THE MARS QUARTERLY

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Cover photo courtesy of Julian Leek

FROM THE FLIGHT DECK

Welcome to the fall issue of *The Mars Quarterly*. I hope you enjoy the series of interviews and articles regarding the Mars Science Laboratory mission which launched on November 25, as well as the interview with Dr. Steve Squyres regarding the progress of MER *Opportunity* as it continues to surprise us with important new discoveries.

The Mars Desert Research Station underwent a comprehensive refit this summer thanks to generous donations and the hard work and dedication of our many volunteers. The 2011-2012 season began December 3. Dr. April Andreas provides us with information regarding "Mars 101" a new educational program that will be offered this season, and Astronomers Peter Detterline and Haritina Mogosanu update us on the status of repairs, upgrades, and exciting new educational opportunities at the Musk Observatory.

On a more somber note, as we go to press, there is a very real battle taking place on Capitol Hill to preserve funding for NASA's future Mars missions. If you have not already contacted your representatives in Congress to voice your support for our Mars programs, please take a few minutes to do so today.

On to Mars!
Susan Holden Martin,
Editor-in-Chief

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A Call to Action: Save the Mars Missions!

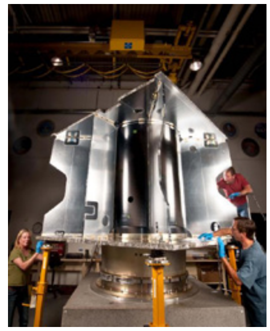
Robert Zubrin, President, The Mars Society

The Office of Management and Budget (OMB) has zeroed funding for NASA's future Mars exploration missions. The Mars Science Lab, *Curiosity*, has launched, and the nearly completed small MAVEN orbiter scheduled for 2013 will also be sent, but that is it. No funding has been provided for the Mars probes planned as joint missions with the Europeans for 2016 and 2018, and nothing after that is funded either. This poses a grave crisis for all of us hoping for a human future in space.

NASA's Mars exploration program has been brilliantly successful because, since 1994, it has been approached as a campaign, with probes launched every biennial opportunity, alternating between orbiters and landers. As a result, combined operations have been possible, with orbiters providing communication links and reconnaissance guidance for surface rovers, which in turn can conduct ground-truth investigations of orbital observations. Thus, the great treks of the rovers *Spirit* and *Opportunity*, launched in 2003, were supported from above by Mars Global Surveyor (MGS, launched in1996), Mars Odyssey (launched in 2001), and Mars Reconnaissance Orbiter (MRO, launched in 2005). But after serving 10 years on orbit, MGS is now lost, and if we wait until the 2020s to resume Mars exploration, the rest of the orbiters will be gone as well. Moreover, so will be the experienced teams that created them. Effectively, the whole program will be completely wrecked, and we will have to start again from scratch.

Furthermore, if the OMB cuts are allowed to prevail, we will not only destroy America's Mars exploration program, but derail that of our European allies as well. The 2016 and 2018 missions have been planned as a NASA/ESA joint project, with the Europeans contributing over $1 billion to the effort. But if America betrays its commitment, the European supporters of Mars explorations will be left high and dry, and both the missions, and the partnership, will be lost.

America's human spaceflight program is currently completely adrift. Unless it is reorganized as a mission-driven directorate committed to efficiently achieving important objectives within a meaningful timeframe, it may well prove to be indefensible in the face of the oncoming fiscal tsunami. But the Mars program is defensible. It has real and rational objectives, reasonable costs, and a terrific track record of success. It can and must be saved.



There is no justification for the proposed cuts. The U.S. federal government may be going broke, but it's not because of NASA. Since 2008, federal spending has increased 40 percent, but NASA spending has only increased 5 percent. Trillions of dollars of out-of-control entitlement spending cannot be remedied by cuts in NASA, or even in the entire discretionary budget, defense included. Rather, the financial bleeding needs to be staunched where the hole is, and nowhere else.

In any case, cost is not the issue. With the Europeans putting up their share, a matching $1 billion contribution from NASA spread over the next six years would be sufficient to fund both the 2016 and 2018 missions at a level of a billion dollars each. This would require less than 1 percent of NASA's current budget. There is no excuse for not doing this.

The Mars program is not being terminated to make funds available for future missions to other planets. In fact, there is no money in the OMB plan to fund any of them, either.

America's planetary exploration program is one of the great chapters in the history of science, civilization, and of our country. Its abandonment represents nothing else than an embrace of American decline. This is unacceptable.

Mars is key to humanity's future in space. It is the closest planet that has all the resources needed to support life and technological civilization. Its complexity uniquely demands the skills of human explorers, who will pave the way for human settlers. It is, therefore, the proper goal for NASA's human spaceflight program, and the proper priority for its robotic scouts. The human spaceflight program may be in disarray, but the scouts have been making progress, and are set to make more, if only we continue with them.

If we allow the OMB to shut down the Mars exploration effort, NASA will lose its most effective endeavor – one of the few that delivers the goods that justify the entire space program as a national enterprise, the nation will lose one of its crown jewels, the scientists will lose their chance to find life beyond Earth, and humanity will lose the one significant effort that is making real and visible progress towards opening the frontier on another world. We can't let that happen.

So friends, here is where we need to make a stand. There is no excuse for wrecking the Mars program. The nation can afford it, and walking away from it is walking away from success, from our allies, from science, from greatness, from the pioneer spirit, and from our future. Everyone needs to mobilize now to save the 2016 and 2018 Mars missions! Write your congressman, or better yet, call up his or her local office and set up a meeting. Have a talk with your Senators' local staffers as well. Write the White House, and let the people there know what you think. Write to NASA Administrator Charles Bolden. He needs to hear from you too.

This is a fight we can and must win. It's time to speak up!

SPACE LAUNCH SYSTEM – HEAVY LIFT LAUNCH VEHICLE

William H. Gerstenmaier , Associate Administrator
Human Exploration and Operations (HEO) Mission Directorate, NASA

TMQ: What are the plans for the SLS and the Orion multi-purpose crew vehicle heading toward an asteroid mission?

GERST: Our first concept is to take hardware that exists in both the shuttle program and the Constellation program. We are putting together a concept that takes hardware from some existing contracts, some new contracts, and builds essentially a HLV that can grow to 130 metric tons lift capability. The SLS first flies in a 70 metric ton launch capability. We take the Orion capsule that we were working on before, because it allows us to carry four crew to destinations beyond LEO. And the big thing is that it has the ability to directly re-enter at about 11 ½ kilometers per second or roughly the lunar re-entry velocity, which will cover us whether we are returning from an asteroid or Mars. So it has the ability to directly re-enter Earth's atmosphere from these beyond LEO destinations.

We have a flat-funding profile, so we had to pick pieces from existing systems that had significant development behind them – so we didn't do a lot of new development. We are pretty budget constrained in trying to deliver this system, and we want to deliver it as soon as we can. We envision an uncrewed test flight in 2017. Then we have a crew capability in 2021 that allows us to go essentially into orbit around the moon, but that's not a particular destination we have chosen. It is just a representation of the kind of capability the vehicle and the system has. That is our basic construct.

