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Roundup

Are we alone in the universe?

This time-lapse image, which was taken during the Perseid Meteor Shower on Aug. 12, 2002, shows a Perseid meteor streaking across the beautiful desert skies over Joshua Tree National Park. Read about how scientists at Johnson Space Center are "more convinced" than ever that evidence found in meteorites supports the existence of primitive life on Mars. *See story on page 8.*

guest column

INTERNATIONAL SPACE STATION PROGRAM MANAGER, MICHAEL T. SUFFREDINI

Back on track

After a hiatus of more than three years we are back on track to fulfilling our commitment, to ourselves and our International Partners, of completing assembly of the International Space Station (ISS) by 2010. With the launch of Space Shuttle *Atlantis* (STS-115) on Sept. 9, we embarked on the most challenging chapter to date of the ISS Program.

The next several assembly flights include installation of the port inboard (P3/P4) integrated power truss segment, activation of the central cooling system, transition to the main bus switching unit power distribution system, reposition of Node 2 during three stage spacewalks, installation of the International Partner pressurized elements, and activation of the final power truss; and all of this will make for a daunting challenge.

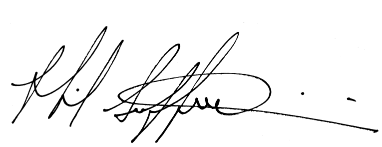
Thanks to the hard work of many folks on the ground and the extreme dedication of the STS-115 crew, we are off to a great start! With the installation of the P3/P4 truss, we have doubled the station's ability to generate power and added 17.5 tons to its mass. This was an extremely complex set of tasks and the success of this mission was crucial to enable the next phase of assembly that will be performed during the STS-116 mission, scheduled to launch in December.

Many have asked why we are building the space station. My response is, because the station is the "toehold" for human exploration of the planets. Every day we learn something more about living and working in space that can be applied to the preparations for these interplanetary trips. The space station will serve as a "test bed" for exploration systems and is the first stop for the Crew Exploration Vehicle, whose continued dockings and stays on station will help ensure its readiness for interplanetary crew transport.

The space station provides the opportunity for us to study human physiological and psychological adaptation to long-term stays in orbit. In addition, the shuttle's hiatus has provided us an opportunity to learn how to efficiently operate an orbital post with limited resupply opportunities. This knowledge is extremely important as we develop strategies to keep crew members and systems healthy during long-term stays in space far from our home planet.

So we find ourselves here at this time because we want to complete the journey that is the assembly of the space station. We want to get on with using the station in the way this world-class orbiting research facility was intended to be used. We want to complete this new star that one day will be bright enough to be viewed racing across the sky in daylight. We want to complete what has been called the most challenging engineering feat in the history of humankind. Accomplishment without challenge is just work, but doing what has never been done before is making history.

I am constantly in awe of the abilities and accomplishments of the JSC team. I know you will be successful in this journey we call ISS assembly, and I'm proud to be with you as you make history.



Can you hear me *now*?

by Brad Thomas

Satellites orbiting more than 22,000 miles above the Earth provide NASA with the ability to almost continuously monitor human spacecraft as they orbit the Earth. Tracking and communicating with the International Space Station and space shuttle is therefore relatively convenient.

But that has not always been the case.

Prior to the Tracking Data and Relay Satellite System (TDRSS) currently in use at NASA, the Mission Control Center (MCC) at Johnson Space Center had to rely on tracking stations situated in remote locations around the globe to track and communicate with human spacecraft. This system was called the Manned Spaceflight Network and later was referred to as the Ground Network.

MCC Operations Manager Jim Brandenburg has worked with both the Ground Network and the TDRSS. He said there is a huge difference in the coverage capabilities between the two systems. "Back then we had an average of 17 to 20 minutes of coverage per orbit," Brandenburg said. "Now with TDRSS, we have pretty much continuous coverage."

Brandenburg also said that back in the early days there were rare instances when as many as three hours could pass before a spacecraft's orbit would take it into the range of a ground station.

