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ON THE COVER

This artist's concept shows the Crew Exploration Vehicle docking with a lunar lander and departure stage before heading for the moon. NASA's next-generation spacecraft will use an improved, blunt-body capsule with an outside diameter of approximately 5.5 meters—more than three times the volume of the Apollo capsules. The spacecraft will have a total mass of 25 metric tons and will be able to dock with the International Space Station and other exploration elements.

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The Academy of Program/Project & Engineering Leadership (APPEL) and *ASK Magazine* help NASA managers and project teams accomplish today's missions and meet tomorrow's challenges by providing performance enhancement services and tools, supporting career development programs, sponsoring knowledge sharing events and publications, and creating opportunities for project management and engineering collaboration with universities, professional associations, industry partners, and other government agencies.

ASK Magazine grew out of APPEL's Knowledge Sharing Initiative. The stories that appear in *ASK* are written by the "best of the best" project managers and engineers, primarily from NASA but also from other government agencies and industries. These stories contain knowledge and wisdom that are transferable across projects. Who better than a project manager or engineer to help a colleague address a critical issue on a project? Big projects, small projects—they're all here in *ASK*.

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In This Issue

Ed Hoffman's Director's column ("Thinking About Excellence") and Laurence Prusak's Knowledge Notebook piece ("How Does a Learning Organization Learn?") make related points that define key themes of this issue of *ASK*. Hoffman notes that excellence comes from paying attention to the experience of real work—learning from reflection on successes and mistakes. He suggests that learning and excellence tend to be the product of group, not individual, effort. Prusak also emphasizes the social and experiential nature of learning. People learn with and from each other; the learning that "sticks" is what they need to know to do their jobs well.

Many of the articles here touch on the value of learning from experience and the importance of being open and attentive to what experience teaches. In the interview, Michael Coats talks about applying lessons he learned as an astronaut to his work as Director of Johnson Space Center and also about learning from veterans of the Apollo era by inviting them back for conversation and consultation. David Oberhettinger describes a process developed at Jet Propulsion Laboratory to ensure that the lessons of experience are not only recognized but influence future behaviors. Recognizing that making use of the wisdom of experience is often a tougher problem than capturing it, his Lessons Learned Committee emphasizes "infusing" valuable lessons into practices to make them part of how people work.

One of the barriers to learning is people's understandable reluctance to admit mistakes (compounded by an even stronger disinclination to talk about them). But mistakes are great teachers, and effective project teams and learning organizations find ways to make examining them acceptable. Wernher von Braun biographer Bob Ward says that von Braun gave a bottle of champagne to an engineer who revealed that he had made the mistake that destroyed a Redstone rocket. This reward—and, even more, the absence of punishment—was an important signal that encouraged others to be open about errors. Von Braun attributed his German scientists' expertise to the fact that they had more years to make mistakes than their American counterparts. So it is not surprising that Vern Weyers' analysis of the characteristics of outstanding project managers includes openness and a determination to recognize and deal with problems as soon as they become evident. Ignored problems never go away; they get worse. Stephen Denning's "Challenging Complacency" is a more systemic look at strategies that can help organizations look at uncomfortable truths and risks that successful, results-oriented organizations tend to ignore.

Learning is an aspect of most of the project stories in this issue. The Genesis team made sure that what they learned about the causes of the crash landing of their vehicle was communicated to the Stardust team (where it influenced their re-entry preparations). The Stardust project itself was characterized by openness and communication that fostered group learning and problem-solving. (HyTEx showed a similar spirit, with clarity about roles and responsibilities contributing to cooperation.) Clarity and openness foster trust, which, as Prusak notes, also contributes to an effective learning environment.

Don Cohen
Managing Editor

From the Director

Thinking About Excellence

BY ED HOFFMAN

We talk a lot about "excellence" at NASA. That's no surprise. Our mission calls on us to create and manage complex, innovative technologies with little margin for error. Failure can mean the loss of missions costing years of work and many millions of dollars and sometimes the devastating loss of life. So excellence in what we do is not just desirable; it's required. I'd like to reflect a little here on what excellence is and how it develops.

Most of us believe we recognize excellence when we see it. We can probably agree on a definition, something along the lines of "superior quality or performance produced by outstanding knowledge and skill." That's a good start, but I think looking further can provide clues about how to achieve and maintain excellence in our work at NASA.

People who excel usually start out with a basic aptitude for whatever it is they become expert in, but a lot of learning goes into achieving excellence. Initially, that means formal education, studying the basics and then the depth and subtleties of a field. Schooling alone doesn't produce excellence, though. Even the most promising newcomers need the learning that comes from long experience before they become experts who excel in their work. In fact, "expert" and "experience" (and "experiment") come from the same Latin word, *experiri*, which means "to put to the test." Excellence can only be achieved by testing, extending, and refining "book learning" day by day through the experience of real work.

Having experience is not enough, of course. You have to learn from it, and learning from experience depends on a couple of things. First, you have to be willing to recognize and admit mistakes quickly, to learn from what goes wrong. (To make that happen, your organization also needs to treat mistakes as learning opportunities rather than opportunities for punishment.) Second, you have to reflect on experience. Some of that reflection is personal; excellence means continuously striving to understand what your work experience is telling you. Some is more public. At NASA, this magazine and APPEL's Masters Forums are among the ways that people share what they learn from experience. Possibly the most valuable reflection happens in teams and groups that work together. That is why some organizations have adopted the Army's after-action review process, which gives groups an opportunity to compare what they expected to happen to what really happened in an event or project and talk about what they learned. NASA's demanding schedules and tight budget make it hard to find time for group reflection, but I think there is no denying its importance.

We sometimes associate excellence with individuals—the talented surgeon, the outstanding engineer—but when work is complicated and collaborative, excellence depends more on how well a group works together than on the skill of any one person. In a study of surgeons who perform coronary bypass operations, Robert Huckman and Gary Pisano of Harvard Business School found that the success rate of surgeons who divided their time between two hospitals was significantly higher in the hospital where they performed more surgeries—that is, where they and their operating room team had the most shared experience. Their conclusion—that excellence depends more on the quality of teamwork than the talents of an individual "star"—is an important one for NASA.

What Makes an Effective NASA Project Manager?

BY VERN WEYERS

The varied responsibilities of NASA project managers include technical, cost, schedule, and team management aspects of their projects. The PM must deal with people and problems continuously and must evaluate the risk involved with each decision. Some project managers consistently meet these challenges more effectively than others. In my thirty-five years at NASA and nine years of consulting for NASA and commercial aerospace companies, I consider myself fortunate to have participated in more than fifty space flight projects that ranged from $100,000 studies to multi-billion dollar projects such as the Hubble Space Telescope. As a project manager myself and then as the Director of Space Flight Projects at Glenn Research Center and Goddard Space Flight Center, and as a member of independent review teams for Goddard, Langley, and Jet Propulsion Laboratory missions, I have had the opportunity to observe, work with, advise, and learn from many excellent NASA project managers.

There is no standard recipe for outstanding project management, but the twenty or so project managers I consider among the most effective I have seen have had important traits in common. Without exception, they were capable, respected, and charismatic. Here are some examples from my experience and observations that show why these traits matter.

Being Capable

In addition to being at least reasonably well-organized, the capable project manager is knowledgeable, decisive, persistent, and a good risk manager.

The PM must understand all aspects of the project, its goals, requirements, challenges, and risks. That is not to say that she must be an expert in every area. Rather, she needs to have a broad understanding of the technical subsystems involved in order to understand their functions, interfaces, and risks. She must be sufficiently *knowledgeable* about technical aspects, financial management, and scheduling to ask the right questions, evaluate the risks, and make valid trade-offs and decisions. Virtually all the effective aerospace PMs I have known have considerable expertise in at least one technical area, most often the area in which they worked prior to becoming a PM or an area in which they previously resolved a major problem. Most PMs will admit that, from early in their careers, they were interested in the broader picture of the entire spacecraft, launch vehicle, or system and not only in their particular field of expertise. This desire to understand the overall system serves the project manager well. The effective PM is a fast learner who can quickly gather enough information about any system to be able to make prompt and reasonable decisions in response to challenges or problems.

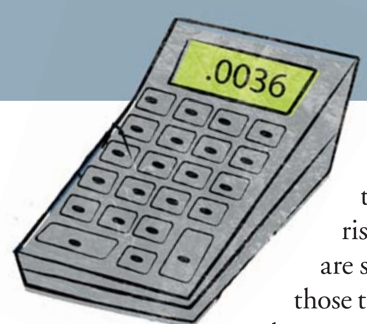
Secondly, the effective PM must be *decisive*. One of the most effective PMs in my experience often said, "There is no such hing as a bad decision, except one which is not nade promptly. The important thing is to make the decision and move on. If it is not the best course of action, that will soon become obvious and then another decision must be made to change direction."

Unless there is more relevant information pending, a test to be completed, or another credible opinion to be solicited, delaying a decision has only disadvantages. Many decisions involve choosing the best among two or more options. Often the very fact that the decision comes to the PM indicates that all the options are feasible and none will be catastrophic. Some of the most difficult decisions involve contractors who are not performing well. In those cases, the PM must lead the effort to fix the problem. If working with the contractor's team and its management to improve the situation is not successful, then key people need to be changed or the contract terminated and the work transferred elsewhere.

Early in my career as a director, I was involved in the decision to terminate a major contractor on an important project whose primary source of profit was its work on classified programs. The contractor personnel assigned to our project were mostly new hires who had not yet received security clearances. Once their clearances came through, the better performers would be quickly transferred to a classified project and replaced on our team by another inexperienced person who needed to be trained. Terminating this contractor was a big decision but the right one because we could not be confident that the contractor's assigned team could do the job. Delaying the decision would only have harmed the project. Several of the contractor's vice presidents visited us and pleaded for one more chance. It was too late.