We just did the developmental test firing of the five-segment solid rocket motor that will be used on the first test configuration set up, moving to an advanced booster concept, and that could be a liquid or solid booster strapped to the side that will eventually get the vehicle up to 130 metric tons. So we are trying to build a system that has low developmental costs, low operational costs, a large payload volume, a large lift capability, and allows us to do many of these demanding missions beyond LEO.

TMQ: You originally looked at three different engine designs. Can you tell us why you chose the one that you did?

GERST: We looked at the core configuration. We looked at a couple different engines. We looked at LOX/Hydrogen system that could have been the RS-68 or RS-25, which is the shuttle main engine. We also looked potentially at the J-2X, and LOX/Kerosene engines for the core. When we sorted through all those, again with the constraints of our schedule and the funding limitations of a flat-lined budget through this period, the shuttle main engines had a significant advantage to us. There are 15 RS-25 engines available to us from the shuttle program that are flight-ready and could be used as the core engine. So there is no real development activity that needs to be done. The RS-25 is a very reliable engine with over a million seconds of test time and a lot of flight experience, having flown on all the shuttle missions. It is a very mature engine and ready to be used. This saves us time and money in developing a new engine for the core.

The other advantage of the shuttle engine is that it has a very high specific impulse, which is another way of saying fuel efficiency. So the tank for that can be a smaller diameter – it can be a 8.4 meter diameter tank, whereas if you went with a RS-68 you

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need to go to a larger diameter tank. When you use a smaller diameter tank it allows us to use all the test and ground facilities at the Cape that we do processing in today – we don't have to redesign them. We can use the mobile launch platform we developed for the ARES-1 rocket for the HLV with that tank diameter. So the shuttle main engine gave us, first of all, a reduced development cost up front, and allowed us to phase that development later. We will need to lower the manufacturing costs and reduce manufacturing time of the shuttle engines in the future.

For Mars studies, we think having the capability to launch 130 metric tons really makes a Mars missions more achievable.

By using 15 shuttle engines, it saved us all of the costs associated with the unique stuff we would need if we went with another tank diameter at the Cape. So those are the things that kind of drove us to that configuration. We could have stayed with the same tank diameter for the RS-68, but then the rocket would be so tall we couldn't have gotten it out of the VAB.

TMQ: In terms of the HLVs, you looked at five of those, so why did you choose the one you did?

GERST: We took those five configurations and found none of those could satisfy our constraints of the lift capability within the flat-line budget. So we took the best features or best design features of those five and built the configuration we have now – the SLS. I think the other thing that is important is that this vehicle has the ability to fly at different thrust level configurations. It can fly in a lower thrust level configuration without an upper stage or we can add an upper stage if we need the extra performance. We are going to manufacture the upper stage and the core stage at the same facility. We will use the same techniques and same personnel; so if we need to add an upper stage later to get more thrust capability, we can do that at marginal cost. We don't need a new plant built, we don't have to have new tooling, we don't need to bring in a new workforce – we have all the folks that are manufacturing the core who can step up and build the upper stage.

What's important is that we have a rocket that has variability in thrust, it has a larger diameter faring, which we think has applications for other users beyond just human space flight – potentially some of the robotic Mars missions and other things that are off in the future. Having a faring size of 10 meters will have some real advantages that will help with the packing constraints of trying to get the right cargo into a certain size shroud. So we tried to pick a configuration that not only met our needs, but also would have applicability for other potential users. The goal is to have a cost effective system with reasonable recurring costs.

TMQ: Obviously SpaceX is working on the Falcon Heavy, and some of our Mars friends have come forward and suggested that rather than NASA using funds to develop the SLS in parallel, why not use NASA funds to develop the additional hardware that would be needed to support a manned mission to Mars using a SpaceX rocket? How would you respond?

GERST: For Mars studies, we think having the capability to launch 130 metric tons really makes a Mars mission more achievable. It requires fewer rocket launches to actually pull the mission off. You can do it with the smaller lift capability, but then you are going to require more infrastructure, on orbit construction and operations. These launches will have tight launch constraints and require more orbit assembly and integration. We think having the 130 metric ton capability still requires multiple launches to achieve what we are trying to do with a Mars mission. But we think that if you look at the total area under the curve of how many rocket launches it would take, we think that the 130, if we can keep the cost down, helps us from an overall cost standpoint. The other point I would make is that we also are not precluding - potentially we are going to put different boosters on the side of this core configuration – that we could have a LOX/Kerosene system, derived off of what SpaceX is thinking about for their Heavy that could actually satisfy some of those needs. We are still looking at a competition, where even for our 130 metric ton rocket, there still could be some components of a LOX/Kerosene system that sits on the side.

TMQ: We always have folks who come forward and ask why we aren't creating a mission first and then developing the technology to implement it? So here we are developing SLS, Orion, etc. What do you say to those folks? Should we produce this rocket first and then design missions around it?

GERST: Our past experience and past history has been that it is advantageous for us to have a defined mission and a goal to go forward. That is the way we did Apollo and that's the way we have done other things. But I think in today's environment if I were to pick a specific destination or specific mission, there will be supporters of that individual mission, but then there will be lots of others who don't like that particular mission. And they probably will be as vocal for whatever that particular mission is, as the supporters are. We then could end up in a dilemma where the negative press picks up more weight than the positive press and we end up not moving forward. We definitely need a heavy lift launch capability. It will support a variety of missions – it helps us in a Moon case; it helps us in an asteroid case; it helps us in a Mars case; and helps us in LaGrange points. It really gives us a capability we need. The fact that we can vary the thrust level and save some pieces, potentially some upper stage parts, etc. it gives us a flexibility that makes an affordable solution.

We definitely need this heavy-lift configuration along the lines of what we picked. And we definitely need a crew capsule. We looked at other options where we would return to LEO, braking in LEO and then re-enter from LEO to the Earth in another vehicle – these are extremely propellant intensive activities. So you really need a vehicle that can re-enter at the higher speeds for which Orion is designed. We see both the heavy lift vehicle and the Orion as necessary steps in any destination going forward. What we are trying to do is put together an infrastructure or set of hardware that is affordable and which we can piece together into a mission. And we are going to need other pieces to do an actual mission. We are going to need a habitation module. We will try to do some of that development in-house with NASA civil servants. We will need a lander if we are going to land on another body. The idea is we are going to try to build enough infrastructure to actually get close to a mission. When we are close enough to do a real mission we will go forward to our elected officials and say – "Hey, in 5 or 6 years we could probably do this kind of mission with the infrastructure we have in place." So we are doing what Norm Augustine said – we are building a capability or infrastructure that is as affordable as we can maintain. Then, when we amass enough hardware such that we are 5 or 6 years away from an actual destination, I think we can talk about a real destination and move in that direction. I think there will be support for that as we move forward. That is the overall concept of what we are trying to do.

TMQ: How difficult is it going to be to work this plan and keep it under the funding curve during the life cycle – the out years?