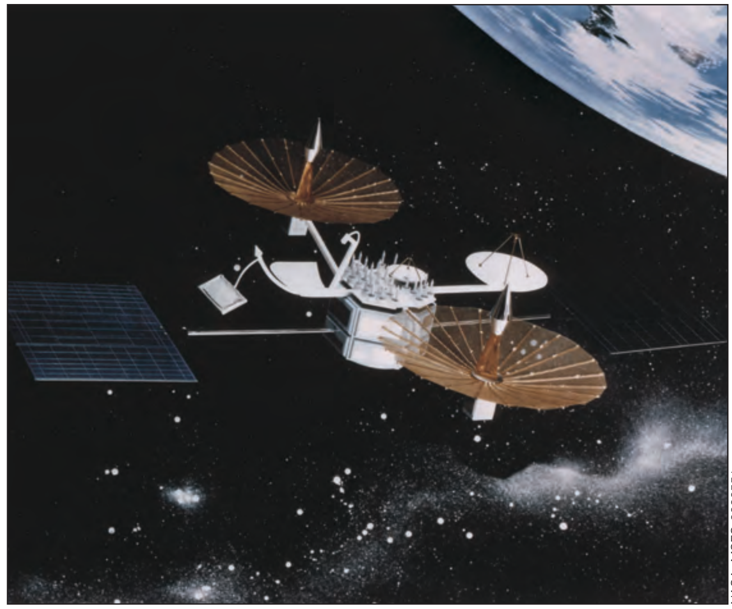
TDRSS became operational in 1986. This network of satellites is referred to as the Space Network. Most of the TDRSS satellites are controlled by two stations at NASA's White Sands Test Facility (WSTF) in New Mexico. The ground stations are operated by the Goddard Spaceflight Center. There is also one TDRSS satellite that covers the zone of exclusion (ZOE), which is controlled by a station in Guam. The ZOE is the area where there is no coverage provided by the other TDRSS satellites.

The satellites, which weigh 4,600 pounds and measure 57 feet across the solar arrays and 44 feet across the antennae, provide support to spacecraft in S-band and Ku-band frequencies.

Roy Harris, operations manager for the Mission Support Operations Contract for Honeywell, spent two years at the ground tracking station in the Canary Islands and two years in Guam in the 1970s. He also served as operations manager at the TDRSS tracking stations at WSTF from 1981 to 1990.

Harris said that the amount of data dispersed through TDRSS is about 1,000 times faster than could be transmitted in the past. Prior to TDRSS the information was transferred between the MCC and the ground stations and was transported by undersea cables and modems. "Now we can downlink 48 megabytes per second," Harris said. "The (maximum) rate for Apollo was 51.2 kilobytes per second."

The use of TDRSS also eliminated the inevitable blackout that occurred during entry for missions prior to 1986. Radio waves were unable to penetrate the cone-shaped sheath of ionized air that engulfed the spacecraft upon entry. Since a TDRSS satellite is in orbit, it can transmit and receive signals through the sheath. In addition to increased coverage and communication capabilities, TDRSS changed the way work was done. "With the remote tracking stations, everything was manually configured and required each station to be staffed by 80 to 100 people," Harris said. "With TDRSS, everything is automated."


NASA MSFC-8893551

This artist's concept drawing depicts the Tracking and Data Relay Satellite-C (TDRS-C), which was the primary payload of the Space Shuttle* Discovery *on the STS-26 mission, launched on Sept. 29, 1988. The TDRS-C was the third TDRSS satellite to be launched.

John Cornwell also served at the ground tracking station in Guam and is currently a telemetry and command manager for Honeywell. His group handles telemetry and command for the space shuttle and command for the space station. The group also handles scheduling TDRSS assets for shuttle and station missions. Cornwell said that life with TDRSS isn't always smooth. Since TDRSS is used for other orbiting U.S. spacecraft besides the station and shuttle, there are sometimes scheduling conflicts. The ever-changing dynamics of a shuttle flight forces schedulers to be on their toes, especially compared with the static station schedule. "After you lift off, you are constantly refining the schedule," he said. "The scheduler is always busy."

Even though life before TDRSS was not easy, those involved with the human spaceflight program got the job done. "It was a fact of life," Brandenburg said. "That is the way we trained and the way we flew."

White Sands behind the scenes

by Cheerie R. Patneaude
NASA White Sands Test Facility

Nestled in the remote desert near Las Cruces, N.M., the White Sands Test Facility (WSTF) plays a necessary behind-the-scenes role in space shuttle missions.

This unique testing facility supports the NASA mission of safe human spaceflight through its distinctive expertise in testing all materials used in spaceflight, such as orbital maneuvering and reaction control subsystems. WSTF also handles hardware refurbishment and maintains specialized proficiency in hypergol-handling and oxygen systems hazard management.

"The level of commitment from White Sands is just incredible. If there's an issue, we're there," Brooks Wolle, chemical specialist for Jacobs Sverdrup, said. "There are a lot of go-to people out here. If they want something quick or need an answer, the phone rings."


NASA/Elliott WSTF0905E07647

Employees from all over White Sands worked together to solve a shuttle thruster anomaly.

For instance, during the launch of STS-115, "one of the protectors blew off of one of the thrusters, and there was an issue with water," Wolle said. "And they were out here in the chamber lab testing to make sure everything was okay."