Any decision is likely to be questioned and challenged, but even questions from well-meaning, dedicated stakeholders should be raised and resolved before a decision is made. Afterward, it is important for all parties to accept the decision and for the PM to remain firm and not second-guess himself. Good ideas always arise during a project that would make it better—more reliable, more capable, more robust—but, as has often been said, "better is the enemy of good enough." The PM

THERE IS NO SUCH THING AS A BAD DECISION, EXCEPT ONE WHICH IS NOT MADE PROMPTLY. THE IMPORTANT THING IS TO MAKE THE DECISION AND MOVE ON. IF IT IS NOT THE BEST COURSE OF ACTION, THAT WILL SOON BECOME OBVIOUS AND THEN ANOTHER DECISION MUST BE MADE TO CHANGE DIRECTION.



must hold the line on requirements and keep the work moving forward on the accepted design.

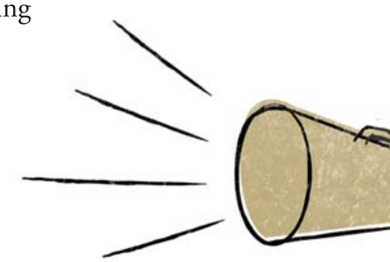
During development of one of the Great Observatories, it became obvious that a filter on one of the major instruments had partially delaminated during ground testing. The science community wanted to remove the instrument from its cryogenic container, replace the damaged filter, reinstall the instrument, and retest the observatory. After determining that the instrument could meet all its requirements in its existing condition and that the filter replacement would cost around $50 million and cause a six-month launch delay, the project manager stood firm and obtained Headquarters' approval of his decision to launch with the degraded filter. Excellent performance after launch confirmed the decision as correct.

Often, an effective PM must be *persistent*. One project I directed for a number of years required extraordinary persistence on the part of the PM who reported to me. Every year, NASA zeroed the budget for the half-billion-dollar technology project. Just as reliably (although not quickly enough), Congress reinstated the funds needed for the next fiscal year. Every year, the project was in limbo. By expressing his optimism and confidence that the money would be forthcoming, the PM managed to keep his team in place, motivated, and enthusiastic. Each year, he would ensure that enough funds remained from the previous fiscal year to allow the work to proceed, albeit at a reduced level, during the months of uncertainty. The launch date slipped a number of years as a result, but eventually the project met its cost cap, flew, far outlived its planned lifetime, and succeeded beyond expectations.

An effective PM is also a *risk manager*. I have heard good project managers say that project management is nothing more than risk management. All projects involve risk. Many of them—often technical risks due to the use of unproven technology or a technology in a new application or environment—can be identified early. Insufficient reserves and major technical problems cause financial and schedule risk. Weakness or a key vacancy in the project team are sources of risk. The hardest risks to deal with are those that are unknown at the start of the project; when they eventually do become apparent, there is little time to understand and mitigate them. An effective project manager will identify, plan for, and mitigate risk in all areas. The risks must be tracked, reported, and addressed on a continual basis throughout the project. Brainstorming among the project team is often effective in identifying mitigation steps.

Being Respected

Unless most of the people comprising a team respect the project manager, he will have a difficult time motivating the kind of coordinated and cooperative effort needed to achieve success. To be respected, a project manager must be capable, but there is more to earning respect than competence.



After hearing a former supervisor address a NASA Project Manager training session, I remember telling some of my classmates, "I would follow him anywhere." He knew his project, its challenges, and its goals and had a clear vision of how to accomplish them. He was enthusiastic about its eventual success but realistic in evaluating the challenges that stood in the way of achieving it. He was convinced it was a valuable undertaking and that he could lead the effort to make it happen. He inspired his team and made each individual proud to be included. And he respected his team members.

Respect is reciprocal. A project manager who desires respect from his team must treat team members fairly and with respect. That does not mean always agreeing with them. It means being willing to listen to what each stakeholder has to say, honestly

THE HARDEST RISKS TO DEAL WITH ARE THOSE THAT ARE UNKNOWN AT THE START OF THE PROJECT; WHEN THEY EVENTUALLY DO BECOME APPARENT, THERE IS LITTLE TIME TO UNDERSTAND AND MITIGATE THEM. AN EFFECTIVE PROJECT MANAGER WILL IDENTIFY, PLAN FOR, AND MITIGATE RISK IN ALL AREAS.

considering that input in making his decision, and then conveying his reasons for choosing the selected approach. A person whose ideas are sometimes rejected but who knows that he has been heard and has been treated fairly will continue to respect the decision maker and perform well.

Being Charismatic

Webster defines charisma as "a special, inspiring quality of leadership." A charismatic project manager makes the team not only willing but excited to have her as its leader. Some elements of charisma are hard to define, but others are fairly clear. Probably the most important trait contributing to a PM's charisma is being a *good communicator*. As the spokesperson for the project, she must be able to articulate her position, decisions, and expectations. It is critical for a PM to be able to communicate clearly, succinctly, persuasively, and openly.

A *positive (but realistic) attitude* is also important. NASA is known as a "can do" organization, and the history of NASA is rich with examples of successful outcomes of projects that faced daunting challenges.

In the first months after discovering the spherical aberration in the lens of the Hubble Space Telescope, it was difficult to feel positive about the likelihood of recovering planned performance. But the PM assigned to lead preparations for the repair mission was greatly respected based on his leadership of a previous successful in-space repair mission. He eloquently communicated his certainty that such a mission would succeed. He expressed nothing but full confidence in his team members and their abilities. He encouraged a broad solicitation of ideas on how to approach the task and led the effort to carry out the selected approach. The flawless repair mission resulted in better-than-design performance and the most productive telescope in the history of mankind.

Last, but probably not least, most of the many effective PMs I have known have had a *sense of humor*. All projects are challenging and face low points. Being able to step back, take a broad perspective, and share a laugh with the rest of the team is important. If a project is fun to work on, the team's enthusiasm and performance will reflect that, to the benefit of the overall effort.

Part way through a two-stage launch vehicle project, someone from another part of the managing center was assigned as project manager. He was a virtual unknown to the team and some members doubted his ability to lead the project. When a critical decision was required and the participants were clearly grim and doubtful, the new PM would ask, "Now tell me again, which of the stages goes on top?" That would invariably break the tension and lead to substantive discussion and a decision. Within a very short time, the team felt comfortable with the new PM and worked hard to help him succeed.

The Complete Project Manager

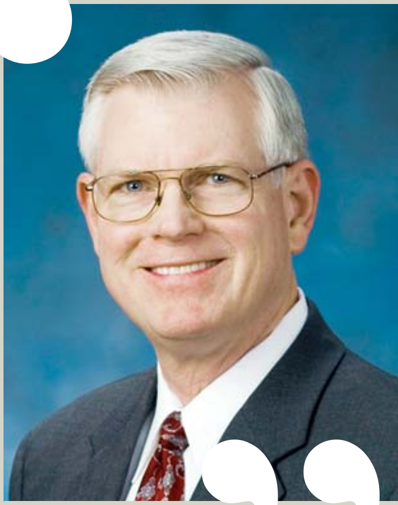
I have described a broad and impressive range of traits that make some project managers especially capable, respected, and charismatic. Not all successful project managers possess all those qualities and abilities in equal measure, but the challenge and complexity of most NASA projects requires their managers to call on most of them in the course of their work. That is why effective project management is so demanding and why it is important to observe the best project managers in action and learn from their examples. ●

VERN WEYERS spent 35 years with NASA at Lewis (now Glenn), Headquarters, and Goddard. He was Director of Flight Projects at Goddard during the Hubble Space Telescope repair mission, launch of the GOES-I weather satellite, and numerous other flight projects.

INTERVIEW WITH

Michael Coats

BY DON COHEN



Former astronaut Michael Coats joined NASA in 1984 and flew three shuttle missions before leaving the Agency for Lockheed Martin in 1991. He was appointed Center Director of Johnson Space Center in November 2005. He talked with Don Cohen in February 2006.

COHEN: Johnson has major responsibility for the Crew Exploration Vehicle [CEV] and related work. What is your role in making these things happen?

COATS: Our first priority is to fly out the shuttle safely. When that last one rolls to a stop, I'll feel good if I can look back and say I had something to do with that. Operating the space station is important to us. We'd like to finish building it and start the real science with a much larger crew up there. Now we're starting the Constellation program, which is the future of NASA. The exploration program is exciting for us because for the first time in maybe forty-five years we've got clear direction from the president and administration and Congress about where we're trying to go. Just to know that we need to go back to the Moon and learn to use it as a test bed to get ready to go to Mars is exciting. My job at the Johnson Space Center is to make sure that we—3,000-plus civil servants and 10,000 contractors—can support the programs here and learn from each other. I hate the word "synergy," but that's what we're looking for. How do we take lessons learned from the shuttle and station and forty-five years of experience and apply it to Constellation?

COHEN: How do you make sure people learn what they need to know from the people who have important knowledge?

“WHEN YOU’VE BEEN up there, YOU START thinking MORE LIKE A member of the human race THAN AN AMERICAN…”

COATS: One big challenge is making sure that the experience that we have accumulated doesn’t walk out the door as people retire. Fortunately, the people who have worked in this business for decades love it. I’ve had most of the former center directors in here so I can pick their brains. Every one of them is dedicated to the space program and proud of what’s been accomplished. They’ve had very productive and satisfying careers. Starting from scratch and landing people on the Moon in eight years—the blink of an eye—was amazing. And they had no infrastructure. They had an open checkbook, but they had to invent everything as they went along.

COHEN: **Their Apollo experience is going to be useful for the CEV.**

COATS: Mike Griffin calls the CEV “Apollo on steroids.” We’re taking the lessons learned from Apollo as well as the Soyuz program and applying them along with our operational experience on the shuttle and the station. I need the shuttle folks to work on the shuttle right up to the last flight, but I also need to draw on their experience as we design and build the CEV. So I’m going to co-locate those folks. My support organizations, like finance and procurement, are going to support both programs so that they’re married as much as possible. We’ve also got a fantastic mentoring program here with over 400 mentors and 600 protégés signed up over the last couple of years. It’s working very well.

