access to these resources will mean an improved Earthian economy, reduced need to damage Earth's environment through mining, reduced international conflict, and an abundance of the necessary materials for constructing space cities and vehicles in Earth orbit and other locations throughout the solar system.
- Mars has a surface area approximately equal to the land area of Earth. The colonization and subsequent terraforming of Mars will therefore provide the human race with almost double the territory in which to live. This will only be the beginning; the experience of inhabiting and developing just one such planet will teach us how to colonize many thousands.

Survival

While infrequent, it is known that mass global extinctions caused by asteroid impacts have occured several times in Earth's history, and will almost certainly occur again. Hence, in order to ensure the long-term survival of humans as well as many other Earthian species, there are only two reasonable options:

1. Establish human colonies at other locations in space, so that in the event of a major impact the human species will survive and may potentially re-inhabit Earth afterwards.

2. Learn how to modify the orbits of asteroids, or how to break them into smaller pieces, so that a potential extinction-causing impact can be prevented.

Both of these solutions require increased technical capability in space.

If an impactor is above a certain size or velocity, it will impossible to divert or destroy it; furthermore, extra-terrestrial colonies will probably be dependent on resources from Earth for centuries. Hence, the optimal strategy for the long-range survival of humanity requires both of these solutions.

Increased Global Collaboration

At our current level of technology, exploration and development of space is still fairly expensive and complicated. Furthermore,

considering that the effects of space research are often global in application rather than restricted to specific nations, there is overwhelming incentive for international collaboration in space activities. This has been one of the primary benefits of the International Space Station, which has brought together many of the greatest countries of Earth into a noble and productive exercise.

During the past century several arenas of activity have replaced military conflict, including sport, tourism, international trade, and collaboration on technological development. The nations of Earth have started to realise that co-operation, instead of competition, leads to an improved outcome for everyone. By building on the success of the ISS and continuing with international collaboration on space development, the nations of Earth will be drawn into an even closer partnership. This can only lead to peace and an improved quality of life for everyone on Earth.

Technological Innovation

Countless examples already exist of technologies that were developed for space and have since been applied on Earth (computer technology, structural analysis, the hand-held video camera, communications, IT, sports training, energy storage, robotics, materials, etc., etc.). The question is, would these technologies have still been developed if people were not striving to solve difficult problems in space?

When given an inspiring and challenging problem, the human mind begins experimenting with solutions and gathering information, both consciously and subconsciously, with the result being eventual inspiration and breakthroughs. The challenging environment of space presents unusually hard problems, which thus tends to attract the most brilliant minds, resulting in especially innovative solutions that can have enormous application and value on Earth.

For example:

- Technologies developed for space settlements, such as atmosphere processing, in-situ resource utilization, recycling, etc., can similarly be applied to open up huge uninhabited regions of Earth, while also improving the efficiency and function of existing cities.
- Advanced robotics technology developed for exploration, mining and construction in space can be applied on Earth to an extremely wide variety of tasks, decreasing the cost of materials, products and services, and improving health and safety.
- Energy production methods developed for space applications, such as space solar power or nuclear fusion, can be applied on Earth to provide abundant electricity and thus improved quality of life to all people.
- Biotechnology developed for space agriculture or terraforming can be applied on Earth to drastically improve global food production and health.
- Carbon nanotube technology developed for space elevator applications can be applied to create all manner of ambitious structures and equipment on Earth, as well as space structures and vehicles.
- Planetary engineering strategies developed for terraforming Mars can be applied to Earth in order to improve the global environment, including cleaning the atmosphere and oceans, bringing life to the deserts, and stabilizing global climate.
- Vehicle technology developed for space applications will increase the speed and lower the cost of travel on Earth, vastly improving the efficiency of human transport, resource distribution, package delivery and emergency response.

The colonization of space offers hope for humanity. It is simply the only path to an abundant and peaceful future for an expanding human civilization. It will bring us everything we need to develop and grow; without it, our future will be one of increasing restriction, compromise, difficulty and conflict. If the number of people continues to increase while the amount of available resources remains the same, then, logically, this means a reduced share for all. The only other option is population control, which is not freedom; in fact, it would require increasing control by global authorities, and we would ultimately lose many of our technological capablities along with our peace and freedom.

As an analogy, consider a tribe living on a small island. Their population steadily increases, but the amount of land they have available to grow food remains the same. They know that across the sea is a large, uninhabited continent with abundant resources, but they decide not to risk investing in trying to reach this place, and to focus all their energy on the immediate problems of survival. Eventually they begin to fight over the dwindling resources and further damage is inflicted on the island, and the tribe, until only a few remain to pick up the pieces.

Compare this with another tribe in a similar situation. They, too, are growing in number and approaching the population limit that the island can sustainably support; they also know about the abundant resources across the sea. Even though they are experiencing challenges, they realise that these problems will only get worse unless they find a way across the sea, so they begin researching boat technology while also tending to their immediate problems. This tribe is more optimistic - they know that their problems are temporary, and that soon a new era in their civilization will begin: one of peace, expansion and security.

At this juncture in human history, with the challenges that now lie before us, opening up space should be made an absolute global priority. It should not be something of marginal interest, or a heavy load to be pulled along by a dedicated few, or something we will do "when we get around to it" or "when things are better". The sooner we become a space-based civilization, the sooner tensions on Earth will be relieved and we can enter an golden era of peace, harmony, expansion, abundance, adventure, freedom, health and happiness. It should be commenced immediately, and should be undertaken with wholehearted passion and commitment.

The following strategy is suggested:

1. The establishment of an Earth Space Consortium (ESC) comprised of governments and government agencies, private corporations, academic institutions, space advocacy groups and philanthropists. This organization would be funded by both public and private money, with each member contributing an appropriate percentage of GDP or profits. The function of the ESC will be to organize a substantial fraction of Earth's resources (in particular, at least 10-30% of Earth's finest minds) into a unified and cohesive strategy for providing the people of Earth with access to the abundant resources and limitless expanse of space.

2. Government-sponsored financial benefits, including tax exemption or discounts, and/or investment, should be available for all companies involved in space exploration and development, environmental engineering, and the development of critical enabling technologies such as aerospace vehicles, solar power and robotics. This will hasten the development of solutions to immed-iate global problems, and more quickly secure a better future for all people.

3. A dedicated, coordinated and well-funded global program for reducing the cost of access to space. Everything depends on it; at this point, the primary obstacle preventing humanity from becoming a space-faring civilization with the resources of the Solar System at its fingertips is the exorbitant cost of reaching free space from Earth. The initial phase of a unified Earth space program should be primarily focused (90%+ of expenditure) on advancement of space transport technology.

4. A global program to develop space solar power as a method of providing continuous, reliable and abundant clean energy to Earth, while simultaneously increasing our capabilities in space and developing technologies for on-orbit construction.

5. A global program to develop space tourism as a viable economic motivator for the private space sector, a source of inspiration and adventure to the people of Earth, and an essential precursor to space property development and colonization.

6. Development of a robust and profitable space mining industry. This will simultaneously provide three enormous benefits: an economic incentive for space development; a great abundance of metals, carbon, water and other materials necessary for construction of a space civilization; and development of technologies and methods for defending Earth from asteroid impacts.

7. An international collaborative effort to establish permanent human settlements in Earth orbit and on Luna and Mars. These seeds will become new branches of human civilization, thus ensuring the long-term survival of humans and many other Earthian species. The exercise will also teach us about advanced recycling, nanotechnology, robotics, resource management, advanced biology and chemical engineering, planetary engineering, how to successfully create harmonious, close-knit communities, and many other things that can be applied with tremendous benefit on Earth.