GERST: I think it is going to be difficult, but I think we picked the basic architecture and construct in that it gives us the most flexibility – the strongest possibility of being able to achieve what we want to do overall. We have staggered development; we have taken a lot of high-risk development off the critical path. We have some flexibility in contracts; we can do so some stuff in a fixed-price environment, we are going to minimize the facility and infrastructure needs for this concept to try to lower costs. We have put together the best plan we can from all the lessons learned from all our other projects, using an approach we think will give us the best chance of being able to achieve these projects through the budgets we have laid out. We have constructed this from the ground up. Picking pieces that give us an affordable solution that will allow us to achieve these capabilities in the timeframe we have talked about.

I need to look at the macro level here - do I give up and say "give me a mission" and then we don't try something? I think we need to work within the constraints we are given. We really need to look strongly at doing both robotic activity and human activity more synergistically than we have in the past. By that I mean we need to look at this new launch system assisting the robotic missions, and then use some of the data we get from the robotic missions to lower risk and impacts to the human missions that follow. I don't think we need to have an "either-or" discussion, but it's much more "how" we work exploration. Exploration has a robotic component and a human component. We need to blend those together to keep moving, so we keep exploring as a species.

The Human Exploration and Operations (HEO) Mission Directorate provides leadership and management of NASA space operations related to human exploration in and beyond low-Earth orbit, and also oversees low-level requirements development, policy, and programmatic oversight. The directorate is similarly responsible for leadership and management of NASA space operations related to Launch Services, Space Transportation, and Space Communications in support of both human and robotic exploration programs. Courtesy: NASA.

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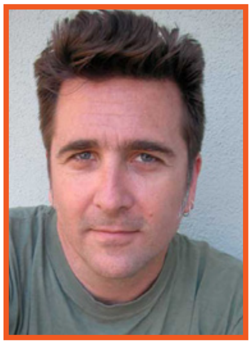
MARS SCIENCE LABORATORY – SKY CRANE SYSTEM

An Interview with Dr. Adam Steltzner



TMQ: Adam, I understand you are the EDL Phase Lead on the Mars Science Laboratory mission. Tell us about the Sky Crane technology that will be used to land the rover on Mars.

ADAM: Although the Sky Crane looks a little crazy, and when I have an opportunity to talk to people about it, it is not an easy conversation to start because the person starts from a position of incredulity – flabbergasted that one could imagine to do such a thing. But in reality, the Sky Crane is an intellectual evolution from what we did on Pathfinder (MPF) and MER with the air bag landing systems - believe it or not. In both those missions we had retrorockets in the back shell. Just prior to the air bags bouncing on the surface of Mars, they were slung underneath a long bridle, about 20 meters in length in that case, with the rockets above them, just prior to landing the rockets would fire. On MER we just had three rockets. We used radar to look at the ground to decide when at the last minute to fire those rockets to do the additional deceleration over and above that which we could get out of the parachute. That technique was stolen from U.S. military tank delivery systems. There are some equipment delivery systems that use a tractor rocket slung below the parachute train but above the payload that is triggered off of proximity to the surface. They fire the retrorockets to slow the vehicle down just a little bit prior to impact. We were using a similar arrangement for MPF, but we were using radar to look at the ground.

On MER, we discovered that wind could move the parachute train back and forth. So that whole train, including the direction of the thrust vector of the rockets, could be at an angle. We don't want to fire those rockets like that because although it would do a pretty good job of slowing you down vertically, horizontally you would pick up velocity due to the rocket thrust being inclined from the vertical. So on MER, we put in these things called TIRS, "transverse impulse rocketing system" – little tiny solid rockets that we could choose to fire (or not) to help steer the back shell. Then we took a couple of images from the rover camera, or a version of the rover camera that was stuck on the lander. Comparing successive images could tell us what our ground relative speed was and that would help us understand whether we had a wind situation that we would have to correct with the steering of the back shell mounted solid rocket's thrust vector.

With all of that experience behind us, we went to develop the MSL system, which could land a very large rover, the natural forces of spacecraft evolution were at work, the rover ballooned from 500 kilos to 900 kilos by the time we launched the thing. It was a very heavy rover, so a legged lander was really out of the question because it wasn't stable enough – you couldn't put a rover on top of a legged platform and have it stable enough to land widely. You have very restricted landing sites – they have to be very, very flat. We were trying to make air bags work, but when you have a very large, heavy thing, air bags scale very poorly. So we started to take the approach where we would try to slow down the speed at which the air bags would impact. First we put more sophisticated terrain relative sensors in what was like a back shell, but would become the descent stage. We put a very good IMU (Inertial Measurement Unit) and we put a better narrow beam Ka band radar that could do Doppler velocimetry and altimetry. We ended up saying that we can't really do the control with solid rockets. You either choose to fire or not, and we need a throttle-able liquid propulsion system. Once we purchased all that complexity, in terms of difficulty in putting it together, sheer cost in dollars, number of people who have to work on it, and risk and all that stuff, we recognized that we could keep turning the speed knob down until you didn't have to have air bags at all. You could land a rover, or any other payload for that matter, directly on the surface on Mars. That is the intellectual arc that got us to the Sky Crane.

TMQ: What are the risks of using this new technology? What are the things that you worry about at night?

ADAM: Any time you use new technology, there can be a very large risk. We were eyes open at the very outset six or seven years ago to the new technology that we were going to be using. We developed the radar, we developed a throttle-able hydrazine engine that's a variant of the engine that Viking used, and this basic Sky Crane configuration. So we put a technology development and then a flight development program in place that was quite extensive. The Mars technology program had something called the Mars Focused Technology Program for a point in time. And we had quite a bit of money about five or ten years ago to do engine development, to do radar development, to build self-scaled mockups of the Sky Crane to prove that there was no strange control reaction that we didn't understand. So we worked quite early and quite diligently at exposing the risks associated with the new technology. I feel pretty good about that. But what keeps me up at night is that the beast, as it has come to be, is so very complicated in some of the most mundane ways. For instance, simple pyro commands must move from the main computer through one bus to a remote engineering unit, then another bus, then switch boxes, and then off finally to the pyro event. That the sheer complexity of the spacecraft means that a lot of things have to go right to get the simplest actions to take place. My concern is that some simple and very pedestrian transaction will not do what it needs to do and that will bring down this complex beast.