Shuttle support-related projects conducted at the test facility give WSTF personnel the experience and proficiency to be consulted during a flight, meaning many employees are on alert during the mission. In the past, some have been called to support shuttle team members located at Johnson Space Center, White Sands Space Harbor (WSSH), and Kennedy Space Center (KSC).

"We're very big behind the scenes," said Shane Daugherty, a Propulsion Systems test technician for Jacobs Sverdrup. "We do a lot of testing."

WSTF workers perform valuable diagnostics essential to making sure the shuttle flies safety.

"We do penetrative testing, radiograph (x-ray) welds, ultrasound…basically all the disciplines of nondestructive testing to certify that welds and articles are to the right specification and able to be put back onto the shuttle," Wolle said. "We've dealt with the flow liner cracking, and we've done a lot of failure analysis of the coating chipping on the thrusters. A lot of questions get answered here."

During STS-121, an auxiliary power unit (APU), which deploys the shuttle's landing gear, steers the nose wheel and provides braking to the landing-gear wheels, developed a leak. Engineers at WSTF were called in to evaluate whether the leak was hydrazine or pressurant gas, and whether any possible risks could result from the leak.

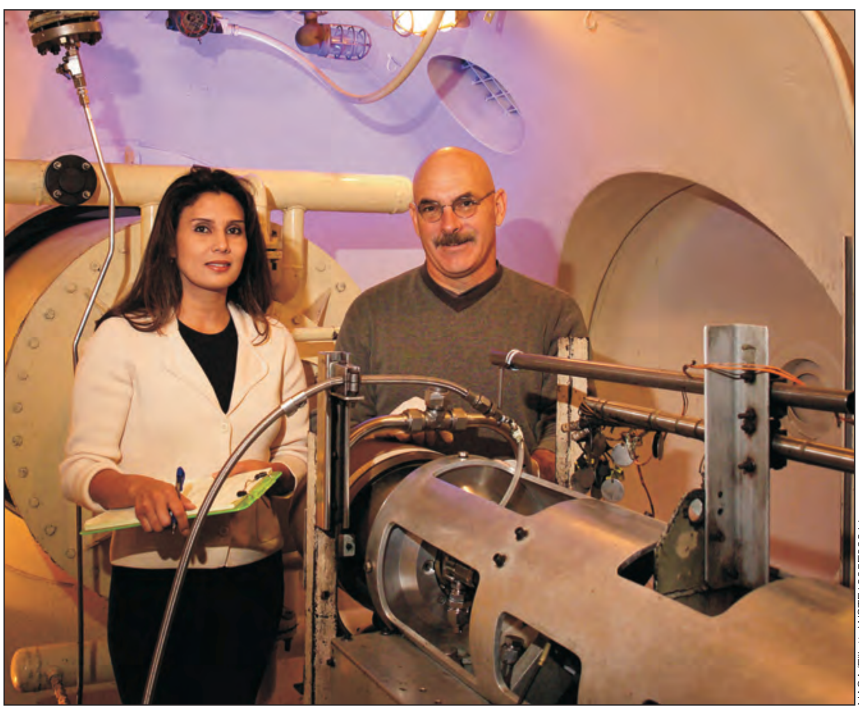
"Recently with the anomaly of the APU, we gathered our people, looked at our data and made some decisions on the APU based on the testing we did," Daugherty said. "There's a lot of real-time interaction between our people here and the people at KSC and JSC regarding what to do in a given situation based on our experience."

The engineers' diagnostics work was instrumental in the decision to advocate landing the shuttle safely with the two functioning APUs.

The WSSH also participates in shuttle missions. As part of the test facility, the WSSH is the primary training area for space shuttle pilots to fly practice approaches and landings in shuttle training aircraft. It is also fully configured to support shuttle landings as one of three continental U.S. landing facilities for shuttle missions. A contingency landing can occur when weather at KSC and Edwards Air Force Base is simultaneously uncertain or the shuttle's flight trajectory requires WSSH be designated the abort-once-around landing site. If an emergency landing is declared, the space harbor can also be used.

NASA/Elliott WSTF1205E09240

Skip Rasmussen, a White Sands Space Harbor landing and runway technician, scans the runways in preparation for a shuttle aircraft training sortie.



NASA/Elliott WSTF1205E09211

Jo Leyva (left), propulsion engineer, and Shane Daugherty, Propulsion Systems test technician, are shown at work in Test Cell 405 on one of the shuttle's Primary Reaction Control System thrusters.

"At the WSSH, every time a shuttle flies, we have a call-down list of preparations that those people go through," Daugherty said.