The time is now. It will only become more difficult over the coming years. The past doesn't matter, and neither do our petty conflicts over resources; all that matters now is creating a positive human future for ourselves and our descendants. The sooner we make space development our utmost priority and open up space for the people of Earth, the sooner we will enter an amazing new chapter of human civilization. We need to pull together as a team, get organized and focused, and create an exciting new future of peace and freedom - in space.

Shaun Moss is a freelance web programmer, dedicated space enthusiast and writer living in Melbourne, Australia. He contributes regularly to numerous space organizations and is interested in space settlement design, ISRU, planetary engineering, robotics and field propulsion.
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Mars: A Personal Journey

by Hugh Downs

In reading this, please keep in mind two things: (1) Truth is stranger than fiction; and (2) futurology is characterized mainly by failure of imagination.

The future invariably arrives sooner and much stranger than we expect it to be. My personal experience with this involves following an adventure strip in the newspaper when I was nine years old. Phil Nowlan and Dick Calkins were the creators of "Buck Rogers in the 25th Century." So when I started reading it in 1930, it was "Buck Rogers, 2430 AD."

Nowlan and Calkins, along with many scientists of the day, believed that humans would go to the Moon and to Mars, but not until 500 years in the future. As it turned out, the first human stepped onto the moon 39 years after I started reading the strip.

Suppose a fortune teller had come along and told me this, along with another true circumstance: that at the time I was reading "Buck Rogers", there was a newborn baby 16 miles to the south of me, who would be the first man to walk on the moon. His name was Neil Armstrong. I think such a story would classify as totally fantastic and improbable in the extreme.

But in the town of Wapakoneta, Ohio, which is 16 miles south of Lima, where I was growing up, Neil's parents were friends of my parents -- my mother having been born in Wapakoneta. I never met Neil until he was an astronaut. I was the first to interview him and the other two members of the Apollo 11 crew on their return from the moon and after their brief quarantine. (There was a fear that Armstrong and Buzz Aldrin and Mike Collins might be bringing back some contagion for which humans had no immunity -- but the quarantine was discontinued for later Apollo missions.)

The adventure strip was not as well drawn as a companion strip called "Flash Gordon", which was more fantasy than science fiction. Actually the "Buck Rogers" authors displayed some sound science in depicting the airlessness of space, and the relation of Mars to its two moons. In one episode, an evil Martian city was destroyed by slowing the orbiting velocity of Mars's smaller moon and causing it to crash onto the surface of Mars at the precise location of the city. A rocket ship, nose down on the small moon, applied steady pressure to alter the orbit in a calculated way that produced the results desired. The action was pretty sound, scientifically, even though the city on Mars was not.

But the romance of space travel was heated up in me by my encounter with Buck and Wilma and Dr. Huer. Space had enthralled me since I was five, and I learned from my father that the moon was 238,000 miles away. I think I was so flattered to be given a grown-up answer to my question, that this was a factor in setting fire to my imagination. I had no idea how far 238,000 miles stretched -- not sure I grasp it with exactness even now -- it's farther than ten times around the world. And of course it is much closer than the next planet out from us, named after the god of war because of its redness.

How blessed we are to have Mars as a neighbor -- of a size not to have surface gravity unfriendly to humans. Not too far from the sun to have the benefits of radiation; possessing a day that is nearly the same length as ours. And having many of the resources necessary to give serious consideration to eventual terraforming.

My youngest great-grandchild (my grandson's daughter) is three now and can name every planet out from the sun. The pre-kindergarten crowd is getting that kind of education today. Her brother, now six, wants to be a scientist and go into space. It might be a stretch to suppose he could be among the first to reach Mars, but surely one of his children could be in that first expedition, if I'm not suffering from failure of imagination.

And maybe I am. I am thinking of the amount of time under present transportation methods that it takes to get to Mars one-way -- a couple of years. Crossing the Atlantic by ship went from several weeks (sail) to four-and-a-half days (steam) and then six hours or less by air. Now low earth orbiting objects circumnavigate the globe in 90 minutes. There may be a means of propulsion that will cut the time way down for a Mars trip. Best not to count on this, but don't rule it out.

So my vicarious trips to Mars take three forms: childhood imagination, adult enthusiasm flavored with wishful thinking, and relishing the possibility that descendants of mine are likely to actually go there.

Hugh Downs, longtime anchor of ABC Television's primetime news magazine 20/20, has enjoyed a distinguished 66-year career in radio and television as a reporter, newscaster, interviewer, narrator and host. He has received six Emmy Awards and numerous other literary and honorary awards, and has authored 12 books, including an autobiography. Downs hosted PBS's "Live From Lincoln Center" for a decade. He helped launch NBC's Tonight Show in 1957; he anchored The Today Show from 1962 to 1971, and has broadcast numerous specials and documentaries. Downs is a pilot, with a current medical rating, along with ratings from multi-engine to hot air balloon. He has been an advisor to the National Aeronautics and Space Administration (NASA), and is currently the chair of the Board of Governors for the National Space Society.in Washington, D.C.

He and his wife Ruth, live in Arizona. They have two children, two grandchildren, and now two great grandsons and a great granddaughter.

Simplifying the Difficult

by U.S. Rep. Pete Olson

When President Bush announced the Vision for Space Exploration in January of 2004, he did so at a time when interest in exploring Mars was at a high. The rovers, Spirit and Opportunity, had just landed on the Red Planet. Amazing when you think that over 5 years after the landing, and under a different Presidential administration, the rovers are still sending science back to analyze. A major component of the vision announced in 2004 was a human mission to Mars. I am a strong advocate of that goal, it is a worthy goal. Readers of this journal know the benefits of such a journey, but are we in the majority of Americans? Have we made the case to our fellow citizens, to the public, and to my colleagues on the Hill?

Have we made the case to our fellow citizens, to the public, and to my colleagues on the Hill?

It doesn't hurt to assume that a majority - as well as the odds - may be against us. This is not the Apollo-era, when the nation stood willing to sacrifice whatever it took to beat the Russians to the moon. Having to state our case will keep our focus sharp and our arguments focused on the areas and points that most resonate with the public to gain their support. The ability to turn that support into funding will be what ultimately leads to the success or failure of such a grand goal.

During your annual Mars Society convention, at least 150 conventioneers will venture to Capitol Hill to meet with members of Congress or their staff to share your agenda. I wish you well and offer a few suggestions for your visits to make them most effective.

It is important for you to know your audience and demonstrate that you understand the unique challenges that each congressional district faces. Each member has unique backgrounds with respect to the leading industries, educational institutions, and demographic makeup of their district. A district suffering from high unemployment in this economic environment might present a harder sell for the Mars program as opposed to one with a hi-tech employment base.

In making your case, the ability to broaden your perspective is immensely helpful. During the presidential campaign, then-Senator Obama's four main priorities were clear: energy, education, the environment, and the economy. Space and exploration were not included, but we can tie exploration and the space program directly to each of these priorities. Can you make the case that sending a human to Mars is worth funding in comparison to improved healthcare?

Are robotic missions a wiser investment than energy technology? You must be prepared for those questions, because while the federal budget appears limitless, the hard truth is that it is not.

It's important to face the challenges head-on. Admit the failures of the past, particularly the budgetary challenges the program has faced. This, if nothing else, demonstrates just how difficult these goals are, and thus all the more worthwhile when we commit to them.

Finally, your enthusiasm and the ability to share your inspiration will the make the time well spent. Just think about the impact Steve Squyres would have with 30 minutes in each congressional office. Find opportunities to include the overall benefits of a Mars mission. Your perspective and the reason you individually and collectively feel strongly about this critical issue will go a long way.