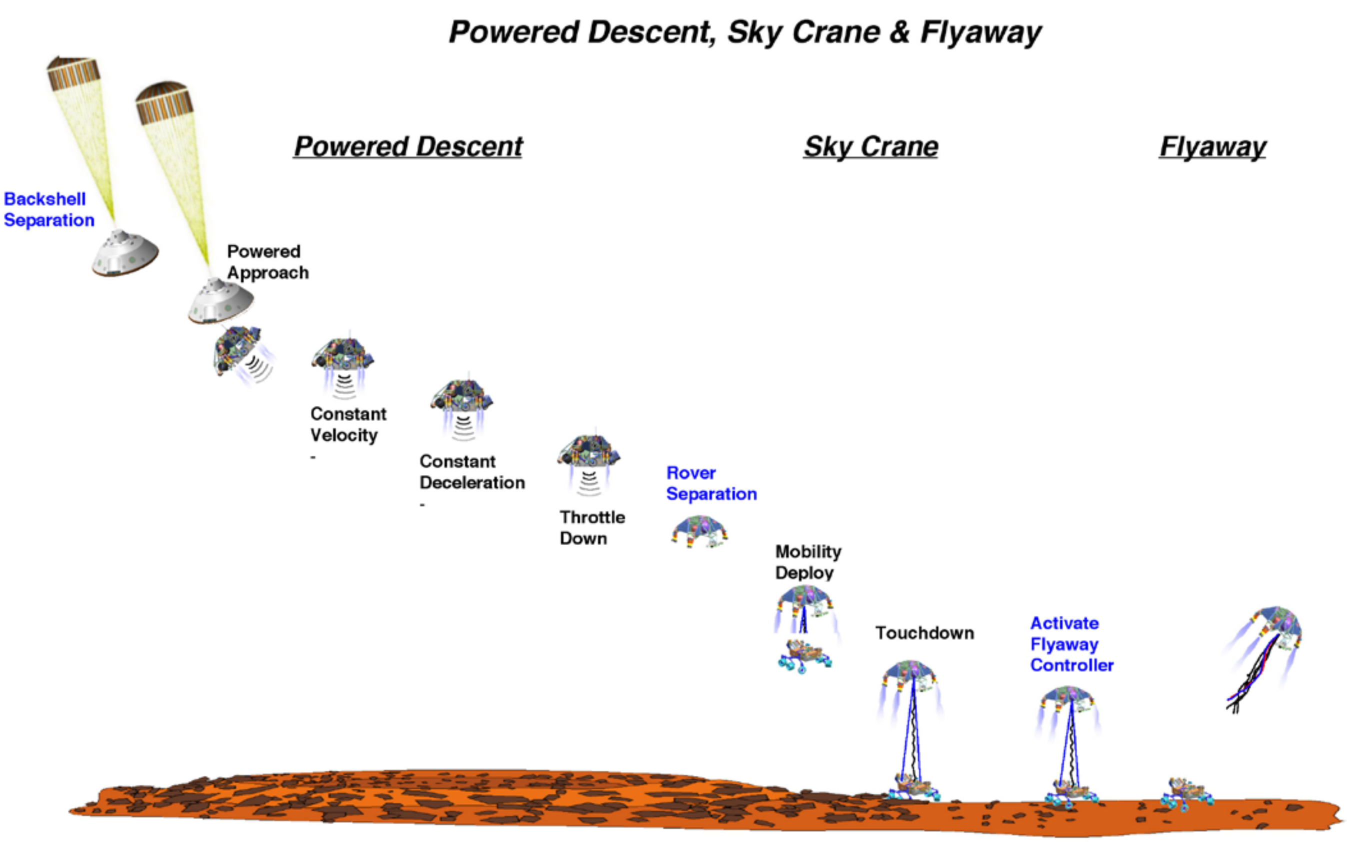
We have accepted a certain degree of single point of failure because we can't double up on everything – that becomes impossibly complex and heavy.

TMQ: Is it possible that there is any one single point of failure here – or just the overall complexity?

ADAM: There are lots of single points of failure – this is not for the faint of heart. From a cultural perspective, doing entry, descents and landings, I was chief mechanical engineer for EDL on the MER, you have to be prepared to handle risk. Thankfully, this isn't my first rodeo. We have accepted a certain degree of single point of failure because we can't double up on everything – that becomes impossibly complex and heavy. There are lots of things that have to go right for us – all of our pyro devices have to function. We have to separate the cruise stage, heat shield, back shell, all of the bits and pieces of the vehicle; and themn we have to reconfigure ourselves as we are hurtling through the Martian atmosphere. All of our engines have to work; our radar has to work; there is a single point of failures waiver list that is quite extensive. The way we get ourselves comfortable with that is by testing very thoroughly all of the pieces and proving to ourselves that during this relatively short period – the seven minutes of terror as people like to call it – the likelihood that we will get one of these items to fail randomly is very, very low.

TMQ: Once the Sky Crane deploys the rover and fires away – what is the length of that burn – how many meters away will it land?

ADAM: We have a timed burn of 6 seconds that is designed to take us at least 150 meters away. As it has come to pass, we do much better than that, 400-500 meters typically. If we get it at least 150 meters away and it explodes with all the force it has left in it, there is an acceptably small probability of a small piece of shrapnel



NASA/JPL

coming back and hurting the rover.

TMQ: I understand that the Sky Crane technology is something that you intend to use on future launches. How is it adaptable to other configurations and deliveries?

ADAM: Think of the rover as a generic payload. Because the payload is delivered under slung below the descent stage in the Sky Crane Configuration, during the Sky Crane Maneuver, the payload really can be anything because we deposit the payload at very slow velocities; about ¾ meter per second vertical, and really essentially nothing horizontally, although we have an error budget that allows us to go up to half a meter per second. That is much less shock than the average box would get being moved by movers and dropped from six inches or so on Earth. So we recognize that you could really deposit anything. Now the Sky Crane maneuver can happen over any terrain – the descent stage doesn't care whether it is rocky or steep, although the payload might, however there is a beautiful synergy and it is no accident with regard to the MSL rover that it is essentially tolerant to any item below that which we can see from orbit with the HiRise imager on MRO. So if you can see it – it can kill us potentially. If you can't see it, it won't kill us, largely. Now as it came to pass, the exact resolution of HiRise wasn't quite what we all hoped it would be so there is a small gap, but the interpolation between the rover's tolerance and the HiRise resolution is very, very small. The rover is tolerant to .6 meter rocks and the HiRise definitely resolves .75 high meter rocks. We can use a rock model to get across that, but really it is easy for us to see things that can kill the rover. That means that there is very little ambiguity about this terrain-related risk where we are going.

...the Sky Crane maneuver can happen over any terrain – the descent stage doesn't care whether it is rocky or steep...

Also, because we use guided entry, on the entry we have a symmetric vehicle, but we have asymmetric mass properties and because of that the vehicle flies at a cant; that canted angle develops lift, and we steer that lift to the vehicle up and down the atmosphere to find the density altitude that it is expecting. So if we show up and it is a warm, low density day, or a cooler more dense day, or windy day, the vehicle can fly out that variation in the atmosphere; that means that ellipse on the surface of Mars isn't 100 or 150 kilometers in length, it's 15 kilometers in length, and 12 or so kilometers across. It is easy for us to fully photograph with hi-resolution imagery the entirety of the ellipse and know with high certitude the risks that we are going to encounter with respect to the terrain. That is one of the beauties of the rover, but even if you are depositing a payload that is less tolerant and has more susceptibility, with this small landing ellipse and with this delivery system we can put anything on the surface of Mars. That's why there is a certain advantage to this architecture, the Sky Crane and the guided entry, being reused.

TMQ: What are you working on right now?