When the need arises for WSSH to be designated the primary landing site, a Holloman Air Force Base convoy of medical and support personnel will be launched. The White Sands Missile Range will also gear up support, augmenting the WSSH convoy contingent.

On the second and third days of a landing window, if the shuttle has not yet landed, WSSH is called into action and could be selected as the primary landing site.

WSTF personnel were also part of these high-profile projects during the recent STS-121 mission:

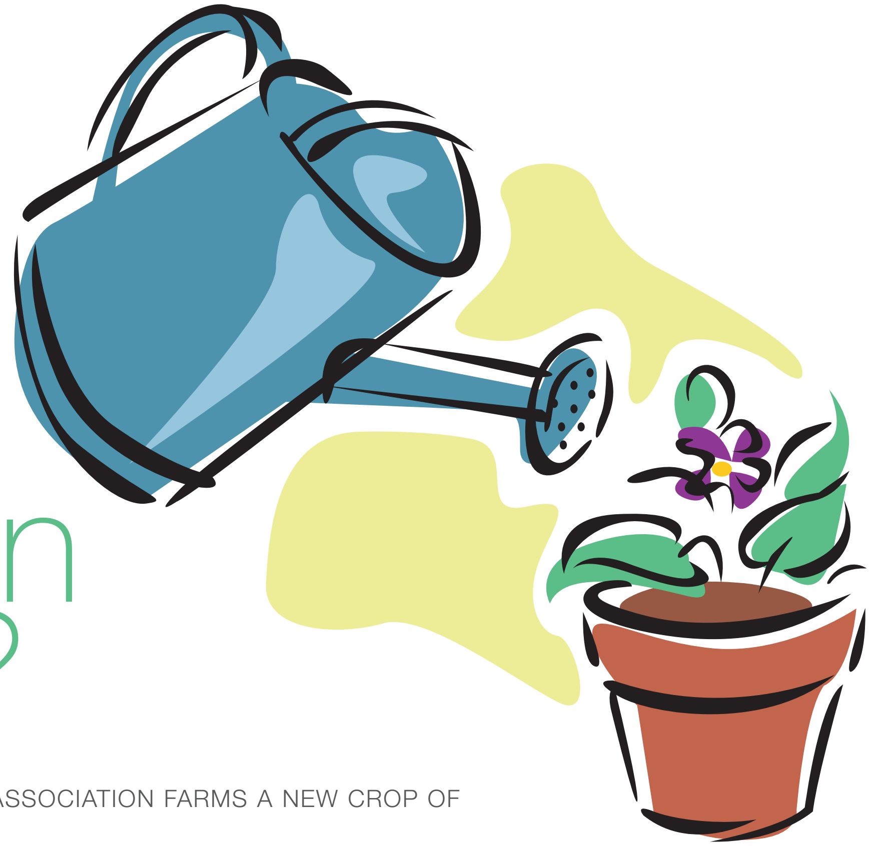
- Advanced Crew Escape Suits, Oxygen Fire Hazard Control
- International Space Station's Oxygen Generator Assembly
- Standard test on STS-121 repair materials
- Imagery calibration on Reinforced Carbon-Carbon testing
- Quick-don mask assemblies

While supporting NASA's exploration goals at WSTF and WSSH is always exciting, it becomes even more so during shuttle missions.

Employees at both facilities have worked together to ensure the safe launch and return of shuttles and crews since the inception of the program in the early 1980s.

"We love what we do," Daugherty said. "It's a great place to work, a lot of fun. We're real happy to be part of the shuttle team."

How does your garden grow?



JSC NATIONAL MANAGEMENT ASSOCIATION FARMS A NEW CROP OF LEADERS FOR THE FUTURE

by Amiko Nevills

It's been said that innovation distinguishes between a leader and a follower. No place exemplifies this statement more than NASA. The National Management Association (NMA) chapter at JSC also understands leaders are not born; they are made, or rather grown.

JSC founded its chapter of NMA, a national professional development organization, to cultivate its garden and grow innovative leaders. It's no surprise what an organization gains when its people inspire and engage others, envision the future together and foster teamwork. But what's in it for you?

"JSC NMA isn't just for managers," JSC Director Mike Coats said. "It's for anyone interested in developing their leadership skills for the future. Whether through monthly lunch meetings or training courses, JSC NMA provides its members an opportunity to learn and grow."

Leadership is critical to success. Such success relies on an organization's employees and their initiative. The philosophy: You get out of it what you put into it. JSC NMA gives employees the tools to harvest the leadership that brings success.

For years, JSC NMA has offered members and guests a chance to hear from experts on related topics as well as opportunities to build networks. This knowledge sharing is what sets an organization apart from others and creates leaders.