In your last edition of The Mars Quarterly, Chris McKay wrote about continuing robotic missions to lay the groundwork for future human ones. I could not agree more. The problem that faces our space program is that we are looking inward and not upward. We have the ability to learn from our successes and our failures to achieve a worthwhile goal. It is up to us to demonstrate the value of that goal. If we fail to do so, we'll fail to start, let alone finish, a great journey.

Rep. Pete Olson serves the 22nd District of Texas. He currently serves as the ranking member of the Space and Aeronautics Subcommittee of the House Science and Technology Committee.

Illustration "Chasma Borealis" by Greg Martin
www.ArtOfGregMartin.com

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Of Time and Money

By Patricia Czarnik,
Director of Membership

In this issue I want to talk about membership, more to the point, why your membership is important. There are two components of membership - a contribution of time and a contribution of money. The Mars Society could not exist without both.

• Contribution of time: there are members who donate their time on mission support, telemedical support, various task forces on outreach for education and political action, to name a few. They head up the University Rover Challenge, maintain the website, coordinate and maintain FMARS and MDRS operations and make our annual international convention the premier event it has become. They produce this publication you are reading now. Got talent? Volunteers are always needed in every aspect of everything we do.

• Contribution of money: we have several large financial donors but most of our income is generated from our members. Each and every dollar you contribute via membership and donation is added to the pool of every other member to allow us to continue our goal of seeing humans on Mars in the near term. It all adds up. Got money? Money is always needed in every aspect of everything we do.

Most people join an organization based on its mission statement and goals. They want to be a part of and contribute to an organization where they feel their contribution will make a difference. I am often asked "What do I get for my membership?" My simple answer is "You are supporting the goal of seeing humans to Mars in the near term". The answer doesn't stop there. I continue to explain that The Mars Society not only discusses how and why we should go to Mars, but takes action on critical components of getting us to Mars. So where does your membership contribution go?

• **Mars Analog Research Stations:** FMARS and MDRS. 100's of participants have taken part in analog studies of what it will be like to live and work on Mars. Together these stations are able to support human mission simulations for ten months out of the year, investigating subjects crucial to future Mars exploration, including field geology and microbiology, human-robot interaction, advance space suit design, collaborative telescience protocols, remote communications systems, assistive computing

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York University Runs Away With the Title at URC

By Kevin F. Sloan

Just one year after first and second place were separated by just one point at the University Rover Challenge (URC), York University swept in and dominated the competition at this year's event, more than doubling the point total of their nearest competitor.

York topped a field of seven teams from three countries that made the trip out to the Mars Desert Research Station (MDRS) to fight off the late-May scorching sun and fierce desert winds. They were able to build a substantial lead during the first day's events, winning the Construction Task, and putting in a solid performance in the Extremophile Search Task. The second day of competition got off to an exciting start as York, the first team to attempt the Emergency Navigation Task, became the only team all day to successfully locate the distressed astronaut hidden in the field. And for the second year in a row, the team that won this task went on to win the entire competition. Closing out their day with another great showing in the Site Survey Task, York seemed to be the only team able to survive the stress and rigors of URC without any major breakdowns.

"I had expected our rover to not be as complete and fine-tuned as the other rovers. Our team made a decision at the beginning of the year to build a completely new rover," said Vincent Huynh, Co-Caption of the York University Rover Team. "You can say that our rover by far exceeded my expectations this year!"

Brigham Young University (BYU) leveraged a great performance in the Site Survey Task, as well as a relentless performance in the Construction Task after a touchy control system sent their rover's arm flailing, snapping a cable and losing the socket needed to secure the bolts. They were followed closely in third place by the University of Nevada, Reno, who thoroughly impressed the judges with their expertise in the Extremophile Search Task. The field was rounded out with impressive showings all around by the 2008 champions from Oregon State University, Georgia Institute of Technology, Warsaw University of Technology, and the University of California, Los Angeles.

Students from York's team will be in attendance at the 12th Annual International Mars Society Convention this summer, where they will be talking to other attendees about their experiences at URC, and will then be honored for their success at the convention's Saturday evening banquet.

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systems and human factors studies.

• **Tempo3:** This was the winner of The Mars Project Challenge in 2008. It will be the first step in testing artificial gravity for a crew on their way to Mars, a critical component in allowing the crew to arrive physically fit for their exploration of Mars.

• **University Rover Challenge:** Now entering its fourth year, the URC calls on the best and brightest college student teams to design and build the next generation of Mars rovers that will one day work alongside astronauts on the Red Planet.

• **Political Action:** The Mars Society has established an all-volunteer, grassroots Political Task Force whose purpose is to promote human missions to Mars as the primary goal of the U.S. Space Program. Members conduct congressional meetings locally and in Washington, D.C., meet with presidential candidates and campaigns and periodically visit both houses of Congress en masse.

• **Educational Projects:** Exploration of another planet cannot be undertaken in a year or two, or even in a single generation. The Mars Society is committed to engaging the imagination and intellect of the next generation. Educational projects range from the local level, with classroom visits by society members to elementary and secondary schools to a larger scale, including exhibits of stations before they were deployed at Kennedy Space Center and Adler Science Museum. For the past three years under a cooperative agreement with NASA, the Spaceward Bound program had brought many exceptional college students and primary/secondary school teachers to train at MDRS.

I'm not going to tell you that if you give up one latte on the way to work we will get to Mars in 10 years. I am going to tell you that your continued support via donations, membership dues, and volunteering will get us to Mars. This is why your membership is important.

As always, I look forward to your comments and suggestions about membership and chapters. I hope you are having a great summer!

Contact Patt Czarnik via email at Patt@MarsSociety.org

Passion: Don't Leave Home Without It!

An Interview with Andrew Chaikin, author

Carberry: Looking at your strong ties to the Mars community, I think the first question I'd like to ask is - why now? Why didn't you write *A Passion for Mars* earlier?

Chaikin: It was really kind of an accidental process. It started when I contacted Erik Himmel, the Editor-in-Chief at Abrams. I'd gotten to love Michael Benson's book *Beyond*, which is just a wonderful compendium of planetary images - beautifully designed book. Michael did a superb job and of course had Abrams production quality behind it. I very much wanted to do something in that vein. I've always loved doing illustrated books as well as books like *A Man on the Moon*, where it's not illustration driven, but text driven. So I got together with Abrams and Erik and I decided that I would do a Mars book.

It started out as being just an illustrated history of Mars exploration and a few months into the process Erik said, "Gee, I really don't like the idea that you are going to do a great book on Mars exploration and then someone else will come along and do one that is not as good, but [people] won't know the difference. Is there any other way that you can think of to make this book any more bullet proof, so that it will really stand out?" And I said, "Let me make it personal." From that point, it evolved over a number of months into the history of Mars exploration through the lense of people I have known and encountered over the years who have really been the real movers and shakers in Mars exploration. Not that it is comprehensive by any means, but it is a story that is meaningful to me and I do try to tell an overarching story about Mars exploration - telling as much about the people as I do about the planet.

What I realized when I got into writing that book - as opposed to the one that I had originally embarked upon - as I started to look back at my own history, I realized that Mars really was a thread through my whole life. It goes back to my early childhood when I fell in love with the planet. As I said in the book, Mars was the planet that made me feel most like an explorer.

Carberry: I think the fact that it was personal made it more compelling, and makes it a must-read in the space community.

Mars was the planet that made me feel most like an explorer.