ADAM: We are combing through the system, making sure that all of the tests and analyses that we need the flight vehicle for, to be certain that we are ready to launch, have been completed acceptably and that we are ready to launch. And so we are going through that accounting process looking down into the very fine levels of detail to make sure that we understand our launch preparedness and that we are ready to hurtle this spacecraft out towards Mars. As soon as that is done, we will start our final set of landing preparations. We are already stress testing EDL trying to force very bad days on Mars to occur to try to stress out the vehicles response because the vehicle autonomously navigates itself to the surface of Mars. We are putting it through all sorts of terrible concoctions of Mars that could cause you to have a bad day. For instance, externally, if not enough molecules are in the atmosphere on Mars on the day it lands, high winds, dust storms, extra bad terrain, or internally, trying to cause the avionics to see upsets, or we try to throw collisions between triggers to make sure the computer won't lose its mind if something happens that it is unexpected. So stress testing, launch and landing preparedness is what we are all about right now.

Adam Steltzner is the Phase Lead for Entry, Descent and Landing on the Mars Science Laboratory mission, and in charge of all of the technical aspects of making sure that the EDL phase of the mission works. He leads a team of 25 people spread out over several different NASA centers: JPL, the Langley Research Center in Virginia, the Ames Research Center in the Palo Alto area, and the Johnson Space Flight Center in Houston. Spanning across that set of NASA centers, Adam's team has designed, developed, and will fly the spacecraft safely to the surface of Mars. Adam has a bachelor's degree from the University of California at Davis in Mechanical Engineering (1990), a master's from Caltech in Applied Mechanics (1991), and a PhD from University of Wisconsin-Madison in Engineering Physics (1999). He was raised in northern California, and was originally a musician. "All this [rocket science] stuff", as he says, came a bit later in life for him.

MARS SCIENCE LABORATORY PREPARES FOR LAUNCH

Jason Rhian, Staff Writer

NASA's Jet Propulsion Laboratory hosted an event in early August to highlight the next mission to Mars – the Mars Science Laboratory (MSL) or *Curiosity* as it is more commonly known. The rover, the Sky Crane that is tasked with landing the rover safely on Mars, and the aeroshell were all on display in a cleanroom at Kennedy Space Center.

Before the media had the opportunity to view the flight hardware, they were given a briefing and then asked to suit up in what are euphemistically known as "bunny-suits." This protective garb, along with a number of other requirements, is put in place to minimize the risk of any Earth-born contaminants heading to the Red Planet.

In the cleanroom, *Curiosity* took center stage. About the size of a small car, with her robotic arm extended (and a California license plate underneath that) the rover was very impressive. To the left of MSL was the rover's aeroshell, and to the left of that was the Sky Crane.

The Sky Crane is arguably the most controversial piece of equipment on this mission. While on its approach to Gale Crater, the rover's proposed destination, the rover will be lowered from this jetpack-like device as it is firing its thrusters, keeping both it and the rover airborne. The umbilicals then lower the rover to the Martian surface, the lines are severed and the Sky Crane is released to impact the Martian surface.

"I oversee the team of engineers and technicians that actually puts the spacecraft together," said Ben Thoma, JPL's Mechanical Lead for Assembly Test and Launch Operations. "The job is both fun and hard. Anytime that you build something that's going to go to Mars it has its challenges. Anytime you do something for the first time, anytime you send a new vehicle to Mars it can be difficult, stressful – but we're very excited to close out our vehicle in preparation for launch."

Curiosity is, in many ways, very similar to the Mars Exploration Rovers *Spirit* and *Opportunity*. There is a central mast that has cameras and other sensing equipment built into it, six wheels and a remote manipulating system (robotic arm) with a number of instruments in it to examine the surface of Mars.

"The most obvious things that strike you about the rover are the mobility features. The remote sensing mast and the arm are the most prominent elements of MSL and represent the base capabilities that MSL possesses," said JPL's Peter Illsley, the integration lead working on MSL.

The Mars Science Laboratory launched from Cape Canaveral Air Force Station's Space Launch Complex 17 on November 25, 2011. The rover launched on a United Launch Alliance (ULA) Atlas V 541 rocket. MSL will take approximately 8½ months to reach Mars and is scheduled to spend at least two years exploring the Martian landscape. The team of engineers and scientists that are working to prepare MSL for launch have little doubt it will be a success. "I'm sure that MSL will work as advertised. I work with a team of world-class technicians and quality assurance engineers to ensure that the rover is built the way that the engineers designed it." Illsley said.

OPPORTUNITY AT ENDEAVOUR CRATER

Steve Squyres, Principal Investigator

TMQ: The road trip to Endeavor got underway in August of 2008. When was the decision made to send it there?

SQUYRES: About three years ago. We finished up at Victoria Crater and we had to decide what to do next. At that point the rover had been around a long time. Once we came out of Victoria Crater we could have gone in any direction. If all we were going to do was to look at sedimentary rocks out on the plains, any direction was almost as good as any other. But somehow noodling around out on the plains until the wheels fell off didn't feel like the right thing to do to me. I wanted to pick a goal, even if it was an impossible one. I wanted to energize the team and make it worthy of this project and this rover. The obvious thing to do was to try to head to Endeavor, but it seemed ridiculously far away. Was I convinced we could get there? No, I absolutely wasn't. If you had asked me to give the odds, I don't know what numbers I would have given you, but they wouldn't have been particularly high. I wanted something that would be this wonderful goal on the horizon that would stir us onward. One of the consequences of this was that rover drivers who had left the project came back on as soon as they heard about this, because they thought it would be such a great challenge to try to get to Endeavor – and they are still with us.

TMQ: What made Endeavor crater intriguing to you?

SQUYRES: The reason it was special was because unlike all the other craters we have looked at, this was not a crater formed in the sulfate sediments that we have been driving around on. It is under that and then the crater rim is sticking up through it. So this is a completely new geologic material. We knew all along that if we could get to this stuff, it would be like an entirely new landing site. We have crossed the boundary from the stuff we were in to the stuff we are on now, and the stuff we are on now is older and completely different from everything we have seen in the last 7 ½ years. It is like a new mission.

TMQ: What have you discovered to date?

SQUYRES: Fundamentally the rocks at this location seem to be what I will call a basaltic breccia. Basalt of course is very common to igneous rock and it is common at many places on Mars. Breccia means a rock that has been fragmented and then fused back together - so it is pieces of rock all jumbled up together. It is the kind of a rock that you would expect to find on the rim of a big impact crater. So if you had an impact into basalt, and most of the Martian crust is made of

basalt, then finding basaltic breccia on the rim of the crater is just exactly what you would expect. The thing that is interesting and unusual and what we are still kind of grappling with, is that the chemistry – the composition of this rock - is unlike anything else we have seen in any other Martian rock. There are a number of interesting characteristics, but the one that really jumps out at you is that it is anomalously high in zinc. Zinc is a chemical element that is readily mobilized by water – especially hot water. There are zinc ore deposits in the Canadian Shield and there are zinc deposits in various places on Earth, and in virtually all cases they got that way as a result of there being hydrothermal systems. So water that is heated and percolates through the ground, then dissolves zinc out of some rocks and re-deposits it into others and causes enhanced zinc concentrations. Are we dealing with the remnants of a hydrothermal system here? It is too early to say. But that is the hypothesis we are working with and it is a reasonable one because if you think about it, this is a 25 kilometer impact crater – a great big hole in the ground, and it was caused when a large object struck Mars. It comes in at many kilometers per second - a huge amount of kinetic energy. When it hits the surface that energy has to go somewhere, so it goes into heat and it is going to heat the ground substantially. Immediately after the crater forms, you expect the materials at the rim to be quite hot. If there was water, if there was ice beneath the ground at the time of impact, then hot rock and water are the fundamental ingredients for a hydrothermal system. A hydrothermal system at this location, perhaps one that was created by an impact, is our working hypothesis at the moment. I wouldn't say that we have confirmed that by any means, because we haven't really gotten into one of these rocks yet.