In the face of accelerating change, amidst exciting innovations while NASA takes the next steps in exploration, knowledge now is more vital than ever before. NMA looks for ways to build on the emergence of knowledge.

JSC NMA is led by a board of members and supported by a web of committees and advisors dedicated to promoting leadership growth. The chapter not only embraces leadership and management skills, but also serves as a forum for the exchange of ideas and information and encourages the spirit of cooperation among leaders at all levels across government and industry.

"My number-one goal for JSC NMA this year is to drive a stronger professional development program and introduce dynamic speakers on a variety of topics more relevant to today's management challenges," said Jeanie Carter, JSC NMA president and longtime member.

Developing your professional self will also grow a better you. Leadership and management skills spill over into all areas of life, including friendships, family and finances.

Several new prospects for professional development are cropping up for budding leaders.

JSC NMA is making available to its members a quarterly Folklore Series, where retired leaders will share their experiences. Working internationally and managing information and knowledge are among the topics. Also, the program will tap into JSC's Joint Leadership Team for quarterly talks with practiced leaders. Talk topics will be based on specific areas of the NASA Leadership Model.

"We're partnering with the Joint Leadership Team to offer training opportunities targeted for existing and emerging leaders," said Brady Pyle, JSC NMA Professional Development Committee chairperson.

JSC NMA members will soon mine valuable learning from one-on-one coaching and developmental reviews using the Birkman Method, which is designed to help individuals reach greater performance. The JSC Mentoring Program will also become available to all members next spring.

"Both of these opportunities will prove beneficial for those members who don't currently have access to such resources," Pyle said. "JSC NMA has made a difference for many of us who are actively involved. The increased focus on professional development will take you to the next level."

Some members have remained active for many years, gaining a wealth of professional and personal growth.

"Since we are so spread out as a NASA community, we have the opportunity, through NMA, to get to know what other folks are working on and the status of the various programs and projects they support," said Ann Hammond, past program chairperson and NMA member since 1984.

Hammond, a former NASA program analyst of 40 years, still seeks leadership guidance from guest speakers and community leaders. She has retired and returned as a consultant for Al-Razaq Computing Services.

"I continue to be interested in hearing how the rest of the community manages their business challenges," Hammond said.

Speakers have been lined up for the rest of this year and into 2007.

For more information on JSC's NMA chapter, and for a schedule of upcoming events, go to: **http://nma.jsc.nasa.gov/index.cfm**

A peek at future speakers

October
John Lienhard
"The Engines of Our Ingenuity"

November
Bill Gerstenmaier
"Shuttle and Station as Training Grounds for Exploration"

December
Childcare Center Choir
"Holiday Music"

February
Diane Savage
"Motivating the Workforce"

Stay tuned for the upcoming member incentives during the SC NMA Membership Drive in October.

Members of the JSC chapter of NMA attended a luncheon recently at the Gilruth Center.

NASA JSC2006E40769

Is there life elsewhere?

TEN YEARS LATER, JSC SCIENTISTS 'MORE CONVINCED' THAN EVER

by Bill Jeffs

Ten years after announcing finding evidence for primitive life in a meteorite from Mars, Johnson Space Center's astrobiology chief scientist is "more convinced" than ever the claims were accurate.

"I am more convinced today than I was 10 years ago," said David McKay, NASA chief scientist for astrobiology at JSC and lead author of the 1996 paper published in the journal *Science* that detailed his team's findings. "We have not been able to convince the outside community, but I think we will because we have a lot of data and we have a lot of features that can only be explained or can best be explained by past life in these samples."

For the past 10 years, McKay, Everett Gibson, Kathie Thomas-Keprta, Sue Wentworth, Dorothy Oehler, John Lindsay and Penny Morris-Smith have continued to study the meteorite called ALH84001 as well as other Martian meteorites and terrestrial analogs. Older than any known rock from Earth, ALH84001 was discovered in 1984 in the Allan Hills region of Antarctica by an annual expedition of the National Science Foundation's Antarctic Meteorite Program. Its Martian origin was not recognized until 1993. One of 38 meteorites discovered on Earth thought to be from Mars, it is a softball-sized igneous rock weighing 1.9 kilograms (4.2 pounds). ALH84001 is 4.5 billion years old.

Scientists continue to debate whether the meteorite contains biogenic evidence, but they do agree that it has become the most studied geological sample in human history. Tiny samples of it have been sent to thousands of researchers worldwide who have published hundreds of papers. McKay, Gibson, Thomas-Keprta and fellow scientist Simon Clemett have published 10 additional papers and more than 50 abstracts on ALH84001.