COHEN: **The mentors are actively engaged in program work as well as mentoring?**

COATS: Yes, they’ve got their regular jobs. We send them through some training so they know what to expect. I’ve got people who are both mentors and protégés. Contractors are doing the same thing. The whole aerospace industry is getting pretty senior, so we’re worried about the knowledge walking out the door.

COHEN: **My sense is that mentoring usually works better than documents at passing on that knowledge.**

COATS: One frustration is that we do a good job of documenting lessons learned—we’ve developed fantastic books of lessons learned that we put on a shelf, and no one uses.

COHEN: That's an almost universal story in organizations; it's easier to collect information than have people use those documents.

COATS: And they tend to disappear over time. I lived through the Challenger tragedy. We learned a lot then and tried to document it, but after Columbia folks had a hard time finding that information. We're trying to figure out a way to make sure that the final reports on the Columbia accident will be readily accessible to somebody down the line—hopefully a lot of years down the line. With the Internet, all you need to do is Google a few words and print out all the information you want. We ought to have a similar database available for the space program, but how you go back and capture what was done for the last forty-five years is a challenge. If you're an engineer designing a reaction control system for the CEV or the lunar lander, wouldn't it be nice to type in "reaction control systems" and call up the history of all the space programs, including Russian vehicles, so you don't have to reinvent the wheel? It breaks my heart that something like the Apollo fire happened to the Russians several years before it happened to us. It would have been good to learn those lessons before we paid such a steep price.

COHEN: You can capture important data in a system, but what about the subtler stuff that maybe mentoring and experience teach more effectively?

COATS: I think both government and industry do a good job of training and educating people through formal programs. The government has excellent program management classes, but we don't do as good a job making sure they have the breadth of experience they need to step into a program-managing job. If a person is in engineering or operations or safety or finances, they tend to spend their career there. There's nothing wrong with an engineer who just wants to be an engineer, but he shouldn't be a program manager. But if they're successful and talented, we say, "This guy is a shooting star!" and make him a program manager. Program managers need to understand all the disciplines and challenges they are going to face. We want to identify people who have the inclination and desire to move back and forth between programs, and we need to do a better job of rotating people around to get the breadth of experience they need to speak the language of each of the disciplines. Ninety percent of any job is knowing the right questions to ask at the right time and how to ask them. You need to read between the lines of what people tell you. You need to know about the potholes in the road. That comes from experience.

COHEN: How has your astronaut experience affected the way you see the challenges ahead?

COATS: Everybody that's flown in space looks back at the Earth and realizes what a tiny little spaceship Earth we have. One of my strongest impressions when I got up there on my first shuttle mission was, "Holy cow, it's a little bitty Earth; it's beautiful, and it's going through a great big black void of nothing." We'll explore, but billions of people will never leave the Earth, so we've got to learn to take care of it. When you've been up there, you start thinking more like a member of the human race than an American or Texan, which means you've got a lot in common with other people who have worked in this business. I believe any big venture in the future will be international. The space station is setting the precedent. Space is expensive; it's better to share that cost. It's also a tremendous way to open up communications between countries. Communication between scientists, engineers, astronauts, and cosmonauts can be a foundation for countries working together. Even during the cold war we shared information with the Russians and their program—a lot of medical information, for instance. Right now, India and China are producing many times the scientists and engineers than we are, but the space program is one area that attracts young people into thinking about math and science. The kids in the national technical honor society group I talked to last night are excited about the exploration program. I also talked about nanotechnology that will have a tremendous impact on our lives. If I have a frustration in life, it's that I can only expect to live another twenty to twenty-five years, and I want to live longer so I can see this stuff we'll discover. I told the kids last night that I envy every one of them. I said, "You were born at a great time. You're going to see things that we can't even imagine."

COHEN: Is the Constellation work going to involve all the NASA centers?

COATS: We have to use all the strengths of the NASA team wherever they are. I would like Johnson Space Center to lead the team as much as possible. I want the first word to be spoken from the surface of Mars to be "Houston" just like it was from the surface of the Moon. To make that happen, we've got a lot of work to do. We've got to get expertise and team up with the expertise we don't have, because missions to Mars are going to be deep-space operations involving robotics as well as humans. We don't have that deep-space and robotics expertise, JPL [Jet Propulsion Laboratory] does. I've been working with Charles Elachi out there. We obviously work very closely with Marshall and Kennedy. We need to continue to build on that, but we also need to take advantage of the strengths of Ames and Langley and Glenn. I agree with Mike Griffin: to be a strong Agency, we need ten healthy centers. Four centers have focused primarily on aeronautics work, but the budget is not there for aeronautics. We need to help those centers keep the aeronautics work alive but also need to keep them strong helping us with space flight. We have to find the work packages that can move to the centers that are hurting right now to make them healthy. We are challenged to do long-term, self-sustaining human space flight, which we've never done before. The furthest we've ever been from mother Earth is two and a half days. Now we're talking about two and a half years. When you fire those engines to head off to Mars, you're on your own and you're not turning around. How can you be truly self-sustaining? How do you recycle everything that can be recycled? How do you take along the pharmacology you might need? How do you protect from radiation? There are a lot of medical questions that need to be answered, and we've got a lot of work to do before we're ready to be truly self-sustaining.

COHEN: So there's a lot of need for communication and coordination among centers.

COATS: Mike has a monthly senior management council where all the center directors and associate administrators get together. We move it around to different centers, so we see each other face to face at least once a month. I'm still a believer in meeting face to face on a regular basis. Communication is about ten percent verbal and the rest is body language. I knew most of the center directors already.

COHEN: Are there other aspects of your astronaut experience that are especially useful now?

COATS: I've seen the science side of NASA as well as the operation space flight side, so I hope I've got a balance, but I look at things from an operator's point of view. How can we design our vehicles, robotic or human, to be operator friendly? I think that's especially important when we're talking about longer and longer flights. Mass is always going to be a challenge; having to lift everything out of Earth's gravity well is expensive. How can we design a vehicle that's as efficient, lightweight, safe, and operator-friendly as we need? I'm interested in how to design a spacecraft that is both functional and comfortable for the crews that are going to spend a long time on them. I have an appreciation from my shuttle flights, which were only seven or eight days long, of what's important when you're trying to live and work in that environment. And part of the operator's mentality is always thinking, what's my backup, what's my out? It's a way of thinking you develop as a military pilot, a test pilot, and an astronaut. As you're flying airplanes, you're always thinking, if the engine quits, where am I landing? You do it automatically. We've got to keep that in mind as we're designing the series of vehicles we're going to need for Constellation. How can we make them as safe as we can afford to make them? That's the operational mentality at work. Different perspectives are important. I learned to respect scientists, engineers, and medical doctors who have a different way of thinking, but we astronauts had to teach them to think operationally. You'd ask a scientist, "How long is it going to take you to perform this procedure with the mechanical arm?" "Oh, twenty minutes," they would say. Then we would say, "How about two hours?" We knew it takes a while to do things.

COHEN: I think in the Mercury and Apollo days there was a good bit of friction between pilots, engineers, and scientists.

COATS: Healthy tension is good. You need debate. Somebody may say, "That's stupid, you ought to do it this way." Then you think, we can do it even better this other way. I've seen it happen many times. It's beautiful to watch; you come

I'M STILL a believer IN MEETING face to face ON A REGULAR BASIS. Communication IS ABOUT TEN PERCENT VERBAL and the rest IS BODY LANGUAGE.

up with some elegant solutions when you have the openness and freedom to say, "That's really stupid."

COHEN: Have you had any surprises in the months you've been center director?

COATS: Surprise may not be the right word, but I've been impressed by how much talent and dedication there is.

COHEN: I'm struck by how positive people are about working for NASA.

COATS: In the space business, you have tremendous highs and tremendous lows. When a mission succeeds, whether it's the shuttle or a crew coming back from the station, or Stardust, everyone is on cloud nine. You work for years to pull off something challenging and you do. It makes you feel you've done something special in this world. On the other hand, when we have a Columbia, it doesn't get any worse than that. It's never, never boring. People love working here. When I ask a question or say I'd like to research a certain area, people make things happen, to the point where I've got to be careful about thinking out loud.

COHEN: What kinds of things are they researching?

COATS: I've asked them to do some long-term planning. In the government, we have a five-year plan and nobody looks past that. Now that we've got direction about where we're going to be going for the next twenty-five, thirty, or fifty years, we need to do long-term planning to understand what facilities, core competencies, and skills we'll need.

COHEN: There's a real contrast between the excitement within NASA about Constellation and some of the public who are complaining that the Agency is doing the same old thing over again.

COATS: I think the public is so unaware of what we're doing, they don't even know what questions to ask. The results of focus groups we've conducted were depressing. We asked people what they think of the space program; the answer is, they don't. Not one person had heard about exploration. After we told them about it, they thought it was great. At NASA, we live in our own little world. Occasionally we make headlines, but the general public doesn't know what we do. The Space Act of 1958 requires us to disseminate information on our activities to the general public, but we don't do it well.

COHEN: Do you see a lack of public understanding of the grand plans and the achievements that benefit people directly?

COATS: We've got partnerships with medical institutions for medical research we need for long-term space flights—research on bone loss, radiation, early diagnostics. I try to use medical examples when I'm talking to the public because everybody has got someone in the family who has osteoporosis or cancer. I'll say, how many of you have had Lasik eye surgery? Maybe half raise their hands. I say, "You're welcome. We use NASA's tracking to develop that technology." We're doing a lot of things for bone loss that applies to the general public. The list of direct applications is huge. We've got to make the public aware that they're getting something for their space dollar. You can argue all day long about whether we should be going to the Moon and Mars. All I want is a chance to discuss it, because John Q. Public doesn't know what we do.