We have looked at one rock, and the surface texture of the rock was so rough and rugged that it was impossible for us to use our rock abrasion tool on it. The rock we are at now – we just got the downlink minutes ago – is called "Chester Lake". We are not sure what it is made out of and will find out when we make some measurements on it, but it has a much smoother surface and one we think we can grind into. One of the things we will be discussing in the coming days is if we are going to make some measurements of this rock to determine its composition. The answer is almost certainly yes. The big question is are we going to grind into it and try to figure out what it looks like below the surface – because you really need to get below the weathered surface of a rock and get down into it if you really want to understand its chemistry. I just saw the first good high resolution pictures of Chester Lake minutes ago.

TMQ: How is the Botany Bay area of the crater different, and what might you find there?

SQUYRES: Botany Bay is kind of a gap between rim segments, and so what we expect to see is sulfates similar to what we have been driving around on for the last 7 ½ years. We will take a taste of Botany Bay as we go across it, but we are probably going to scoot across that pretty quickly when we are ready to do it and then go on to the stuff at the south.

TMQ: Will anything you find at Endeavor influence the mission of Curiosity?

SQUYRES: It is too early to say. My knee-jerk reaction is to say probably not because what we are investigating is probably quite different from what Curiosity will be doing. We just got here, have looked at one rock, and have just pulled up to our second rock – so we have a long, long way to go. I learned a long time ago not to predict what you are going to discover on Mars.

TMQ: How long is Opportunity going to stay at Endeavour crater, and then what is next?

SQUYRES: Well that's another thing I have learned not to predict. We will stay at Endeavour as long as we need to stay in order to do the science that we are seeking to do, and that's going to be discovery driven. You have to realize that this rover could die tomorrow. We are living on borrowed time now and, who knows what will happen? So we will just do the best we can do and see what happens.

Editor's note: On December 8, NASA researchers revealed that while at Endeavour Crater, Opportunity discovered what appears to be a vein of the mineral gypsum, which they say is a "slam dunk" sign of past water on Mars. For more information, please visit:
http://science.nasa.gov/science-news/science-at-nasa/2011/08dec_slamdunk/

Dr. Steven W. Squyres is a professor of astronomy at Cornell University, and the principal investigator for the science payload on NASA's Mars Exploration Rovers.
**Editor's Note: This interview was conducted in mid-September.*

MARS DESERT RESEARCH STATION - "Mars 101"

Dr. April Andreas

In January, MDRS will be hosting a slightly different set of visitors. Rather than the typical two-week research stint at MDRS, a group of community college professors will pilot the new "Mars 101" course. Mars 101 participants will not conduct independent research; rather, they will learn the tools and methods of analog field research and conduct one small individual project.

The idea behind Mars 101 is to bridge the gap between the hard-core researcher and the curious undergraduate with little to no formal research experience. "What we want to do is introduce the idea of analog field research to a whole host of students who may never have considered doing this kind of thing before," said Commander April Andreas, of McLennan Community College in Waco, Texas.

Although the initial Mars 101 crew will be seasoned researchers, including an FMARS veteran, a typical Mars 101 crew will consist of an experienced faculty advisor and five students. The team will be made up of students interested in science, engineering, and mathematics, but may include those from outside the typical MDRS selection pool, such as students in business management and leadership. Since the students may only be in their first or second year of college, they may not be ready for a full two-week immersive research experience. However, a one-week Mars 101 course is a perfect fit for a budding researcher in anticipation of a senior design project or senior thesis paper.

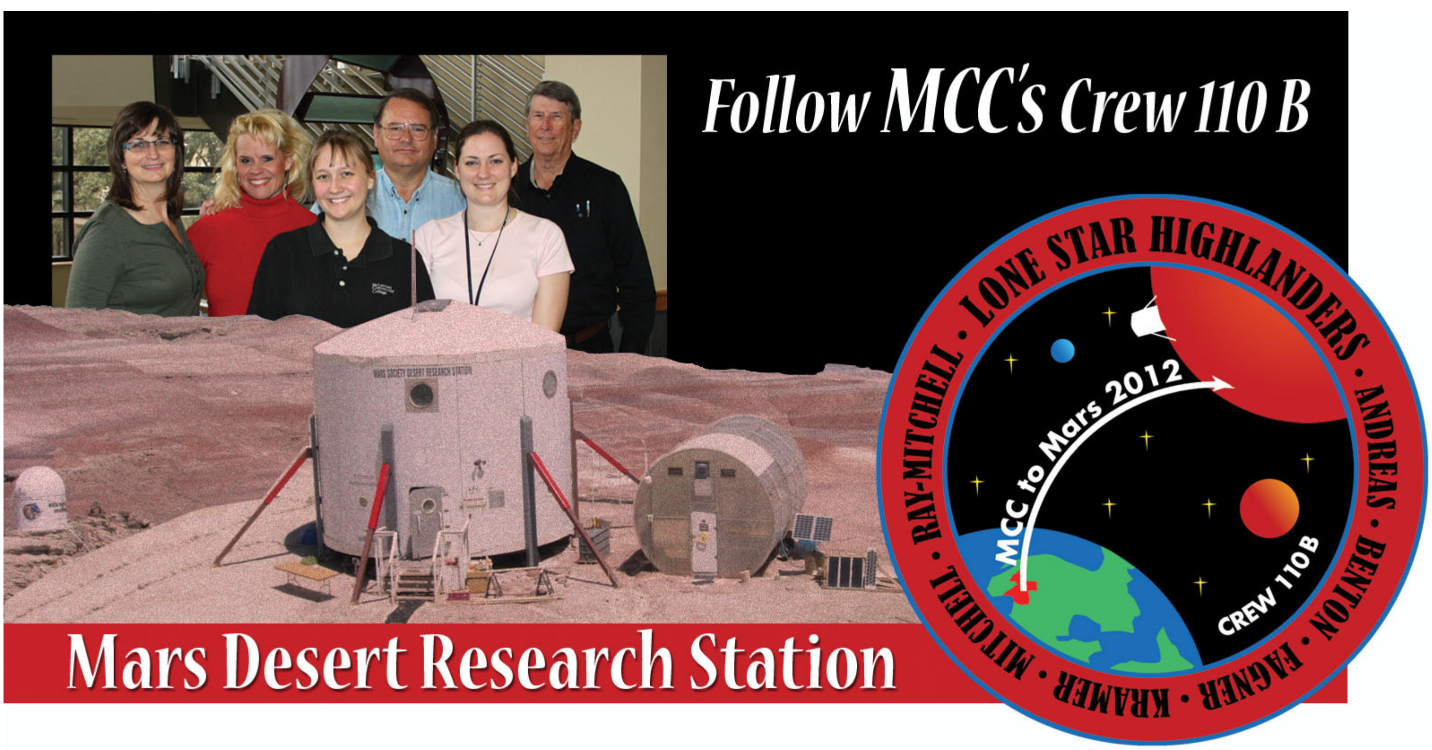
There is a specific day-to-day curriculum that the crew must follow. For example, each participant will complete experiments and lab work in microbiology, geology, chemistry, and astronomy, regardless of their own specialization. All participants will also participate in leadership and management training. Rather than being assigned specific roles, all participants will gain experience in all positions at MDRS, completing lab work, maintaining the hab, and keeping up communications. Also, each student will be required to complete an independent experiment that can be completed in one day at MDRS.