THE MAGNETITE CONNECTION

In the early 1990s McKay and Gibson, NASA senior scientist, began studying what were then a dozen or so rocks collectively called the Martian meteorites to understand the nature of Martian water. As part of that effort, they analyzed the carbonate minerals within the Allan Hills meteorite. Astrobiologists look for carbon and water in their search for extraterrestrial life. Carbon is the building block of terrestrial life, forming the basis for organic chemistry, and water is necessary to support all forms of life on Earth. McKay and Gibson noticed unusual structures within disk-shaped deposits called carbonate globules.

In 1996, McKay and his team proposed a suite of four lines of evidence that, taken together, were consistent as a package with a possible biological origin. The four lines of evidence were: water-deposited carbonates; organic molecules called "polycyclic aromatic hydrocarbons," or PAHs; squiggly shapes that resemble bacteria; and chains of tiny magnetites within the carbonates.

Magnetite is an iron-bearing, magnetic mineral. On Earth, some water and soil bacteria secrete the mineral within their cells.

Magnetite crystals in ALH84001 have been a focus of debate about the possibility of life on Mars. The 1996 study led by McKay suggested that some magnetite crystals associated with carbonate globules in ALH84001 are biogenic because they share many characteristics with those found in bacteria on Earth.

A study led by Thomas-Keprta in 2000 showed that some of the magnetite crystals in ALH84001 carbonate globules are characterized by elongation, a "unique habit" identical to magnetite grains produced by bacteria on Earth.

Critics have claimed that the magnetite in ALH84001 was likely caused by inorganic processes, and that those same processes can be recreated artificially in the laboratory by heating carbonates in a process known as thermal decomposition, forming magnetite that is identical to that found in the Mars meteorite.

The JSC team claims the magnetite in the meteorite could not have been formed by thermal decomposition. One flaw in the artificial method is the heat required to make artificial magnetites was above 450 degrees Celsius. Independent studies done by Cal-Tech, MIT and a German research group concluded that the carbonate globules within Allan Hills never were subjected to heat greater than 110 degrees Celsius. That finding is significant because for life to have participated in their formation, as the team argued then and claims today, it had to have formed at about 100 degrees Celsius. Any higher temperature would have destroyed the biological activity.

Another flaw in the artificial method is that the critics' magnetites do not match the shape of those in ALH84001. And finally, the critics are using pure carbonates in their studies—unlike those in ALH84001.

"You can envision a jar of differently colored marbles," said Thomas-Keprta, senior scientist for Jacobs Engineering. "One marble color represents iron, another marble color is magnesium, another is manganese, and another one is calcium. These marbles are mixed together in this jar. And they say when you heat up the carbonate that only the marbles representing iron will come together and make a magnetite crystal. So that way the magnetite is chemically pure.

"In the case of our critics, they are taking carbonates that are pure. They contain only one type of marble. So if you heat up only one type of marble, you're going to get only one type of product. And the sample that we're looking at doesn't look like that at all."

An overlooked part of the JSC team's 1996 argument is that by proposing that magnetites were present in the rock, the team implied—and its hypothesis assumed—that Mars had a magnetic field, but that was not known 10 years ago.

"By proposing that these magnetites were formed by magnetotactic bacteria, as we wrote in the original paper, that implied that Mars had a magnetic field," said McKay. "At the time we published that paper, it was thought that Mars did not have a magnetic field. Yet these magnetites, if our hypotheses were correct, predicted that we would find that Mars had a magnetic field. In fact within about two years, the orbiting spacecraft detected very strong magnetic strips of rock on the surface. And the interpretation is that those magnetic strips of rock were magnetized by an early strong core magnetic field on Mars that magnetized and then went away at about 4 billion years and younger, leaving these strips. You might say that our paper predicted evidence for a magnetic field on early Mars would be found."

NEW TOOLS, NEW TECHNIQUES

In addition to responding to critics of the magnetite argument, the JSC ALH84001 team has spent years refuting those who have posited nonbiological explanations for the team's other three lines of evidence. For example, critics have claimed that the PAHs resulted from Antarctic ice, not Martian ice. But the JSC team and other groups have shown that while as much as 80 percent of the organic PAHs in the rock did come from water flowing through the Antarctic ice, at least 20 percent bears chemical signatures from Mars. Moreover, these signatures are concentrated in the tiny area of the rock where the JSC scientists claimed existence of life.

The key point, as the JSC team asserts, is that all of the noted biological evidence—the complex carbonate minerals, the PAHs, the magnetites—is in one tiny place in the meteorite. To the team, nonbiological alternative explanations cannot account for all of these features occurring in one place.