Stardust

The Rewards of Commitment, Care, and Communication

BY KEN ATKINS

Stardust Capsule Return as seen from NASA's DC-8 Airborne Laboratory with a mission to explore the conditions during re-entry from the light emitted by the fireball caused when the capsule streaked through the sky. The aircraft was located near the end of the trajectory, just outside the Utah Test and Training Range.

Photo by NASA/Ames Research Center

In the wee hours of Sunday morning, January 15, 2006, a 105-lb. entry vehicle carrying samples of dust from comet Wild 2 and interstellar particles from outside our solar system whizzed into our atmosphere at 29,000 mph. It had been on a seven-year, three-billion-mile odyssey around our solar system and, on the way, had punched through the comet's dust cloud at about 13,000 mph, just 149 miles above the jagged surface, its tennis-racket-sized Aerogel array collecting dust from the particle stream. This carrier-capsule combo had flown halfway to Jupiter, more than 250,000,000 miles from the sun, with electrical systems powered only by sunlight. Over the course from Earth to comet and back, Stardust performed thirty-seven thrusting maneuvers for calibrations and trajectory corrections.

Of course, there had been problems on the way. Fault protection software placed the spacecraft into "safe mode" ten times and nearly forty-two software patches were transmitted and installed to handle needed repairs and upgrades. The most spectacular safing occurred when a massive solar flare hit the spacecraft on November 8, 2000, "confusing" the star cameras and causing the computers to reboot five times in approximately six minutes, eventually taking the ship all the way to terminal safe mode. However, the machine was performing as planned, and the flight team patiently waited until the storm passed and then commanded a recovery to full flight capability, still on course for its January 15, 2006, delivery.

The parachute-deployment failure Genesis suffered led us to reconfirm that Stardust's deployment system had been adequately tested and did not share the Genesis design flaw. Even so, the team planned and trained for unlikely but possible return and recovery contingencies.

Sources of Success

Looking back across ten years, this long, technically and organizationally challenging project had succeeded brilliantly. I attribute its success to the unifying power of an inspiring goal, an effective results-driven organizing structure, and clear and open communication.

Stardust's inspiring goal unified the team and helped even the grumpiest of us get beyond disagreements instead of letting technical issues, schedule, or cost—those three horses of project apocalypse—get out of control. Members shared a commitment to control all three to achieve the goal everyone relished explaining to friends, families, and anyone who would listen. Pursuit of that goal made people selfless. Engineers worked hard in their own subsystems to conserve reserves for others. Principal Investigator Don Brownlee was a master at conveying his enthusiasm for getting at comets, those ghosts of the solar system. I'd known Don and many of his colleagues from my early days at Jet Propulsion Laboratory (JPL), when we worked together to try and get a U.S mission to fly to comet Halley. He was an excellent "missionary" for this adventure. With an engineering degree supplementing his scientific résumé, he understood what engineers could and could not do. Together we became cheerleaders for our team.

In large measure, I credit the NASA Discovery Program Manager, Mark Saunders, and his selection criteria for Discovery 4 with creating the foundation for a results-driven action structure that didn't force me to be the budget bad guy (and force others to hide bad news). In fact, I was able to release reserves to preemptively counter threats and risk. Looking for ways to attack risk before it attacked us, we spent about a million dollars on risk-reduction before launch. Nothing earns trust like being able to go to the people in the trenches and say, "How about if we add some money to your cost account so you have a higher probability of making those milestones at high quality?"

A host of team players orchestrated the action structure to get the job done with focus and efficiency. In development, Rick Grammier, our Project Engineer (who moved on after launch to manage Deep Impact) led a strong systems-oriented group to document all our processes, sweep for risks, and get our flight system produced, tested, and delivered to a successful launch in February 1999.

None of this would have happened without effective communication. Clear communication translates to a high-performing team. It is true that knowledge is power, but only if that knowledge is fully shared.

Openness builds a culture of trust and counters the "us versus them" attitude organizations trying to work together often fall prey to. In addition to providing an accurate measure of where we stood, our performance management system and earned-value metrics shed "sunlight" on facts. Rick's team used an innovative virtual meeting structure, engineered by JPL's Lori Carr and her information technology counterparts at Lockheed Martin Space Systems (LMSS), that included the phone network (including the just emerging, but still "iffy" cellular phone), collaborative servers for near-real-time data access, pagers to summon folks to the network, and secretaries and administrative people who could, as a last resort, quickly track them down to ensure communications were timely and decisions were made and logged without delay. I remember attendees calling into the meetings using seat-back phones on commercial airliners, presentations being made from phone booths, and timely technical answers provided by cellular phone from a car en route to LMSS's Denver plant. The language was goal-directed, not ego-driven or rules-driven. Everybody wanted to know what was happening. Data were open and available. And "What do you think?" was a common inclusive query to keep everyone contributing. I relied on General Bill Creech's insight, in *The Five Pillars of TQM*, that a key communication ingredient is *listening*. He says, "Listen for the echoes to learn if it's all getting through."

IT IS TRUE THAT KNOWLEDGE IS POWER, BUT ONLY IF THAT KNOWLEDGE IS FULLY SHARED.

The Moment of Truth

The Stardust team was flooded with emotion Saturday evening, January 14, 2006, as we realized that the final flight chapter of our ten-year effort was about to begin. I was confident in our team and their work, but there are always unknowns. No vehicle had ever entered the atmosphere as fast as the Stardust sample return capsule. It had a new (in 1997) high-technology heat shield. The chute system had never been operationally used, since Genesis's did not deploy. The recovery team might have a challenge in finding the small capsule if the beacon on the chute risers didn't work or if weather kept the helicopters from flying.

At four hours before atmosphere entry, Stardust successfully "dropped" the sample return capsule right on schedule and, fifteen minutes later, maneuvered to avoid following it into the atmospheric cauldron. My successor, Tom Duxbury, Flight Phase Project Manager, and his Flight and Recovery Team at LMSS, JPL, and the Utah Test and Training Range had done a superb job of flying the spacecraft the Development Team turned over to them almost seven years ago.

Everything went our way: weather clearing so the helicopters could fly, entry at 400,000 feet and 29,000 mph, pick-up by the radars, excellent navigation predictions on touchdown point and time. Then the moment of truth when the small drogue chute was to deploy at mach 1.4 and 105,000 feet. Bingo! Exactly on time, the small, white blip on the infrared tracking jumped upward off the screen. The drogue had deployed to stabilize the capsule through the transonic zone and prevent tumbling. The tracking camera reacquired the white blip of the capsule, and it glowed steadily, without the blinking that would indicate tumbling. Everyone erupted in joy as drogue deployment was confirmed.

Then, standing in anticipation, we waited for the 10,000-foot mark where the main chute would deploy as the drogue was jettisoned. We were euphoric as the call came confirming we were on the main chute, and we could see the ghostly black-and-white image of the 27-foot canopy's reflectors and the tiny sample return capsule swinging below. It was floating down almost exactly as depicted in the pre-launch animation film I'd shown a thousand

LEFT: The Stardust sample return capsule was transported by helicopter from its landing site at the U.S. Air Force Utah Test and Training Range. This image shows the return capsule inside a protective covering.

RIGHT: The aerogel dust collector, an instrument aboard the Stardust spacecraft.

Photo by NASA

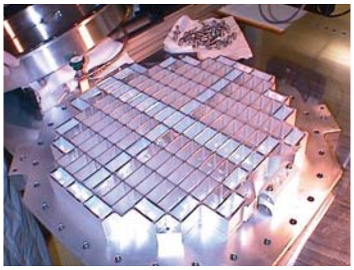


Photo by NASA/JPL

times in presentations I'd given. The pick-up helicopters locked on to the beacon. Touchdown was at nine mph and two minutes early, only four miles northeast of the target landing point due to wind drift. My feelings? Indescribable joy: gratitude for the first-class engineering team from Lockheed-Martin Astronautics that produced and flew the spacecraft and Boeing's tried-and-true Delta II team that blasted us off the Earth February 7, 1999; awe at the skills of the JPL navigators, the operators of the deep-space tracking network, and the recovery team of the Air Force and LMSS in Utah; and giddiness that Don Brownlee and his science team—and eventually teams from all over the world—would indeed get their hands on primeval material unchanged over 4.5 billion years.

There had been many moments in Stardust's ten years when the abyss seemed to open and design issues, scope pressures, test failures, parts, cash flow, contract issues, personal conflicts, unknowns, and loss of signal threatened to end the project. But commitment to the goal, trust, communication, and a results-driven action structure gave us a robust ship that sailed the sea of space, captured the treasure, and returned home to tell the tale. ●

"More Kudos"

Tom Duxbury, the Mission Design and Engineering Manager who took over as Project Manager during the Flight Phase with Ed Hirst and Bob Ryan of JPL, and Joe Vellinga, Allan Cheuvront, and Mike McGee from LMSS put together a Flight and Recovery Team that did a brilliant job of piloting Stardust through three billion miles of adventure to a perfect touchdown. Tom and his team became masters of patience as they flew Stardust through tense times when its signal "disappeared." However, the ship always "called home," and they ultimately trusted that the spacecraft would perform exactly as planned.

Joe Vellinga, our LMSS manager for development and flight, ensured that the flight system met "design-to-cost, test as you fly, fly as you test" goals. With Rick Wanner, our LMSS Assembly, Test, and Launch Ops Manager, Joe fostered the open and selfless engineering that built trust between LMSS and the team at JPL.

Finally, the Project Control Team ensured discipline through the performance management system with a fast, honest collection of earned-value data. They quickly turned data into metrics on receivables, deliverables, events completed, and, most importantly, reserves on cost-to-go. Bredt Martin, Ralph Bartera, and Walt Boyd of JPL teamed with Rick Price, Brian Overman, and their LMSS EV specialists in an open file-sharing approach to earned-value management (EVM) that had enough discipline to be timely and to maintain baseline and data integrity without the unnecessary restrictions typical of a tri-service-validated system. Operationally, all significant variances were investigated by the team and then addressed by the cost-account owners as necessary to explain variations. This tailored approach to EVM made it a legitimate tool to keep the apocalyptic horses in harness. We got a valuable, trustworthy indicator of performance against the baseline plan. While EVM is not applicable to flight phase activity, the cultural discipline from the development phase transferred to Duxbury and Vellinga's Flight Team with excellent results. Stardust achieved a solid reputation for meeting its technical, cost, and schedule commitments.