This pilot course will test the feasibility of the course and begin the training of faculty advisors. The participants plan to deploy Mars 101 for undergraduates during the 2012-2013 field season.

"It is our goal that any graduate of Mars 101 will have the knowledge and confidence to successfully command their own full two-week tour of MDRS later in their undergraduate or graduate careers," said Commander Andreas. "This is an incredible opportunity for our students and faculty, and we are all grateful for the opportunity to contribute."

For those who wish to obtain further information regarding "Mars 101", Dr. Andreas can be reached at: aandreas@mclennan.edu.

Join April and her students at their blogspot: http://mcclifeonmars.blogspot.com/



MARS DESERT RESEARCH STATION
Musk Observatory - Astronomy Outreach Program

Haritina Mogosanu, M.Sc.

Stars have always played a major role in exploration. From the ancient civilizations of Asia and Europe venturing through the seven seas to the discovery of America and the Polynesian way-finding, it was all done by the stars. Stars enticed us to go beyond the naked eye and invent telescopes; wonderful machines we use to uncover places we never imagined existed. Mars Desert Research Station in Utah is one of these places here on Earth. Located in the middle of the Utah desert, away from light pollution and benefiting from a steady atmosphere, MDRS is a research outpost in a landscape that resembles almost to perfection that from Mars. The desert nights are excellent for astronomy, whether you are watching the Moon or the Milky Way rising, or taking long time exposures of the most amazing objects from the sky. The presence of a telescope and an observatory there adds flavor to the station, and serves as a strong outreach tool. Astronomy was the first science that accompanied us throughout the millennia, a very loyal friend, and now we are bringing it to Mars.

Why astronomy?

The future explorers of Mars may find it handy perhaps to be able to find directions without a compass as there is no magnetic field on Mars. Or, they may wish to incorporate into their future buildings' architecture spaces for time telling: noon, equinoxes and solstices just like the Egyptians, Mayans, early Europeans and many other cultures did. Then as the relatively newly formed branch of planetary defense is on the outlook for possible asteroids or other bodies that would threaten Earth with destruction, a Martian sentinel would be able to pick up these threats in advance and alert Earth.

And last but not least, an observatory on Mars will allow us to better measure the distance to the stars using the parallax method. In 1869 Captain Cook traveled to Tahiti to observe the transit of Venus (a forthcoming cyclical event observable from the Southern Hemisphere in June 2012) and used the parallax method to calculate the distance between the Sun and Earth. A short 200 years later we launched Hipparchos, a satellite that measured the parallax of more than 100,000 nearby stars and mapped the immediate neighborhood. That allowed us to search for possible planets. Just like Captain Cook's real mission was to search for Terra Australis and Terra Incognita (Southern Land and Unknown Land), by an interesting twist of the fate, measuring the parallax to the stars, indirectly helps us to do just that. So astronomy cannot be separated from space exploration and furthermore space exploration could be considered merely one of the offsprings of astronomy. But the most beautiful thing we learned from astronomy and space exploration was about ourselves and about Earth, our current home. So there are plenty of things to uncover here. And there are wonders of the universe that await there at our stargate from MDRS.

The new field season 2011-2012 will start with a bright new ST8300c camera attached on the Celestron C14 telescope that will peer into the depths of space and bring back incredible pictures. We are also preparing a very strong outreach program for students from schools and universities. The program will be accessible through Mars Society's MDRS website under Astronomy Outreach. Schools will be able to connect with the astronomers of the crew and remotely take pictures of the sky. They will also be able to participate in our classroom experience and download materials tailored for their curriculum. There will be plenty of work to do with the telescope at the MDRS this field season and we are looking forward to receiving your visit. Stay tuned with us and follow our progress as we are building our astronomy outreach website.

Clear and dark skies!

Haritina Mogosanu is a science communicator and a "starry" teller who loves sharing her curiosity and passion about the exploration of space, (ancient) astronomy and its cultural valences, astronavigation, biology and life, and loves connecting people with knowledge and understanding. In January 2011 she was Executive Officer, Astronomer, Engineer and Biosecurity Officer of Crew 98 Romars stationed at the Mars Desert Research Station (MDRS) in Utah USA. She will be back there in 2012 as Commander of the first New Zealand Crew, KiwiMars, and a mission she is very much looking forward to. After coming back from MDRS she founded Mars Society New Zealand.

Musk Observatory Maintenance – August 2011

By Peter Detterline, Chief Astronomer

The 2011-2012 season at MDRS will see the Musk Observatory fully operational from a Visual Astronomy position, with no problems or issues. For imaging with the new camera however, crew astronomers will need to spend at least 30-40 minutes setting and tweaking the mount to get decent results, and then it will only be of short exposure objects, such as the Moon, and very bright deep sky objects. To achieve the results we really want, we will need to have a shorter focal length telescope attached to the Celestron 14 and a permanently set mount. One of the last crews in the 2011-2012 season will have Astronomer Haritina Mogosanu, who is part of the Astronomy Team, and she will install the short focal length refractor and test it with the new camera.

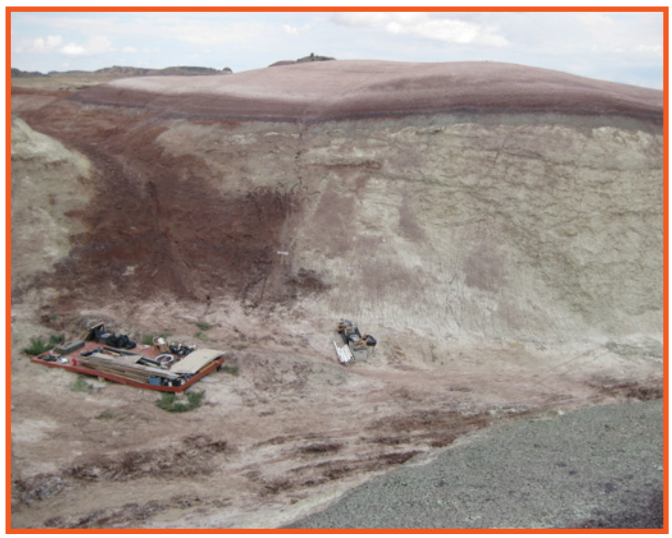
Haritina is also in charge of the Astronomy Public Outreach pages. We expect to have a basic page setup for the start of the 2011-2012 season, including features where students can send questions into a current crew member and lunar image requests and curriculum activities dealing with images taken from the Musk Observatory. We plan to expand this for the 2012-2013 season to include asteroid search curriculum, and deep sky image requests and curriculum.