"To explain these properties, all in the same place, by a nonbiological explanation, seems to me to be extremely difficult, if not impossible," said McKay. "And nobody has done that. The one group that has tried to explain the magnetite has tried to make organics by heating. And as far as I know, they haven't done that. They tried to make these PAHs, and they have not been able to do that. My point is that there are very complex features there, and they're all in this one little tiny area, and taken together only one explanation seems to explain them all rather easily. And all these other explanations may explain one or two but not the whole set."

Using tools that did not exist 10 or even five years ago, the JSC scientists continue to study the Martian meteorite and other meteorites from Mars. They are using a new laser analyzer and an analytical electron microscope to examine the Martian samples in new ways. For example, today JSC scientists are able to identify a small section within a sample, cut it out without destroying the sample, lift it out and place it into another instrument for further analysis and then take that same examined section and place it into a second or third instrument to do additional analyses.

"It's analogous to, say, a deck of cards," said Thomas-Keprta. "If the carbonate is the deck of cards, we can essentially take one card out of the deck now and look at it whereas before we could never do anything like that. So we've got some very interesting techniques now that we're able to use that weren't available five years ago."

Studies will yield a new wave of data that the team hopes will substantiate its initial claims. "We think we're getting new results which, in almost every case, support our hypothesis," says McKay. "What we have learned is that it is a lot more complex than we thought at first. But so what? Life is complex, and the fingerprint of life is also complex."

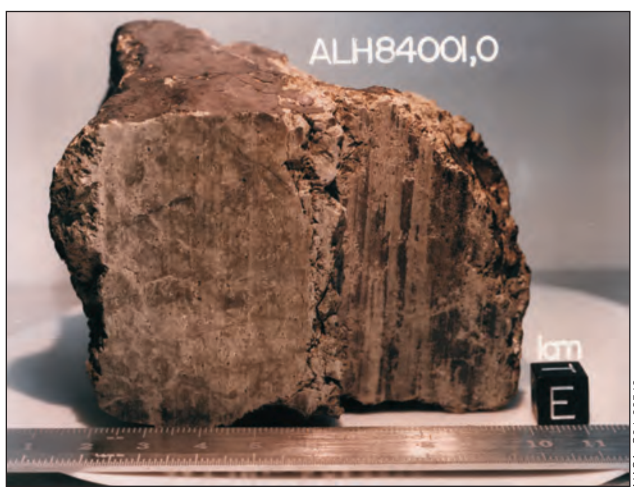
The scientists hope that future studies will help them build a very strong, if not irrefutable, case for their hypothesis.

"Our greatest progress in the next few years will be to detect those organic carbon areas and relate them to the fossil-like features that we see—if they do relate," said McKay. "We don't know that they will, but if they do relate that will be very strong evidence that these are truly micro fossils.

"The other area that we need new techniques is in carbon isotope analysis. What we want to do is not only show that these carbon areas have the chemistry of micro fossils, we want to show that they are from Mars and not contamination from Earth. And the only way to do that is with the isotopic data. And so I would like to go in that direction. That would be such strong evidence that no one could dispute that. If we can show that there is organic carbon and the organic carbon comes from Mars, and it's the same kind of organic carbon that you get today in micro fossils from Australia, but this can't be from Australia, it's got to be from Mars, and, furthermore, it's associated with all these other features, I think we could build a very strong case."

Scientists still argue over the presence of signatures of life in Allan Hills, but they agree that ALH84001 forced NASA and other institutions across government, industry and academia to search for answers to very weighty questions: Are we alone? Is there or has there ever been life elsewhere? And if so, how did it begin?

McKay and his colleagues continue to search for answers to these questions.



NASA S94-32549

Older than any known rock from Earth, meteorite ALH84001, was discovered in 1984 in the Allan Hills region of Antarctica. One of 38 meteorites discovered on Earth thought to be from Mars, it is a softball-sized igneous rock weighing 1.9 kilograms (4.2 pounds). ALH84001 is 4.5 billion years old.

Paper meets technology

by Brandi Dean

Raymond Aronoff would like you to take a moment and think back to the movie "Apollo 13."

There's a scene, just after everything has gone wrong, where everyone jumps up and starts trying to fix it. Books, models and diagrams are dumped on the table, providing the blueprint for saving the day.

FAST FORWARD 30 or 40 years, though, and it might not be that simple.

"Today we're no longer a paper-based world," said Aronoff, former chief technology officer for the Engineering Directorate.

Most of the time, that statement is associated with progress, but technological advancement is creating an interesting challenge: while NASA is transitioning from paper documents, digital technology is advancing rapidly.

NASA is straddling the boundary between the paperless and paper-based world. In an emergency today, rather than turning to books and diagrams, everyone in Mission Control and Engineering would head to their computers. But they might not find what they need.