From June 1995 to August 2000, **KEN ATKINS** was manager of NASA's Stardust Project. He retired from NASA/Caltech's Jet Propulsion Laboratory (JPL) in February 2002 after 32 years. As a retiree, he works part time providing mentoring and education for JPL project managers. Before joining JPL in 1969, he served nine years in the U.S. Air Force as an officer and pilot.

GENESIS: Learning from Mistakes

BY KERRY ELLIS

On the morning of September 8, 2004, in a desert in the middle of Utah, two helicopters waited to pluck Genesis gently from the air and return it safely to the ground. When the capsule hurtled into the Earth's atmosphere and crashed into the desert at 193 miles per hour, it was clear something had gone wrong. Genesis's drogue, parachute, and parafoil were supposed to slow the 500-lb. capsule enough to allow the helicopters to capture it. Their failure to deploy was the obvious cause for the hard landing. Discovering the root cause of that failure—*why* those parachutes did not deploy—was what Mike Ryschkewitsch and John Klein set out to do as part of the mishap investigation.

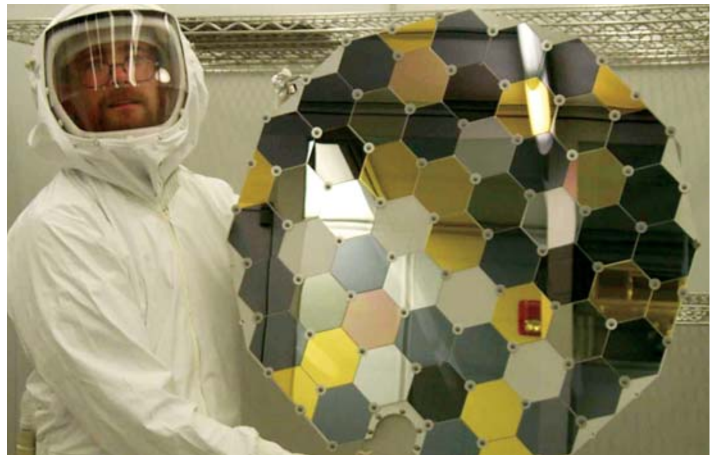


Photo by NASA/JPL

Comet Collector Cell
A scientist holds up the Genesis collector array in a NASA Johnson Space Center cleanroom.

The process of landing Genesis was not a simple one. First, the capsule had to be directed to a tiny spot in Utah, the Utah Testing and Training Range. Then, gravity-switch devices inside the capsule had to sense the braking caused by high-speed entry into Earth's atmosphere and initiate the timing sequence that led to deployment of the drogue parachute and parafoil, approximately nineteen miles above ground. Moments later, when the sample return capsule (SRC) was nearly one and a half miles above ground, a larger rectangular-shaped parafoil—much like a hang glider—would allow the capsule to glide downward at approximately ten miles per hour. The Genesis team had carefully designed, coordinated, and tested the recovery process in order to minimize the risk involved in retrieving the solar-wind samples unscathed and uncontaminated.

After Genesis was recovered and the remnants analyzed, the Mishap Investigation Board discovered that the gravity-switch devices' (or g-switches) installation had been designed incorrectly. The switches flipped, but they were in the wrong position inside the electronic configuration; they could not make the connection needed to start the timing process for parachute deployment. Once the immediate cause for the parachute failure had been identified, Ryschkewitsch and Klein investigated further to discover why the switches had been installed incorrectly.

"You can't just say, 'don't install g-switches upside down,' as a lesson learned from Genesis," said Ryschkewitsch, who was Director of Engineering at Goddard Space Flight Center at the time and chair of the Genesis Mishap Investigation Board. Now Deputy Center Director at Goddard, one of his goals is to share what they discovered about Genesis after its crash and help other projects avoid the same pitfalls. NASA management called together a large group of NASA experts to discover the cause of the mishap.

Many people were surprised when Genesis returned the way it did. The project's design was inherited from Stardust, which had launched successfully in February 1999, two years before Genesis. Stardust's systems had been thoroughly tested, so the problem of drogue deployment evident with Genesis had been unexpected. Those involved with the Stardust project suddenly feared the same problem might happen when Stardust returned a little more than one year after Genesis's arrival.

Upon further investigation, the Mishap Investigation Board discovered that while the design had been inherited from Stardust, it had also been altered. The box that held the g-switches for Genesis was different than the one for Stardust, so the electronics had to be placed in a different configuration to make them fit. The new design for Genesis was analyzed and tested to ensure the switches still flipped, but it was not tested to ensure the switches would start the process for parachute deployment.

"There was confusion around what testing needed to be done and what the tests meant," Ryschkewitsch said. "One part of the team understood that repackaging the electronics meant losing the 'heritage' from Stardust. Other parts never clearly understood that, and it was never clearly communicated between those teams." So when one team verified that the switches did what they were supposed to—which to them meant flipping from one orientation to another—another team thought full testing had been done, ensuring the switches flipped *and* made the correct connections.

This lack of communication and assumption about heritage design are not unique to Genesis. "I hear in proposals all the time that 'I don't have to test because it's heritage,' which is a dangerous thing to say," said Ryschkewitsch. "It's rare you will build something exactly the same way every time. Things aren't coming off a production line at NASA; everything is one of a kind. It's good to reuse hardware, but not to assume it will work the same way every time."

Ryschkewitsch and Klein have been sharing the tough lessons learned from Genesis in a variety of ways. At the time of Genesis's return, several new missions were currently in development at NASA, including Swift, Deep Impact, and New Horizons. "Mike and I have given individual briefings to various

I HEAR IN PROPOSALS ALL THE TIME THAT "I DON'T HAVE TO TEST BECAUSE IT'S HERITAGE," WHICH IS A DANGEROUS THING TO SAY. IT'S RARE YOU WILL BUILD SOMETHING EXACTLY THE SAME WAY EVERY TIME. THINGS AREN'T COMING OFF A PRODUCTION LINE AT NASA; EVERYTHING IS ONE OF A KIND. IT'S GOOD TO REUSE HARDWARE, BUT NOT TO ASSUME IT WILL WORK THE SAME WAY EVERY TIME.

projects in various stages—even before the Mishap Investigation Board report was released—so lessons learned from Genesis are carried on to the new projects," said Klein, who was Manager of Autonomous Spacecraft Division at Jet Propulsion Laboratory during Genesis and is now Deputy Project Manager for the Mars Science Laboratory. "We've also given presentations to new project managers so the lessons learned are incorporated at the beginning of their new projects, such as the proposed Discovery, Scout, and Explorer missions," he added.

They share the lessons learned more broadly as well by having training sessions that discuss in detail the traps Genesis fell into and how to avoid them. These lessons have been shared at systems engineering seminars as well.

In addition, they have been addressing formal changes to NASA processes. Genesis was built during the same time as the Mars '98 failures, so the Genesis recommendations are an amplification and sharpening of the lessons that came from Mars '98. "What it comes down to is making sure you understand requirements, having the requirements written down clearly, and ensuring there is enough dialogue going on between all levels so they all understand what they should be doing and what the risks are," Ryschkewitsch explained.

Evidence of their success in communicating how mission teams can improve their processes and likelihood of success is in Stardust's safe return and landing in January 2006. The lessons from Genesis had an immediate impact on the Stardust team's ability to mitigate and prepare for risk in bringing their sample return capsule home. Though nothing could be done about Stardust's hardware since it was already in space after Genesis crashed, the Stardust team started training early for their capsule's return. They reviewed additional risk scenarios and created emergency action plans that clearly outlined who needed to make decisions and when should a problem occur with the SRC landing.

The Genesis mission has also been labeled a success, despite mistakes made on the project. In April 2005, scientists announced they were able to recover samples intact from Genesis's solar-wind collectors. Scientists will analyze the samples to measure solar-oxygen isotopic composition, the highest-priority measurement objective for Genesis. The data may hold clues to increase understanding about how the solar system formed. ●

Genesis on the Ground
The impact of the Genesis sample return capsule occurred near Granite Peak on a remote portion of the Utah Test and Training Range.