A crew of astronomers will join me in the summer of 2012 to move the Musk Observatory to its new location. With the completion of this phase, crew astronomers will be able to take good quality images of longer exposures, and we will have the Musk Observatory and the public outreach section working at full capacity for the 2012-2013 field season.

MDRS Refit Crew Cleans Up

The Mars Desert Research Station site clean up was completed this year by John Barainca and a team of dedicated and hard working volunteers. The 2011-2012 season began December 3.

BEFORE | **AFTER**



The Mars Society would like to thank its volunteers for all their hard work this summer on the refit of MDRS, and the donors who made it possible. Below is a partial list of repairs/upgrades:

1. Suits/backbacks/radios all repaired/refurbished and checked. 5 operational backpacks.
2. Lab was completely emptied, cleaned and reviewed; a new oven was installed and new lab equipment added.
3. The area around the hab was cleared of vegetation and debris.
4. New mattresses were installed.
5. Fresh paint, including the floor.
6. A new maintenance shed was built.
7. Plumbing and water system repaired.
8. New generators
9. Three (3) new ATVs!

On to Mars!

Welcome to new team members:

Flight Surgeons:
Kris Lehnhardt, M.D., George Washington University EMS

Marc Griofa, M.D., Noninvasive Medical Technologies, Inc.

Engineering:
Judd Reed
Judah Epstein

John Barainca, Engineering Team Coordinator, and Shannon Rupert, Remote Science Team Coordinator, and Crew 108

MDRS Crew 108

Name	Speciality
Charlotte Poupon	Commander
Michael LeClair	Executive Officer / HSO
Ashley Dale	Engineer
Mike Lotto	Engineer
Usha Lingappa	Astrobiologist
Alicia Framis	Artist

MARS DESERT RESEARCH STATION
CREW 108

Annual Convention in Photos...

Pat Duggins/NPR and John Zarrella/CNN

Pat Duggins/NPR book signing

Robert Zubrin and friends share a lively discussion

Gary Fisher with TMS Attorney Declan O'Donnell and wife

Bishop James Heiser and Kevin Sloan

Dr. Ashwin Vasaveda/MSL and Dr. Ian O'Neill/Discovery Channel

Banquet presentation

A salute to all members/volunteers of the Dallas Chapter

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

THE MARS SOCIETY

OFFICIAL DONATION AND MEMBERSHIP FORM

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I'm donating $100 or more, please send an autographed copy of:

__ The Case for Mars __ Entering Space
__ Mars on Earth __ First Landing (a novel)
__ The Holy Land (satire) __ Energy Victory
__ On to Mars 1 __ On to Mars 2
__ Mars Songs CD __ ***NEW!*** How to Live on Mars

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__ Family Membership: __ 1 year .....$100 __ 3 years ...$200

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Fax this form to 307-459-0922, or donate online at **www.MarsSociety.org**

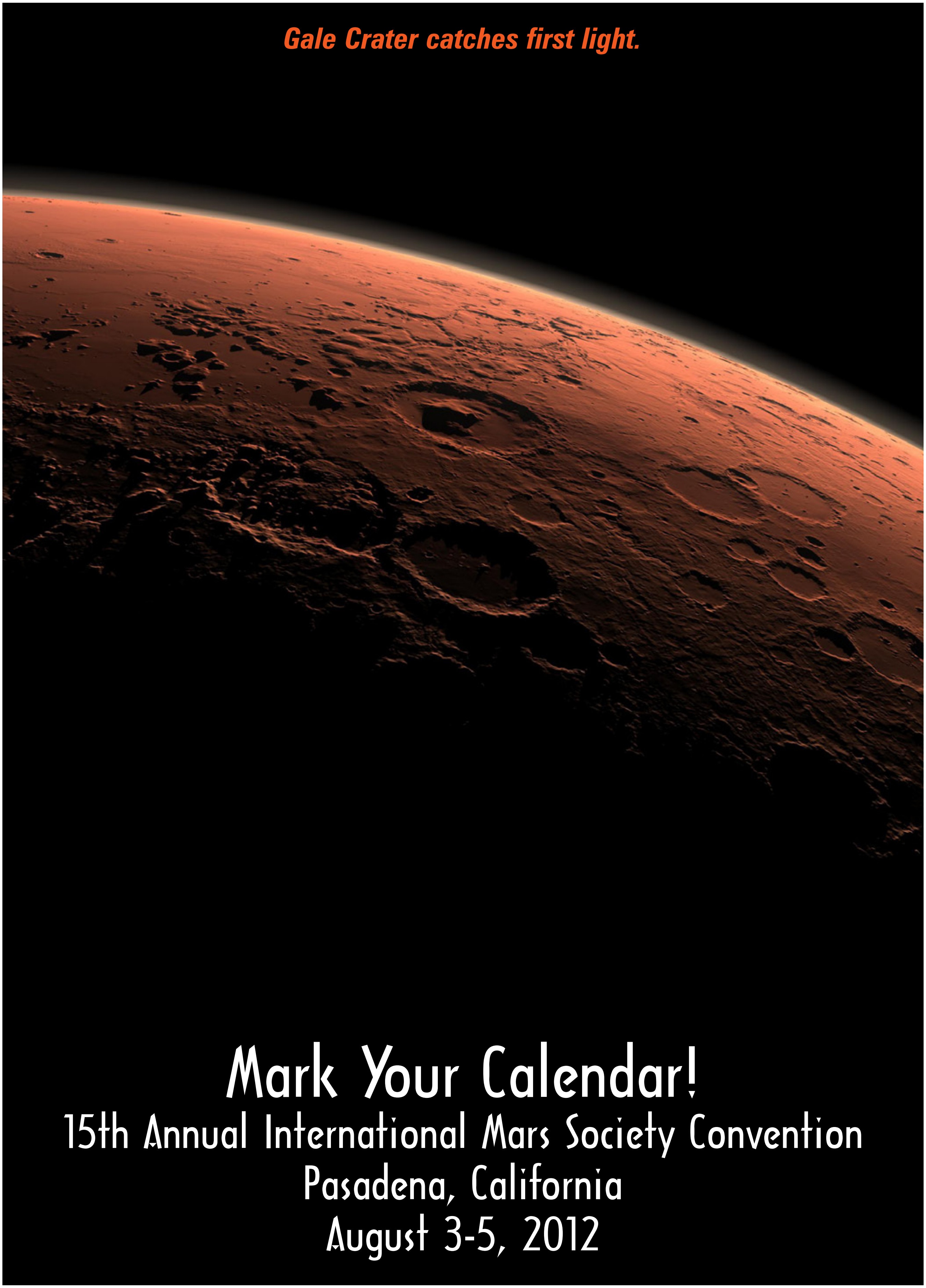

Image credit: NASA