Chaikin: I appreciate that. What happened by accident is the best thing that could have happened as far as I was concerned, because I really feel that this is a book that is meaningful to me on many levels. For example, to be able to write about my college professor, Tim Mutch. His name is probably not known to many people, but he was a tremendously important person in my life and also influenced so many other people. It was certainly satisfying to be able to tell his story and also that of Jerry Soffen. It has really been "neat" on that level.

Carberry: Who do you really think best captured the reasons for going to Mars? Was it Mutch or somebody else?

Chaikin: Well I would say that the person who expresses it the best is Ray Bradbury, who's not a scientist at all of course but one of the giants of science fiction. I call him the poet laureate of Mars exploration because he has an amazing way of expressing why this matters - why it's so crucial that we continue to live out our destiny as an exploring species. Bradbury makes the statement that Mars is a waystation in our path to immortality. By that he means, to become an interstellar species, and truly make the human race live forever by going out in space. The first stop along the way is to go to Mars and live on Mars. Until we've done that, we haven't really cut the cord.

Carberry: When you were working on Viking, did you think humans would be on Mars by 2009?

Chaikin: Probably not when I was working on Viking, but I guess if you'd said to me at the time, "Gee, do you think we'll be on Mars by 2009…" You know that was so far away - that was 30-something years away. So, well sure, I would have hoped we'd be there by then. You know I think when the Shuttle started flying in the early 80s… actually, it was earlier than that. When we stopped going to the Moon, that was obviously a sign that things were not going to continue at the same spectacular pace that they had been while I was growing up. I remember being very disappointed that what was then called the "Grand Tour" was being cancelled. Of course it was resurrected as Voyager. To me the most important thing that the space program is for is exploration - whether it is with humans or with robots. When the Shuttle started flying in the 80's, it just didn't feel like exploration, and neither does the international space station project. I think over time it felt that there was this divide between the human space program and the robotic program. The robotic program was about exploration, whereas the human space flight program was about engineering.

Carberry: There is no question that what we have been doing for the past 30 years in the human space program has not felt like exploration. The cancellation of Apollo was the key problem, but what else do you think went wrong?

Chaikin: It has been the Field of Dreams approach to the space program -- "If you build it, they will come." The idea was 'You won't be

disappointed. Let us build this space station and we'll find so many cool things to do with it. You'll be amazed.' You know, that really hasn't panned out. It would be nice if instead of starting with the engineering and trying to figure out what we're going to do with it, we would start with the purpose that says we want to go places and do things that nobody has ever done before - and let that drive the engineering. I think that the jury is still out on that question as the Obama administration begins to sit down and review the human space flight program. My fondest wish is that we retain the goal of getting beyond low Earth orbit - sooner rather than later. Because for me, the worst thing - I'm probably going to annoy a lot of people in The Mars Society by saying this, but I could live with the notion that we won't get to Mars anytime soon. I can even live with the notion that we won't get back to the Moon anytime soon. What I can't live with is if we are going to be stuck on low Earth orbit for the next twenty years as we have the last 35 years. To me , even if we did human missions to near-Earth asteroids, as a kind of stepping stone to inter-planetary missions, that at least seems to me as though we were back in the exploring game. Of course, I want to see us on Mars! Of course I want to see us returning to the Moon. But, the worst thing to me is not to try to extend our reach beyond what we've already done.

Carberry: Actually, I don't think that most members of The Mars Society would get angry at what you said. While we want to get to Mars as quickly as possible, if it were a choice between exploring near Earth objects or continuing to do what we've been doing for the past 35 years, I for one would pick asteroids. The status quo isn't compelling. The most compelling human space mission is going on as we speak - the Hubble repair mission.

Chaikin: Exactly! Let me give you a perfect example of where I think we've been. In 1997 I went to JPL to cover the Pathfinder mission. Twenty-one years after Viking I'm back, this time as a journalist. I'm there at JPL, just as I was with Viking viewing the first pictures from the surface of Mars in 21 years. I was in the press center and there were two monitors up on the wall. One was showing the Shuttle mission from that time, which was a SpaceLab mission, and the picture that you saw was a bunch of guys in rugby shirts inside a tin can doing who knows what. I certainly didn't feel captivated by whatever they were doing in SpaceLab. The other monitor had pictures of [ ] and the contrast was just startling. There in a nutshell was everything that was wrong with the human space flight program. Just today, as you mentioned, I have on my computer as I'm talking to you the live feeds from the space walks to repair the Hubble. That is the first thing that has happened in years in the human space flight program that has felt like we are using humans for what they're supposed to be used for. I would feel that way again if we could only do something that got us further than we were in 1972 in some way, shape or form. I'm frustrated and have been for decades.

One of the things that was great about writing *A Passion for Mars* was that I got to immerse myself in exploration saga. A multi-decade, multi-generational saga of Mars explorers, that is all about the best qualities that we have as human beings. The curiosity to want to know what another planet is like and where it came from and how it evolved - the ingenuity to build machines to actually answer those questions - the perseverance to keep plugging after crushing disappointments; and the spectacular results that led us on this cosmic narrative that stretches back to the very formation of the solar system. This bears on some of the most compelling questions that we know how to ask, like is there life beyond Earth? Can we live on other worlds? How do planets form and evolve? And then on top of it all there is this bonus - we get this leap in awareness. In fact, one of my favorite pictures in the book is the picture that opens the final chapter, which I call "Tomorrowland" named after a Disney space show in the 1950s. It's an observation about the fact that going to Mars keeps receding into the future. At the opening of that chapter is the view of Earth as seen from Spirit, sitting in Gustav Crater. Looking into the pre-dawn sky is this bright point of light, which is the Earth. To me that is one of the most powerful images to come out of the Mars program, because it really helps us make the mental leap to being on Mars, and at the same time we kind of get an appreciation of the enormous challenges that remain before a human being can have that view.

Carberry: On the topic of life beyond Earth, with the recent evidence of methane, water, etc., do you think they will find life on Mars?

Chaikin: Well, let me put it this way -- I think that the preponderance of evidence has shifted the baseline in a direction of expecting that there is life. It may not show up in the first place we look for it, but I think it would be really surprising at this point, given everything that we know about life and its tenacity and its adaptability and given of what we know about the likely conditions underground on Mars and some of the satellites of Jupiter and Saturn - it would be very surprising if we didn't find life in some of those places. I think it is very possible that if there were aquifers on Mars - you'd have all the conditions you'd need. They say the three things you need are: water, organics, and a source of energy. Those three things may very well exist in the subsurface areas of Mars.

Carberry: In your book, you devote a lot of time to The Mars Underground. How much impact do you think they had? Many of their members (Penny Boston, Carol Stoker, Chris McKay) are extremely active with The Mars Society.

Chaikin: Well, one of the stories that I really wanted to tell in *A Passion for Mars* was this story. The Mars Underground refused to take no for an answer at a time when NASA was ignoring the whole subject of humans to Mars or anywhere else beyond low Earth orbit. These young folks in Boulder were saying "Hold on, just a

second! This is our space program too!" As Carter Emmart in the book, "Damn it! What happened to our future?" they set their own course and showed what passionate people can do. To me, it's one of the most inspiring parts of the book. It shows that a meaningful, important, long-lasting impact can happen on a grassroots level. It's that kind of passion that we will need to have if we are going to get to Mars. It's the passion that says, "We're going to find out how to grow crops on Mars! We're going figure out how to protect the crew from radiation! We're going to figure out how to produce propellant and those other consumables from in situ resources!" These were ideas that were really outside the mainstream before the *Case for Mars* conferences began and now they're accepted and are part of the base-line thinking of how you would go to Mars. The credit for that largely goes to the people who created a *Case for Mars* and the people who attended those conferences and worked together. I remember being at the second *Case for Mars* conference in 1984. Sitting in there with everybody - Penny Boston, Carol Stoker, Chris McKay, Tom Meyer, Carter Emmart, and everyone else - it was like they were creating their own space program - like a parallel space program - except this space program was one that was really about what I wanted us to be doing, and what we should be doing. The other space program was a low Earth orbit holding pattern with the shuttles and diminishing excitement and expectations. I hate to be harsh. In hindsight, maybe I'm feeling a little more harsh than I did at the time, but I feel like it's been 30 years of lost opportunity and we're still trying to get back on track to where we were with the human program when Apollo ended.