"The problem is, (NASA's) programs last decades," he said. "But two years is a decade in the software world."

Music fans should be able to relate. You develop a library of eight-track tapes only to have it become obsolete with the invention of cassette tapes. And then it happens all over again with the advent of compact discs. But for NASA, it's critical information on spacecraft design that becomes inaccessible rather than the greatest hits of the 1970s.

So, a lot of information is stored in hard copy. But paper has its own problems. You can't do a "search" for a particular word or phrase in a traditional book—you have to read it all instead. You also can't upload a piece of paper into an engineer's simulation program—you have to recreate the design.

And it's difficult to cross-reference hard copies effectively. A card catalog is nice, but electronic versions have the capability to be directly linked to each other—double clicking on a citation could take you straight to the work in question.

WORKING TOGETHER

So the solution is not to fight paperless offices, it's to refine them. Patrick McDuffee, Integrated Engineering Capability Project Manager at Marshall Space Flight Center (MSFC), is working with Aronoff to do just that.

McDuffee calls what they are creating a "collaborative environment for engineering data"—a way for engineering data on different projects and in different centers to be stored so that everyone who might need it could access it.

For instance, much of the responsibility for the new crew exploration vehicle falls to Johnson Space Center. But the propulsion part of it is MSFC's domain. The two centers will want to work closely on it, but that can be tricky.

"In the past, that would be really labor intensive," McDuffee said. "You'd have to make a physical trip to the other center or maybe mail the information. And you might just throw up your hands and hire a contractor do to the work just because (the contractor's) closer."

But if JSC and MSFC had a way to share the data electronically and a common method of building and saving it, McDuffee said everyone could work on it together in real time.

Bill Harris, technical manager for the Engineering and Science Contract, said the idea has the potential to prevent a lot of headaches. If different groups are able to participate during the design process, technical review goes more quickly, engineering rework is more easily avoided and problems are less likely to get into the system.

Plus, the ability to electronically store the technical review decisions creates a historical record of the evolution of the design—which can be very valuable in future engineering assessments.

"The electronic environment becomes a very efficient and effective process to develop intellectual products," Harris said. "We are actively working with our Jacobs contractor team to electronically develop and deliver all engineering products in a collaborative environment. Basically, we have come a long way in converting to a paperless system. I have very little paper in my office, and it's getting smaller every day."

INSTANT ACCESS

Harris, Aronoff and McDuffee also believe that it's only going to become more important down the road, as NASA heads deeper into space.

"So these guys are on their way to Mars," Aronoff postulated. "Let's say our grandkids. And let's say they break something. How are you going to get them a replacement part?"

That's why the engineering chief always had a starring role on "Star Trek," Harris said. Whenever anything went wrong, he could pull up the schematics and solve the problem in real time. He didn't wait for someone on Earth to tell him how—he fixed it himself.

"In order to do that, you have to have the raw engineering data with you," Harris said.

If all the engineering data for the mission is stored in one form that can be opened by a particular set of programs, it can be put on a disc for the crew to use while on Mars. You could radio the data instead, but with so much information it would be a prohibitively slow process.

Getting to the point where all the data is compatible and accessible is also a slow process, however. Aronoff said the issue has to be worked both inside and outside of NASA—and at the rate it's going, the change will probably take a couple of decades to pull off.

STAYING POWER

Many of the same tools used by NASA and its contractors are used by other industries such as telecommunications and automotive. But, cell phones are out of date in a matter of months, not decades. Manufacturers don't need access to their design models for long. Even automobile manufacturers, whose designs are expected to last longer, pass the responsibility of keeping up with old parts over to others.

"It's not a cost savings for the other industries to have longevity of design like that required at NASA," Aronoff said. "We're significant, but we're not the only customer base for these technology providers."

NASA's internal challenges are no less difficult. Organizations will have to rethink the way that they initiate, collaborate on and manage engineering information. It's going to be expensive and complex, and call for a willingness to change and a new level of cooperation across centers and projects.

"That doesn't happen easily or quickly," Aronoff said. "It requires patience and persistence at every level of the organization."

Even so, Aronoff said that he's seeing progress.

"Because our visions demonstrate objectives beyond the moon, we're realizing the severity of this issue, and understanding the importance of dealing with it," he said. "We're making some headway."

NASA/Markowitz JSC2006E39960

NASA/Markowitz JSC2006E39970

NASA tests technology in the Arizona desert

Arizona's famed Meteor Crater and Cinder Lake area recently served as a surrogate planet surface for NASA's Desert Research and Technology Studies (RATS) team of scientists and engineers. The RATS team took to the desert to test spacesuits and robotic equipment, as well as to simulate a day in the life of a surface exploration crew on the moon or Mars.

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