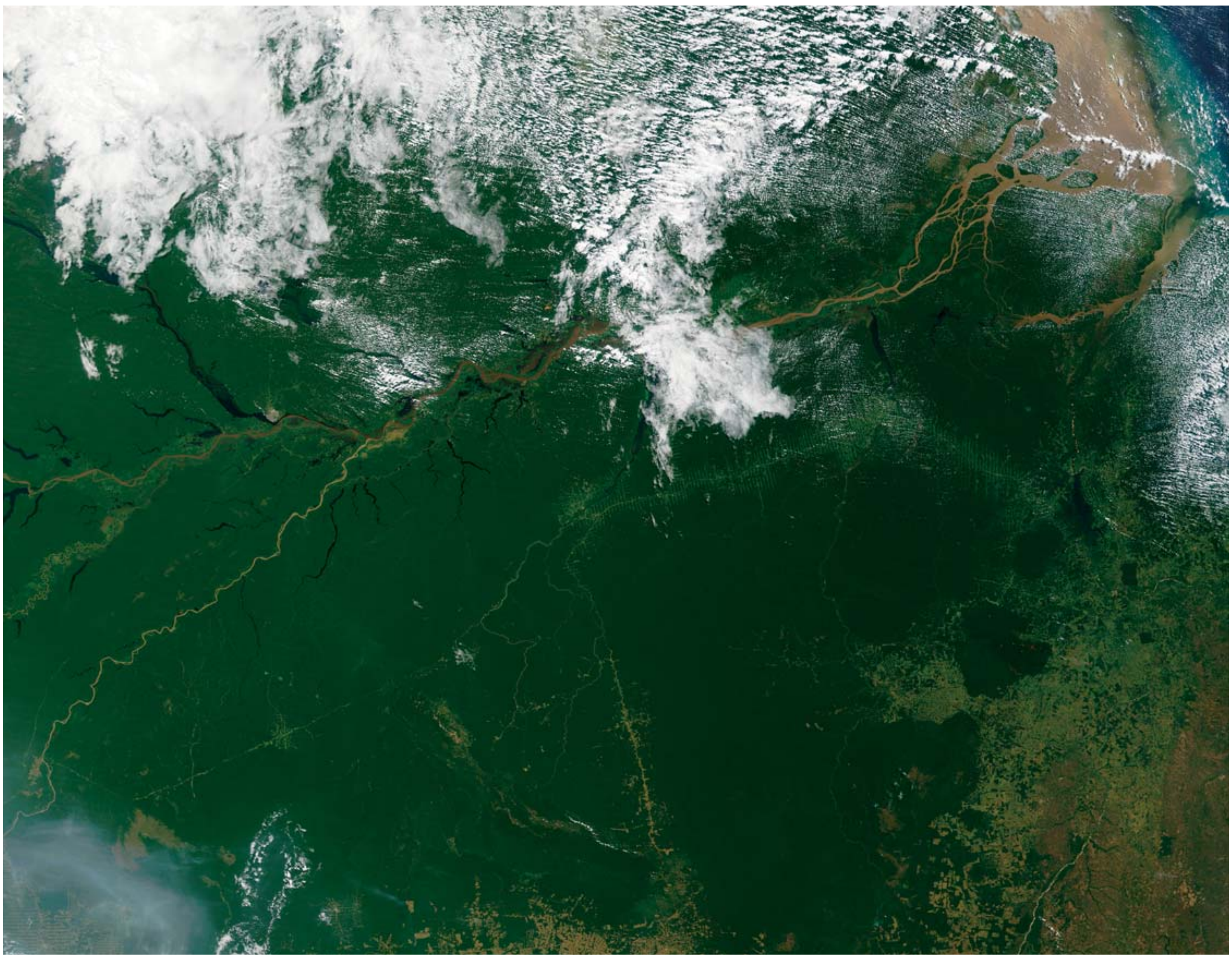
Photo by USAF 388th Range Sqd

The View from Space

BY BEN BRUNEAU AND KERRY ELLIS

NASA's first "blue marble" pictures of our Earth, brought back from a new frontier of exploration, opened a new frontier of imagination and understanding. They have been reproduced again and again because they give us a more vivid image of Earth's beauty, fragility, and oneness than we had ever had before. These and other pictures from space have changed what we knew or had assumed about our planet. In addition to helping us see the world as a whole in a different way, National Aeronautics and Space Administration images provide useful, thought-provoking, and sometimes startling information about many aspects of life on Earth.

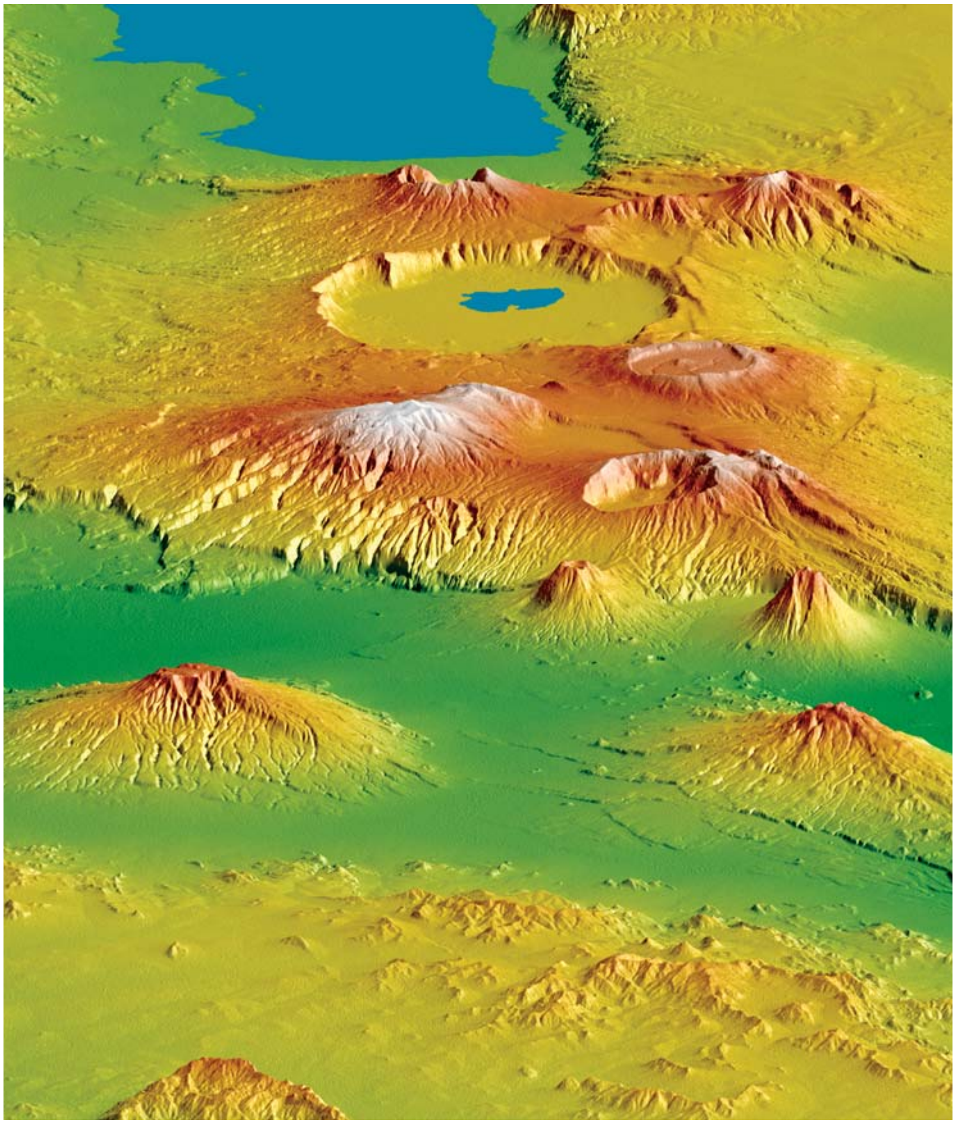
Photographs help us preserve memories, but they also help us shape opinions, make decisions, question what we know, and gain new knowledge. From choosing a hotel room to learning about conditions in other countries, photographs have long been used to teach us about other people, places, and things we may not have experienced directly. And some photographs—like those from NASA—allow us to glimpse things we would never be able to see or imagine for ourselves. Here are a few examples.



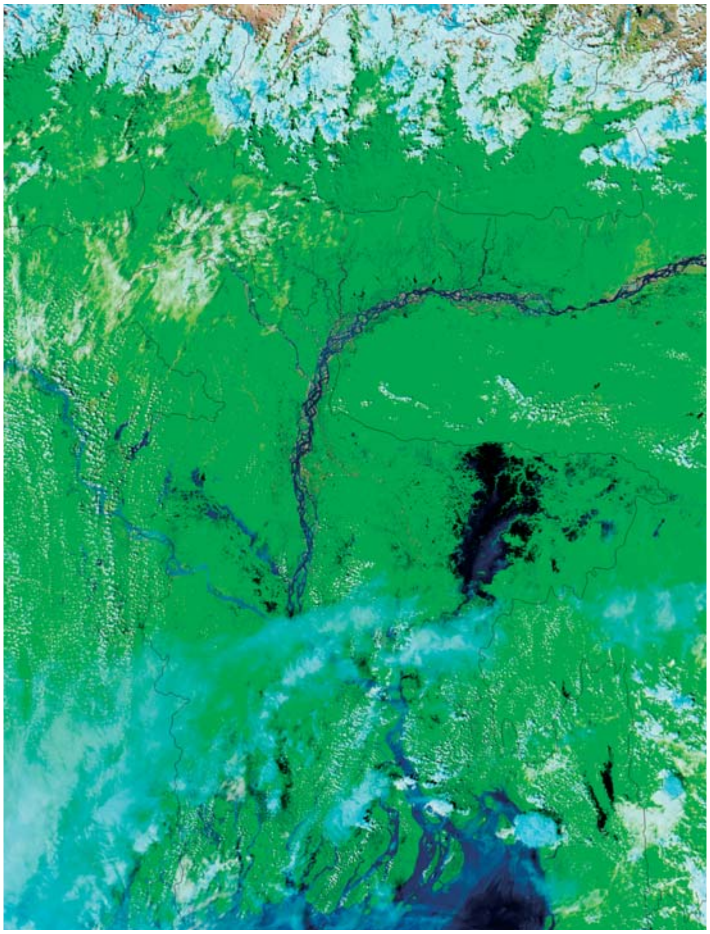
For more than thirty years, scientists have used satellite imagery of the Amazon to seek answers about Earth's diverse ecosystem and the patterns and processes of land cover change.[1] Shown here is the Amazon Rainforest in northern Brazil as captured by the Moderate Resolution Imaging Spectroradiometer (MODIS) on July 1, 2002. At bottom right and bottom center, deforestation and cultivation are evident by the regular, rectangular shapes that delineate plots.

Maps taken from space are invaluable to city planners and state agencies monitoring water quality in urban areas as they provide information about city growth and how rainfall runoff over paved surfaces affects regional water quality.[2] This image, taken by the IKONOS satellite, shows one of the most densely populated cities in the world: Rio de Janeiro, located on the Guanabara Bay in southern Brazil.