Carberry: Yes, who would have thought we'd be where we are 35 years later.

Chaikin: I feel like Mars has some really important things to teach us like 'check your hubris at the door.' Every time we look at Mars and thought we had it figured out, the next time we looked, we were wrong. We had to pretty much start from scratch and reformulate our understanding of Mars. Another lesson is 'Be in it for the long haul!' This is a multi-generational quest. It is not going to be one lifetime or even two. It's really something for us to stick with it and keep our eyes on the prize. I think that the other thing that a *Case for Mars* relates to is harnessing the power of human ingenuity and passion. It's kind of like 'Passion: Don't Leave Home Without it!' There was as much passion in that room in 1984 as I have ever seen in one place. There's a great story that I think Steve Welch told about Ross Bailey who at that time was working at JPL on various engineering tasks. And at one point during the *Case for Mars* conference he stood up and exclaimed "This is what I want to be doing!" It kind of says it all.

It's that kind of passion that we will need to have if we are going to get to Mars.

Carberry: Shifting gears, you also discuss the importance of space art in your book. What impact do you think space art can have (or has had) in promoting and documenting space exploration?

Chaikin: Well, speaking personally, space art is what got me hooked on space. Space art is the spark for me. It all began with my childhood astronomy books and artists conceptions. My favorite words in the books was "artist's conception" because it meant that was looking through a magic portal that let me travel to other worlds at a time that we barely even knew what those other places were like. It was incredible for me and I still remember sitting on the floor in my house, with one or two of these space books in front of me just staring at these illustrations - Jupiter as seen from one of its moons, or standing on the polar ice cap of Mars. Books like *The World we Live In* which was a Time Life compendium of natural history, had a space section and had a bunch of Chesley Bonestell images in there. Or the little *How and Why Wonder* Books. These paperback books, which you look at them today and the illustrations are pretty simple and unsophisticated, but to my five-year-old mind, they worked wonders. So space art really was the rocket fuel for me and continues to be very close to my heart.

One of my favorite parts of the whole story that I tell in the book is the time I got to spend time with the space artists of my generation in places like Hawaii and Death Valley and try to create our own magic portals to take what we know today about the planets and feed that into artistic portrayals. Really a great, fun, group of people -- still some of my dearest friends today. We all owe a tremendous debt to Chesley Bonestell who really shows that space art can do something even more compelling than even documenting scientific knowledge. It's a way of enabling the future by visualizing it ahead of time. I think that the fact that we could see with such spectacular detail and cinematic sweep, what it might be like to go to Mars and go to the Moon and tour the Solar System. It's one of the things that allowed us to accept the reality of space exploration when it came along. We were ready for it. We were certainly more ready than we would have been without those pre-visualizations. I think space art has helped to mid-wife the space age, and continues to be a way to help go places that we can't get to with our machines or ourselves.

Carberry: Once we actually do start exploring again, what role do you think space art will play in documentation (as was done with the American West). The only professional artist I can think of that really documents space exploration from experience is Alan Bean.

Chaikin: I was wondering if you were going to say Alan. You know, Alan and I and my wife have a children's book out on Apollo. It's

called *Mission Control*, This is Apollo. It's the story of the missions, sort of adapted from *A Man on the Moon*. Vickie and I wrote the text and Alan's paintings provide the illustrations. I also have a book out this month called Voices from the Moon. It is quotes from all my conversations with the Moon voyagers, and those extensive quotes - intimate quotes about the Moon experience, paired with these beautiful new scans of the [ ] photography (mention this in interview).

Carberry: What lessons from the history of exploration can we apply to space exploration - whether that be older historical voyages, or from Apollo?

Chaikin: One the lessons from Apollo is the knowledge that we can do seemingly impossible things when we work together for something that is greater than the individual. That's one of the most important legacies of Apollo, but I think even and above that is the view of the Earth and the leap in awareness that we got by going to the Moon and the realization that the Earth is a very finite and precious - and to the astronauts - a seemingly fragile oasis in the blackness of space - in the void; the perspective of the Earth as a world that we need to cherish and protect. That's a perspective that we're still trying to take in and absorb. That is not why Kennedy sent us to the Moon. It's not what was on the minds of the 400,000 people who worked for the better part of a decade to get us there. It was a demonstration that exploration almost always gets us things that we never anticipated, and that often those things can have the most valuable results of all.

Carberry: Do you think the private sector is going to play a role in this at all?

Chaikin: I hope so. A couple of months ago I was out in L.A. and got a tour of the SpaceX factory and saw a Falcon rocket being assembled and saw a mockup of the Dragon capsule. I've really got my fingers crossed that those guys or someone else will be able to really change the rules of the game. It will be interesting if Elon Musk is able to find a way to get people up to the station sooner than NASA does.

Carberry: In the years that you've been involved in the space community, what was the point that you were most inspired, and by the same token, what was the point in which you were most discouraged or depressed?

Chaikin: The inspiring moments for me have really come from the images of the robotic missions. One example that I talk about in the book was the high-rise view of Opportunity at the rim of Victoria Crater, which reminded me of Laurence of Arabia. It was this incredible cinematic moment and it really brought home that this was a real explorer on the surface of Mars. It just made me stop in my tracks for a moment and was a real thrill. Also, that picture from Sprit was that way for me too. So some of the most inspiring moments for me have come out of the robotic missions - and not just Mars of course. The incredible stuff that's been coming back from Cassini of Saturn and the rings and the moons, and the Huygens lander on Titan - stuff that makes me really glad to be alive. The depressing moments have come when I have just felt that we are stuck in old ways of thinking and old approaches to space. When people say that Ares is a result of political forces at work at NASA and that's why that design was chosen - that's very depressing. I don't know if it's true, but that's some of what you hear these days and you think, why can't we ever get to the point where we're making decisions about the space program for the right reasons? I guess the depression is really a feeling of when are we going to learn from experience and realize that we feel the most fulfilled when we're doing what human beings are doing what they're intended to do, which is explore and discover and learn from those discoveries.

Carberry: Which book are you most proud of, and what book would you like to write in the future?

Chaikin: I'll answer the second question first. The book that I'd love to write is about my flight around the Moon.

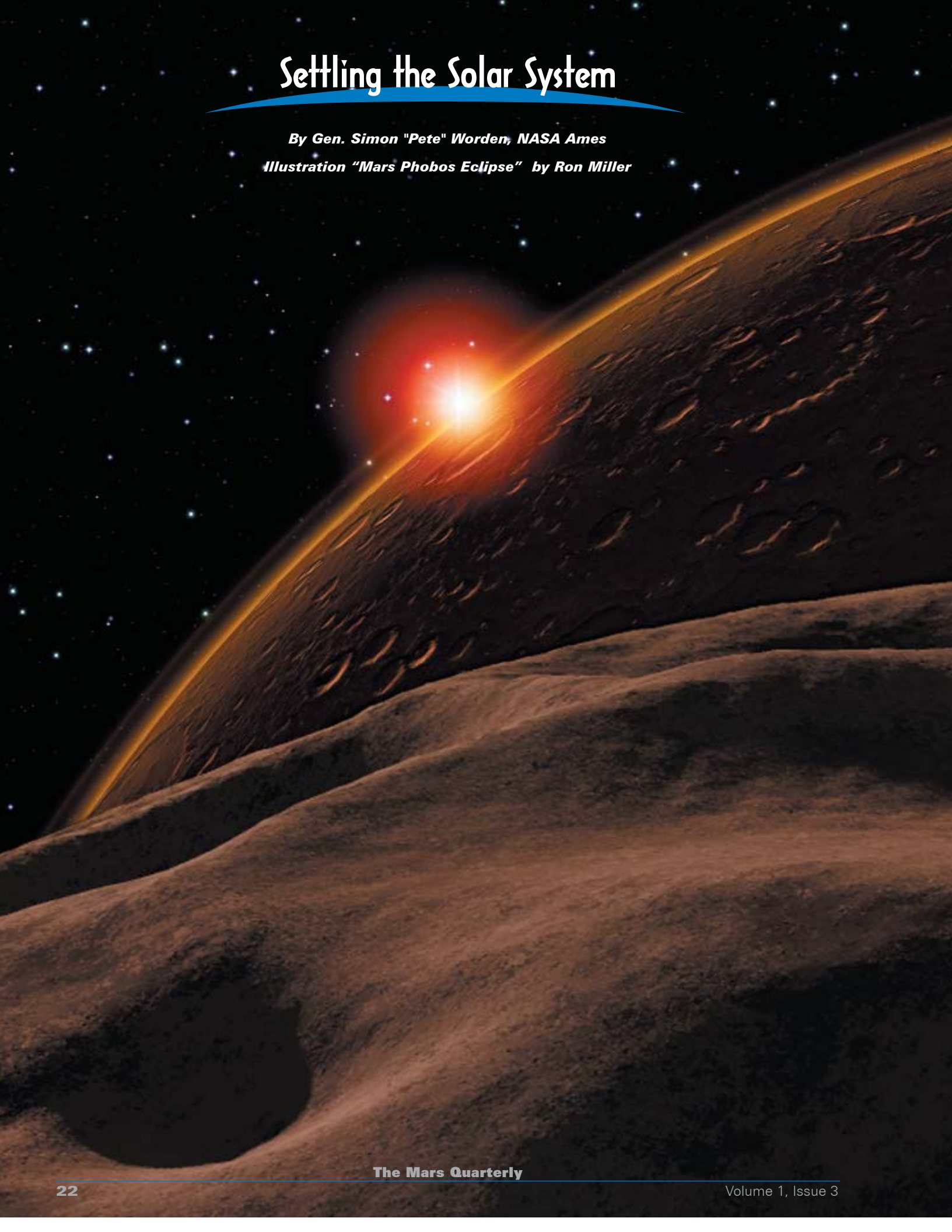
Carberry: I look forward to that one. I hope it comes out really soon.

Chaikin: I guess the book that I'm most proud of is still *A Man on the Moon*. I really do feel that I made a contribution with that book and had I done nothing else, it would make my time on this planet mean something. It was a tremendously difficult project. Those were difficult years, but incredibly rewarding. So, I guess that one would still be at the top. I'm also proud of the Mars book, and proud of *Voices from the Moon*, which my wife and I put together that has just come out. I try to make every book meaningful to me. I try to get every book to tell a story that I feel needs to be told. So hopefully in the future I'll continue to find stories that fit the bill. My hope in writing *Passion for Mars* is that I would be able to give something back to the people who have given so much of themselves to the quest for Mars. I hope the book reaches the Mars community and that they read it and feel that I've done that.

Settling the Solar System

By Gen. Simon "Pete" Worden, NASA Ames

Illustration "Mars Phobos Eclipse" by Ron Miller



On April 1, 2008 a curious web site appeared associated with Google's search engine. It announced a joint venture between Google and Richard Branson's Virgin Corporation labeled "VIRGLE." The initiative solicited volunteers to go to Mars and settle that planet as privately funded pioneers. The web site was, of course a typical April Fools Day prank of the Google Corporation and its equally innovative colleague at Virgin - or was it?

Let's examine VIRGLE's precepts and what we know about Mars to see if its vision makes sense. Are the most innovative businessmen on the planet pointing a way for us to expand human presence into the solar system? I believe they are. Let's examine their assumptions and what we know about Mars and how to get there.

What do we know about Mars?

We are in a golden age of Mars discovery. The first Mars probes in the 1960s and 70s returned disappointing results for those hoping to find another earth. Mars appeared a lot more like the Moon than Earth. That perception has changed based on recent results.

Recent Mars results show the planet has substantial quantities of water - at the poles in polar glaciers, at high latitudes in the form of permafrost and perhaps elsewhere in underground aquifers. Liquid water may even break through to the surface from time to time. Martian surface rocks also show evidence of substantial surface water in the distant past. It appears that much of this water is still present near the surface. There even appears to be snowfall at some locations.

The most interesting regions on Mars are below the surface. Liquid water and other volatiles may even flow at depths of a few kilometers below the surface. Recent terrestrial observations show that methane is released into the atmosphere from sub-surface processes. This variable methane observation is significant. It suggests there are either active geological and thermal processes ongoing below the surface - implying an active source of heat and/or there are current life-processes releasing the methane. Either possibility suggests that Mars holds below its surface environments conducive to life as we know it.

Mars ability to support life, particularly microbial life is central to permanent human settlement of that planet - or any planet for that matter. This is my first critical message: Human expansion into the solar system in dependent on either finding, or creating environments that can support life.

Why is Microbial Life so Important?

Human venturing into space so far has been near-by and short-lived. The Apollo Moon Missions lasted a few days with all consumables carried with the astronauts. The International Space Station now sustains a handful of astronauts more or less permanently. Yet it requires several hundred tons of hardware, frequently re-supplied with consumables such as oxygen, water, fuel, and replacement parts to support these people. Using this approach for a similar infrastructure further into space is prohibitively expensive. NASA's plans for a permanent outpost on the moon identify as the only feasible approach to permanent off-world settlement "living off the land" - In Situ Resource Utilization (ISRU).

NASA's ISRU program focuses on a critical consumable - oxygen. This element is present in large quantities in lunar rocks. It's needed for human respiration and potentially as oxidizer for fuel. Next on NASA's list of consumables is water - or hydrogen from which water can be made. Alternatively, hydrogen could be extracted from water for use as fuel. Water and hydrogen are rare on the moon, with the possible exception of the lunar poles where water may be locked up in frozen deposits at the bottom of permanently shadowed craters. The solar wind may also imbed small amounts of hydrogen in the lunar regolith. Other elements necessary for life, such as carbon and nitrogen are present only as trace constituents. To extract oxygen (or other elements) requires energy intensive chemical and thermal processes. Such technology is available, but it is heavy and potentially difficult to maintain even at lunar distances from earth. Hundreds of tons of sophisticated mining and industrial processing equipment are hard enough to envision on the moon - let alone deeper in the solar system on Mars.

An alternative to expensive hardware for processing extraterrestrial material to support human life is to use life itself to process extraterrestrial material - bio-ISRU. Arguably the earliest form of life on earth, cyanobacteria (or blue-green algae) has for billions of years processed terrestrial material - consuming atmospheric carbon dioxide, water and other trace elements using solar energy transformed by photosynthesis with oxygen as a waste product. It is this process that converted the primitive earth's carbon dioxide reducing atmosphere to its current oxygen rich state that supports us and other higher life forms.