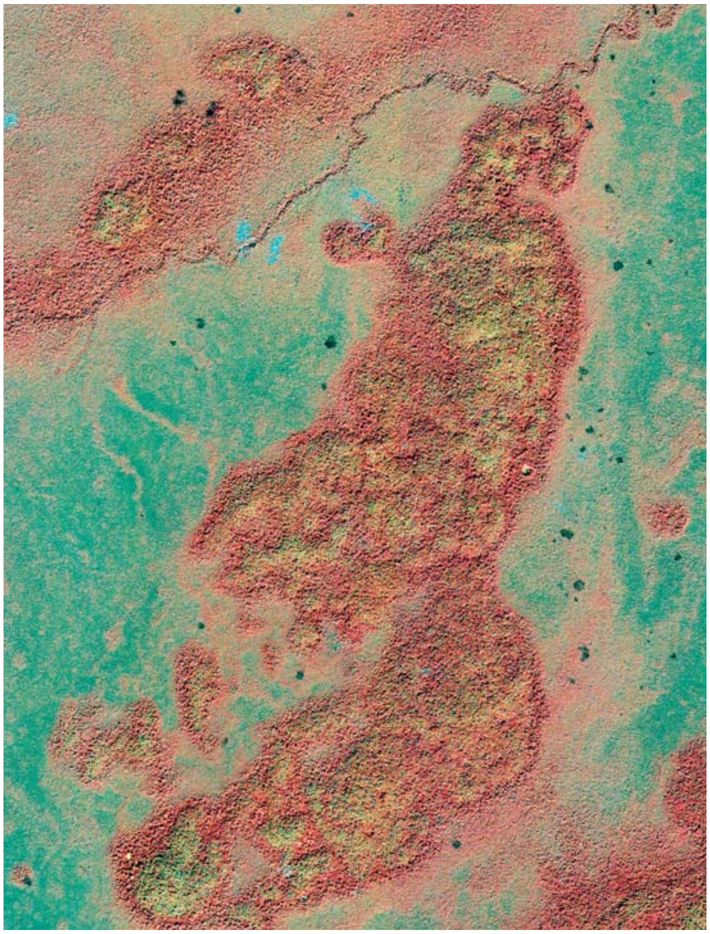
Thanks to radar technology on satellites and shuttles that can penetrate tree canopies, vegetation, clouds, and the dark of night,[3] archaeologists can study the city of Angkor in Cambodia. The Angkor complex is hidden beneath a dense rainforest canopy, making it difficult for researchers on the ground to study the ancient city. The ancient Angkor Wat temple shown here is considered one of the most valuable architectural sites in Asia. Angkor Wat, built by Suryavarman II between 1113 and 1150 AD, is the pinnacle of the city of Angkor, capital of the once-powerful Khmer Empire of Southeast Asia.



The view from space has allowed NASA to map the terrain of Earth, which has important safety implications for the aviation industry; poor visibility combined with uncertainty about terrain causes more than fifty percent of fatal aviation accidents.[4] This view of the Crater Highlands along the East African Rift in Tanzania, obtained from NASA's Shuttle Topography Mission, shows landforms using color and shading. Color indicates height, with lowest elevations in green and highest elevations in white, and shading shows the slope.



Images of Earth provide key data to the U.S. Department of Agriculture Foreign Agricultural Service (FAS), data that can be used to predict the amount of crop damage that might have been caused by natural disasters, such as flooding and volcanic eruptions.[5] In late summer 2002, heavy monsoon rains led to massive flooding in eastern India, Nepal, and Bangladesh. This combined true- and false-color image acquired by the Moderate Resolution Imaging Spectroradiometer (MODIS) aboard NASA's Terra spacecraft shows the extent of this flooding.



On December 15, 2002, IKONOS captured this image of the remains of Mayan structures in Guatemala. In a natural-color image, the changes caused by the ruins would be hard to distinguish from the natural variation in the green forest canopy. The best way to find them is to look at the visible and near-infrared spectra, shown in this false-color photograph. In this type of image, the forest covering the ruin sites appears yellowish, because the Mayan monuments, built from limestone, affected the chemical make-up of the soil as they deteriorated.

1. "NASA Satellite Data Provides Rapid Analysis of Amazon Deforestation," ScienceDaily, September 14, 2005, http://www.sciencedaily.com/releases/2005/09/050914105508.htm.
2. Lynn Chandler and David E. Steitz, "New Satellite Maps Provide Planners Improved Urban Sprawl Insight," NASA News (May 30, 2001).
3. "Archaeologists Dig Space," Jet Propulsion Laboratory Feature Story, January 29, 2001, http://www.jpl.nasa.gov/news/features.cfm?feature=3.
4. Eric Berryman, Carolina Martinez, and David E. Steitz, "Seeing Clearly Now: Sharp New NASA Maps to Improve Lives Everywhere," NASA News (July 11, 2002).
5. Rob Gutro, Mary Rekas, Holli Riebeek, and David E. Steitz, "NASA Satellites Improve Response to Global Agricultural Change," NASA News, January 20, 2004, http://www.nasa.gov/home/hqnews/2004/jan/HQ_04025_agriculture.html.

Featured Invention: Cabin Pressure Monitor

BY CAROL ANNE DUNN

This close-up shows the pager-sized Personal Cabin Pressure Altitude Monitor developed by Jan Zysko, chief of the KSC Spaceport Engineering and Technology directorate's data and electronic systems branch.

For fiscal year 2005, the Inventions and Contributions Board presented 2,917 NASA employees and contractors with more than $1,951,000 in Space Act Awards. In this issue of ASK, *we will focus on the Personal Cabin Pressure Altitude Monitor and Warning System, an invention from Jan Zysko at Kennedy Space Center. The cabin pressure monitor may some day be instrumental in providing a safe environment on small planes and commuter jets where oxygen levels can plunge insidiously and dangerously in a very short time.*

–Roger Forsgren, Director of the Inventions and Contributions Board

When pilot Steve Fossett began his historic, solo, nonstop flights around the world in the Virgin Atlantic GlobalFlyer aircraft on February 28, 2005, and February 8, 2006, an upgraded version of Kennedy Space Center's personal cabin pressure monitor went with him. The device recognizes potentially dangerous or deteriorating cabin pressure conditions and alerts the pilot of the need for supplemental oxygen.

The Personal Cabin Pressure Altitude Monitor and Warning System, which won the NASA Commercial Invention of the Year and Government Invention of the Year awards for 2003, grew out of a project to create a vacuum chamber that would allow astronauts to work in simulated lunar and Mars environments. Jan Zysko, the inventor of the award-winning device, and his team were concerned about air evacuating the chamber while people were still inside. Depressurization of this kind can cause hypoxia, which is a state of oxygen deficiency in the blood, tissues, and cells sufficient to impair functions of the brain and other organs.

Hypoxia is also a concern to flight crews when flying above 10,000 feet because the partial pressure of oxygen—and therefore the oxygen available to breathe—is reduced as altitude increases. The problem is particularly treacherous because oxygen starvation quickly affects the brain, diminishing the ability to recognize and respond to the crisis. Throughout aviation history, there have been numerous incidents where aircraft crewmembers and passengers have been incapacitated by hypoxia.

In fact, two events involving depressurization happened while Zysko's team was investigating how to alert occupants that a "pump down" was occurring in their chamber and revealed the need for a solution elsewhere as well. In June 1997, a cargo craft called Progress collided with the Russian Mir space station, which had three astronauts on board. The cargo craft damaged one of Mir's six modules and caused a loss in air pressure. The crew hurriedly sealed off the module to prevent a further drop in pressure in the rest of the station.

About two years later, in October 1999, a Lear 35 jet veered off course and flew aimlessly until it ran out of fuel and crashed, killing both pilots and all four passengers, including professional golfer and 1999 U.S. Open winner Payne Stewart. U.S. Air Force pilots flying alongside the plane reported that the cockpit windows were obscured by frost, a condition consistent with a loss of pressurization and a subsequent rapid drop of temperature.

After the Payne Stewart accident, Zysko went home for the holidays and began working on a prototype of the cabin pressure monitor in his home shop. "Luckily, I had ordered some transducers to do some other work, but I integrated them into the system just to test the concept and see if we could accurately model the atmosphere with a small, portable device," he said. A transducer is a small mechanism that converts one kind of energy into another, in this case translating atmospheric pressure into voltage. Zysko wanted to see if the transducer could be programmed to indicate depressurization, so he created a prototype that he brought back to work in January.

He proposed using his new project idea as an avenue for exploration in the Multidiscipline Sensors Program, the program he worked under for the atmospheric chamber. His request was approved, and a small amount of program funding was earmarked for his project. Zysko was also able to work with his existing team since his project occurred within the same program.

With funding and a familiar team behind the project, the toughest challenge was ensuring the transducer was accurate over a wide range of pressures and temperatures. Transducers tend to be very temperature sensitive, and the temperature on an airplane can fluctuate depending on ground temperature while sitting on a runway (be it in Alaska or Arizona) and the cooler temperatures at higher altitudes. To test accuracy, the pressure transducers were calibrated in a temperature-controlled environmental chamber. Zysko's team allowed the units to stabilize at a target temperature, then varied and measured the pressure through their desired range, about 1,000 feet below sea level to 45,000 feet above. Their goal was to have the unit accurate to about 100 feet, or one percent, over a typical aircraft's altitude range while varying temperature from about 32 degrees to 110 degrees Fahrenheit.

Before creating a preproduction model for testing, the Applied Technology Office researched cases of depressurization in the aviation industry and contacted the National Safety Transportation Board (NTSB) to hear what that organization thought about the monitor's development and pilots' interest in such an invention. The board responded positively, then asked Zysko's team to visit and speak to one of their accident investigation teams about depressurization. The NTSB team turned out to be investigating the Payne Stewart incident.