Cyanobacteria and other life forms offer a potentially compact and flexible bio-ISRU approach. Some terrestrial microorganisms are already used in "bio-mining" to extract trace metals from low-grade ores. Critical to these processes is the presence of the necessary feed-stock and supporting materials. In all cases we know these materials are water and other volatiles containing carbon and nitrogen. Unless these are found in significant quantities at the lunar poles, an open question, the moon won't be a promising location for permanent off-world settlement.

Biology-based ISRU is the key to settling the solar system. Micro-organisms are the ultimate self-replicating machines. Rather than needing hundreds of tons of sophisticated hardware to extract needed resources one could need only a few vials of properly constituted micro-organisms to survive on another world - IF the necessary raw materials are present,

water and other volatiles. A self-sustaining off-world colony would be a colony of not just humans and other animals and plants - but a complete biosphere based, as life systems are on earth, on micro-organisms and their processes.

One final note about bio-ISRU: We are on the verge of true "synthetic" biology - the ability for humans to construct self-replicating, living organisms from basic amino acid building blocks. As this technology matures it might be possible to construct tailored micro-organisms optimized for alien environments such as Mars and capable of supporting large-scale human societies. My second critical message is that: Finding or developing suitable microorganisms to extract ISRU and support a human biosphere should be a primary objective of space settlement programs.

Where Do We Find Life-Supporting Resources?

As noted above the moon appears to be a poor locale for finding the necessary life-supporting material. This conclusion could be modified if future lunar missions find substantial deposits of water and carbon-bearing volatiles at the poles. Indeed, robotic lunar missions should focus on this objective.

Mars, however, does appear to be a good location for supporting life. It has carbon dioxide it its atmosphere as well as trace amounts of methane. Water is present at its poles and underground at many locales. Where else might we find such materials?

Some asteroids and comets sometimes contain substantial amounts of water and carbon compounds. We know this from a number of sources - most important are pieces of asteroids - meteorites, which we find on the ground. We know that certain asteroid classes such as carbonaceous chondrites are rich in these compounds. The likely source of volatiles, if they exist on the lunar poles, is volatile-rich comets and asteroids that have struck the moon over the past few billion years. My third major point is: Mars and some asteroids appear to be the most likely and accessible source of life-supporting material off earth.

How Do We Get to Mars?

NASA is developing new hardware to take humans into the solar system. Its Constellation program is developing two types of space transportation - a system to take humans into low-earth orbit and a heavy-lift booster to transport rocket stages and human-support modules for journeys deeper into space. The moon is our initial target - although the Obama administration is reviewing the basic approach and objectives. NASA remains committed to an ultimate human Mars journey. However, a government-sponsored Mars journey appears to be a very expensive flags and footprints mission many decades in the future.

We can speculate on an optimum approach for actually settling Mars - the most likely abode for large scale human settlement off earth. I propose the first step be well-funded bio-ISRU development. As synthetic biology develops it may hold the most promise for effective off-world ISRU. Bio-ISRU has the added advantage that similar technologies hold the promise of effective and affordable bio-fuels and other means to remediate terrestrial climate change damage. Large scale biology created the environment conducive to our form of life on earth. It is reasonable to believe applied biology can remediate the damage as well as enable life to flourish on other worlds.

We must determine the suitability of off-world material for supporting biological colonies that can eventually support humans. Robotic missions are ideal. Experiments to set up self-supporting biological enclaves would be a vital step to ensure the microorganisms we choose can stably reproduce and flourish off-world - and if not to develop varieties that can. If the moon has the necessary volatiles it would be a good experimental location. Suitably selected near-earth objects (asteroids) - NEOs - might actually prove to be better targets. From a propulsion perspective some are easier to get to as one doesn't need to enter a deep gravity well as with the Moon or Mars.

Mars is a more complicated target. Before attempting to establish terrestrial life on Mars it's critical to determine if it already harbors life. Robotic missions capable of probing deep below Mars surface, and eventually return samples to earth are essential to determine whether there is extant Mars life. Great caution is called for. Aside from the scientific imperative of not contaminating a life-bearing planet with earth life, it's important not to contaminate earth. Our experience in mixing different life forms on earth is that one often kills the other. While earth life and mars life may share a similar origin through asteroid impact-caused exchange of material over the past few billions of years, the possibility that current earth life could be on the losing side of microbial contamination from Mars demands extreme caution. Should we find that Mars is barren - or only harbors mutually benign life, robotic experiments to creating closed life systems using Martian resources represent a next step.

Sending humans to Mars to stay is hard. It's even harder to send them there and back. Several year-long round-trip missions appear far off, unaffordable and very risky. It is, however feasible to mount human missions to near-earth asteroids (NEOs). Missions to these bodies can sequentially extend our ability to journey ever deeper and longer into space. This "envelope expansion" should have a goal to eventually reach Mars. Human missions to NEOs are within the capability of the hardware being developed by NASA - indeed it may be easier than the difficult lunar landing. Visiting a NEO is a "docking" problem rather than a landing problem due to the almost non-existent gravity of these small objects. This has the added advantage of sustaining excitement as ever more distant milestones are reached - unlike limiting our human visits to just the moon. After all, we visited there almost half a century ago.

The ultimate destination within the next few decades should be one of the Martian moons, Phobos or Diemos. This is true both due to the

complexity of landing and taking off from the Martian surface and our need to rule out extant, potentially dangerous on Mars itself. Phobos has the advantage that it probably has Martian material collected on its surface blasted from Mars by asteroid strikes over the eons. Some experts believe it may be a volatile rich body itself capable of supporting longer-term human activity. Mars-surface robots tele-operated from Phobos (little or no light-travel time delay) could enable a most comprehensive survey of Mars for life as well as suitable colony locations.

What's the Role of the Private Sector?

What I've detailed above lies in the province of governments. Basic research into off-world biological ISRU and synthetic biology is a government function and likely to remain so. Burgeoning private sector interest in this technology for important terrestrial applications could change this. Similarly exploration and life experiments on NEOs now appear to be government functions. But there may be an important role for private sector initiative insomuch as prizes and data purchase rather than outright government sponsorship could be highly cost-effective.

Human missions to asteroids and eventually Phobos seem to lie wholly within government functions due to the cost of the very high reliability required of public space missions - including the key phrase used in President Kennedy's first speech on the topic: "and returning him safely to Earth." But what if we didn't need to return them to Earth?

Robert Zubrin has proposed in his Mars Direct concept with boot-strapped low cost missions designed to establish a sustainable and sustaining ISRU function on Mars. I differ from him only in that I prefer bio-ISRU rather than nuclear-powered ISRU. Zubrin and others demand that with a suitably robust infrastructure be in place before humans arrive. They could then come as colonists, one way to stay rather than as two-way explorers. The cost of these one-way colonization missions are a few billion dollars each from numerous estimates - not the tens of billions needed for a government there and return mission. These colonization missions could best be private sector initiatives.

The private sector has numerous individuals interested in space colonization (including people such as Space-X's Elon Musk, Amazon's Jeff Bezos and Google founders Sergey Brin and Larry Page among others). These individuals wield the necessary resources to mount true colonization missions. They have the interest and the technology is, or soon will be available. History is replete with wealthy, visionary individuals willing to sponsor risky colonization missions. Private individuals can take larger risks - and many would be willing to do so to be the first colonists on another world. I predict we will see such colonists in the decades ahead.

What's the role of governments in private colonization of Mars?

Governments can and should develop the necessary technologies to sustain a colony on another world. The government should survey the stepping stones (NEOs) and environment on Mars for optimum locations for a colony as well as hazards such as extant life. The government should also put in place infrastructure such as communications back to earth and navigation aides such as a Martian GPS. However, the colonists would travel at private expense and at their own risk. Of course once firmly established they could contemplate the means to return to earth - but one would suspect most would choose to stay.

We could imagine an early Mars colony founded at locations such as caves. These might be sealed to maintain an earth atmosphere. Suitable caves or other locations would be scouted out by government systems to be optimum for access to resources such as water. Caves, of which we already know of several on Mars could be ideal as their thermal extremes are less and they provide protection from a hostile radiation environment on the Mars surface. They might also provide underground access to liquid water and thermal sources. My final postulate is therefore: Our exploration program should be focused on developing the necessary, probably biological technologies to enable private sector colonization of Mars.

Conclusion

Humanity has begun its greatest adventure - expansion and settlement of the cosmos. This is an exciting time to be alive and involved. United States and other government space programs focus on this objective. A good beginning has been made - there is now an opportunity to explicitly work on these goals.

To reiterate my specific recommendations and perspectives this great quest should have four precepts - subject of course to revision and replacement as we learn more:

1. HUMAN EXPANSION INTO THE SOLAR SYSTEM IS DEPENDENT ON EITHER FINDING, OR CREATING ENVIRONMENTS THAT CAN SUPPORT LIFE;

2. FINDING OR DEVELOPING SUITABLE MICRORGANISMS TO EXTRACT ISRU AND SUPPORT A HUMAN BIOSPHERE SHOULD BE A PRIMARY OBJECTIVE OF SPACE SETTLEMENT PROGRAMS;

3. MARS AND SOME ASTEROIDS APPEAR TO BE THE MOST LIKELY AND ACCESSIBLE SOURCE OF LIFE-SUPPORTING MATERIAL OFF EARTH; AND

4. OUR EXPLORATION PROGRAM SHOULD BE FOCUSED ON DEVELOPING THE NECESSARY, PROBABLY BIOLOGICAL TECHNOLOGIES TO ENABLE PRIVATE SECTOR COLONIZATION OF MARS.


NASA Ames/Tom Trower

Dr. S. Pete Worden (Brig. Gen., USAF, ret.) is the current NASA Ames Research Center Director.

The 2013 MAVEN Mission to Mars

by Dr. Bruce Jakosky, Principle Investigator

The MAVEN mission was recently selected for flight, to explore the upper atmosphere of Mars and to determine the role that loss of the atmosphere to space played in the history of the Martian atmosphere and climate. Results obtained by many spacecraft over the last decade support the view that there was liquid water at the surface early in Martian history, although it is not stable there today. Increasingly, evidence points to loss of gases out the top of the atmosphere to space as an important, and possibly the dominant, process in the changing climate. Although recent measurements provide compelling evidence that loss to space has occurred, they do not allow a unique estimate to be made of how much gas has been lost or to determine the specific processes by which the loss occurred.

The Mars Atmosphere and Volatile EvolutioN (MAVEN) mission will be the first mission devoted to understanding the Martian upper atmosphere and addressing these questions. These issues get directly at the nature of Martian habitability by microbes and how it has changed through time. As such, they fit cleanly into the Mars exploration program, whose broad goals include understanding the history of habitability and whether any organisms have ever existed on the planet.

MAVEN will launch in November 2013 and will enter orbit around Mars in September 2014 after a ten-month cruise phase. The orbit will be elliptical, allowing measurements to be made at all altitudes throughout the upper atmosphere, at all local times with respect to the Sun, and at most latitudes. The primary mission will last one Earth year, providing sufficient time to make the key measurements to address the science objectives.

There are several ways to look at the measurements that MAVEN will make. From the perspective of the "science goals", it will make three different types of measurements. First, it will determine the present-day composition and structure of the upper atmosphere. Second, it will determine the present-day rate of escape of gas from the upper atmosphere to space. And, third, it will make measurements that allow us to extrapolate this escape rate to past times, when the solar wind and the solar ultraviolet light (that drive the escape) were greater, and to estimate the total amount of gas that has been lost.

From an "observational" perspective, we can also look at the MAVEN measurements in three ways. First, it will measure the properties of the upper atmosphere as the spacecraft passes through the upper atmosphere. These allow a very detailed look at one place in the atmosphere on each orbit, and allow determination of the basic state of the upper atmosphere.

Second, it will make remote-sensing measurements of a large part of the planet from the high-altitude parts of its orbit. This will allow the point measurements to be extrapolated to global conditions, and will provide a good understanding of the geographical variations that can take place.

Third, MAVEN will measure the energy inputs into the upper atmosphere that drive the processes that lead to escape. This will include the properties of the solar wind as it hits Mars, of solar ultraviolet light, and of solar storms, all of which can affect the behavior of the top of the atmosphere.

There are eight science instruments on MAVEN, and they will be provided by three different institutions. Two instruments will be built at the

Artist's conception of the MAVEN spacecraft. For scale, the high-gain antenna (in the middle of the bus) is 2 m in diameter. Instruments are mounted at the ends of the solar panels, on the deck of the bus surrounding the antenna, on three booms at the top of the image, and on an articulated platform at the end of a boom at the bottom of the image.

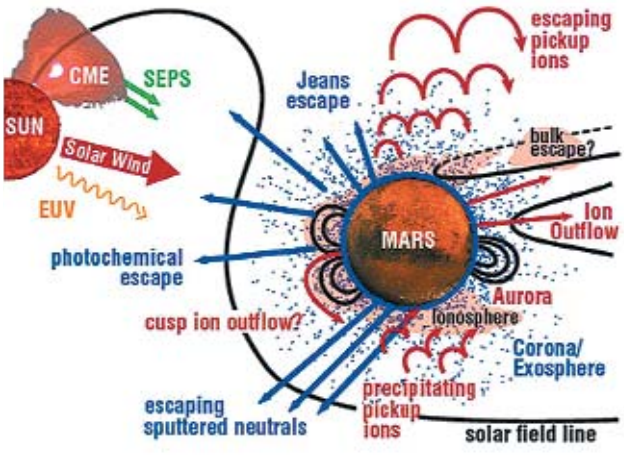


Illustration showing the different atmospheric loss and energy processes that MAVEN will measure. Neutral processes are shown in blue, ion and plasma processes in red, and solar energetic inputs are shown in the upper left.

Laboratory for Atmospheric and Space Physics at the University of Colorado, four will be built at the Space Sciences Laboratory of the University of California at Berkeley, and two will be provided by NASA's Goddard Space Flight Center. Each of these groups has tremendous experience with their instruments, having provided similar ones on numerous other missions.

The spacecraft will be built by Lockheed Martin, which also built the Mars Global Surveyor, Mars Odyssey, and Mars Reconnaissance Orbiter spacecraft, all of which orbited Mars. Lockheed Martin also will carry out the mission operations, using their tremendous experience from having operated these same spacecraft.

Goddard Space Flight Center will provide the management for the project under the direction of the Principal Investigator. And NASA's Jet Propulsion Laboratory will provide communications through its Deep Space Network, as well as tracking and navigation.

After a relatively slow ramp-up this year, MAVEN will be on a natural schedule leading the launch; the bulk of the development will take about four years. The total cost of the mission is capped by NASA to be no greater than $486M (expressed in 2006 dollars, so not including inflation).

The MAVEN mission will provide exciting new science at the Red Planet. Its goals have been a high priority as described by the National Research Council for a long time, and the MAVEN team is excited to have been chosen to implement the mission.

Additional details on the mission can be found at the interim mission web site, located at http://lasp.colorado.edu/maven.

Bruce Jakosky is a Professor at the University of Colorado in Boulder, and is the Principal Investigator of the MAVEN mission.

Archaeologists search for former life on Mars.

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