With encouragement from the NTSB, Zysko's team created a production model. About the size of a large pager, the Personal Cabin Pressure Altitude Monitor and Warning System operates independently of other aircraft/spacecraft systems and tracks the pressure conditions of the local environment. The monitor warns, by means of audio, vibratory, and visual alarms, of the impending danger of hypoxia when cabin pressure has fallen to preprogrammed threshold levels. A lighted digital screen displays a text message of the warning and specifies the pressurized condition causing the alarm.

Human space operations can also benefit from the innovation in Low-Earth Orbit vehicles such as the space shuttle and space station, as well as long-duration interplanetary vehicles and future planetary habitats. Proposed ground-based applications include the Mars Simulation Chamber and the various pressure/vacuum chambers at NASA's space flight and research centers. Applications in its existing form, beyond aviation and aerospace, include use as an altimeter and thermometer for mountain climbers and as a barometer and thermometer for meteorological measurements. With the selection of a different pressure transducer and software modification, the device could be used to track the pressure, depth, and time profiles in human-tended underwater habitats and hyperbaric chambers.

Photo by NASA

Jan Zysko (left) and Rich Mizell (right) test a Personal Cabin Pressure Altitude Monitor in an altitude chamber at Tyndall Air Force Base in Florida.

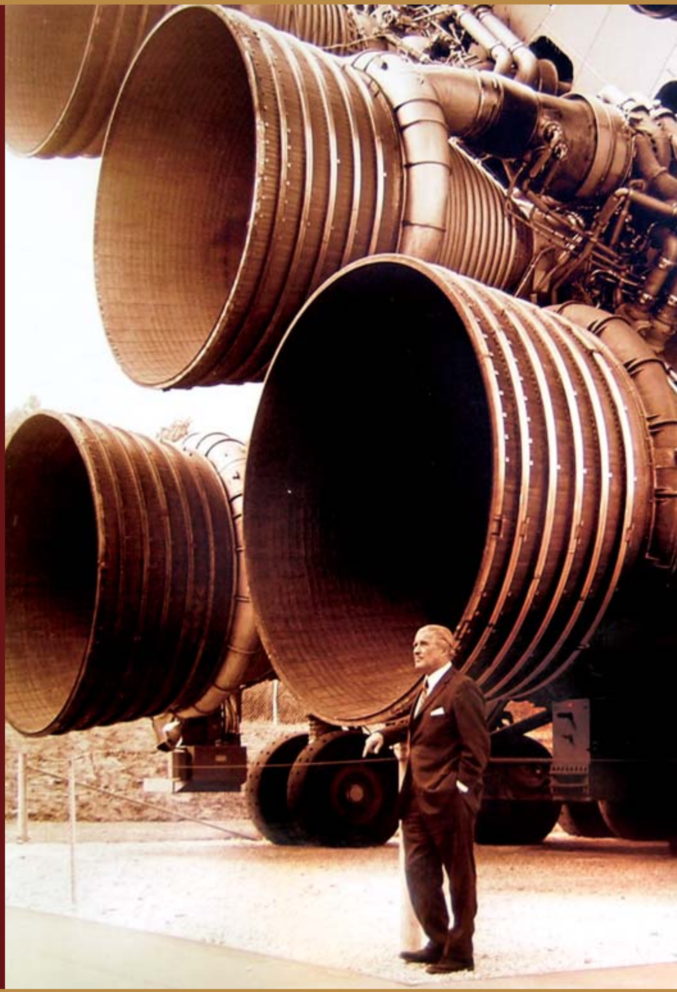
"If this technology can help to avoid even one incident or accident, it will have been worth all the effort and resources put forth," Zysko said.

Zysko recently retired from the National Aeronautics and Space Administration, where he worked for more than seventeen years, and the National Oceanic and Atmospheric Administration, where he worked for fourteen years. Among his many positions at NASA, Zysko was chief of the Spaceport Engineering and Technology directorate's data and electronic systems branch at Kennedy Space Center.

Note: NASA's Kennedy Space Center's Technology Transfer Office is currently seeking a licensee for the Personal Cabin Pressure Monitor. Potential licensees should call Jeff Kohler at 321-861-7158.

CAROL ANNE DUNN currently works as a Project Specialist in the Technology Transfer Office at Kennedy Space Center. She is also the Awards Liaison Officer for the Inventions and Contributions Board.

WERNHER VON BRAUN: LESSONS TAUGHT… AND LEARNED



BY BOB WARD

"Rocket scientist" Wernher von Braun remains a controversial figure. Even today, thirty-six years since his retirement from NASA and almost twenty-nine years after he departed planet Earth at the age of just sixty-five, the German-born engineer and physicist—and one-time enemy of the United States and its allies—still stands as an intriguing, dynamic, complex human being.

Dr. Wernher Magnus Maximilian von Braun was the Superstar of Space of his day. He was rivaled only by some of the earliest astronauts and a bit later by a cool customer named Neil Armstrong. In von Braun's case, the adulation was not universal.

Still, he had a passion for life along with his passion for rocketry and space exploration. It shone through in his work and all his communications. He was a communicator—in a voluble stream of speeches, conversations, briefings, press conferences, testimony, books, articles, technical papers, reports, correspondence, and patent applications. He helped turn much of his lifelong dream into reality, beginning in Germany, and then, for fully half his life, in America. To those who knew him well, von Braun was a larger-than-life, near-mythic figure, and yet also a fallible, feet-of-clay mortal.

He was the director of NASA's George C. Marshall Space Flight Center for its first ten years of existence, and earlier the civilian technical head of the space-history-making Army Ballistic Missile Agency, both at Redstone Arsenal. Before that, he served for thirteen years as the German Army's missile R&D civilian chief. He closed out his career with a largely frustrating two and a half years at NASA Headquarters as the Agency's master long-range planner, and then an upbeat stint with Fairchild Industries in Maryland followed by a drawn-out death from cancer.

I began getting to know Dr. von Braun casually in 1957, the year the space age dawned, as a young and green daily newspaper reporter in Huntsville, Alabama. We got somewhat better acquainted over the ensuing years in "Rocket City, USA" and in his last years with NASA in Washington. I tried hard to maintain a journalist's objectivity about him and keep a professional distance, but he was impressive. He became all the more imposing to me later, long after his death, through my seven years of researching and writing the 2005 biography, *Dr. Space: The Life of Wernher von Braun.*

He was, simply, a genius—as a technology leader, visionary, and as an inspiration to his various so-called "teams" in wartime, peacetime, and during the Cold War. Former astronaut, U.S. senator, and astronaut-again John Glenn told me in a 1999 interview that his longtime friend ranked as a modern renaissance man who possessed a "curiosity about *everything* around him."

Von Braun had a hyperactive, almost compulsive sense of humor, and he used it in countless ways. He lightened the mood for his "board" meetings of laboratory directors and the rest of his management hierarchy with a joke or two. At the launch site, he often broke the tension with some witticism. He warmed up his 1950s audiences for speeches outside the South by apologizing "for my accent," then grinning and adding, "I'm from *Alabama*."

He would protest, "I've never considered myself a genius—and my wife is always ready to attest to this fact!" And in the 1950s and 1960s, when others might suggest their rocket-and-space success record showed his team's German nucleus was "smarter" than everybody else, he would demur: "It's not that we're geniuses. It's just that we old timers have been working on these things so long, we've had twelve more years to make mistakes and learn from them!"

Von Braun, born in 1912, an instant baron as the middle son of aristocratic Prussian parents, was a fast-walking, fast-talking bundle of contradictions. Brilliant as a youth, he became distracted and flunked math and physics. Sent off to boarding school and turned on academically in his early teens by visions of rocket ships in space, he earned degrees in mechanical and aeronautical engineering, plus a doctorate in physics, by age twenty-two. He had been named the civilian chief of the German Army's rocket program two years earlier, before Adolf Hitler gained power. By age twenty-five he was the civilian technical director of the *Wehrmacht* side of the Peenemünde rocket R&D base on the Baltic seacoast. (The *Luftwaffe* ran the other side.)

This paradox of a bold, starry-eyed space cadet was one of the most ultra-conservative of engineers. A blend of visionary and realist, with a natural optimistic bent, he nonetheless inclined to move ahead only in safe, measured, incremental steps. He insisted on testing, testing, and testing again, down to the last component of the last subsystem.

Admiral Alan Shepard, a von Braun admirer, went to his grave believing he would have been the first *human*—not just the first *American*—in space, if only von Braun had not ordered just one more chimpanzee flight-test of Mercury-Redstone. That caution allowed the Soviet Union to send cosmonaut Yuri Gagarin into space in the spring of 1961, immediately before Shepard went up. Yet Shepard *did* have a safe flight aboard a souped-up U.S. Army "Jupiter-C" Redstone missile, as did Mercury astronaut "Gus" Grissom soon afterward. (A decade later, Project Apollo astronaut Shepard caught another flawless ride atop a von Braun launch vehicle—the somewhat larger Saturn V—to the lunar surface.)

Visionary as he was, in the practical world of engineering von Braun strongly preferred the tried and proven. His conservatism showed also in the matter of rocket propellants. Because of liquid hydrogen's dangerous volatility, he had to be forced to use it as fuel in Saturn vehicle upper stages during Apollo. But he readily admitted later that it was the right decision, because of its greater propulsive punch to the pound. Likewise, he had to be *ordered* into an "all-up" launch mode for Saturn V—starting with the first unmanned test flight—if Apollo was to meet its deadline. That meant, of course, that all stages had to be flown "live" on every flight. Von Braun later acknowledged the rightness of that decision, too.

Von Braun's deliberate, step-by-step approach resulted also in the successful orbiting of America's first space satellite, Explorer 1, on the last day of January 1958. An insistence on perfection led to an unprecedented thirty-two successful Saturn heavy-lift vehicle launches out of thirty-two attempts between 1961 and 1975. Von Braun preached perfection and demanded perfection. Long years of experience had taught him that anything less spelled disaster.

When the relatively apolitical German Army's revolutionary, 46-foot-tall, 200-mile-range V-2 missile was ordered prematurely into mass-production by the Hitler regime in autumn of 1943, six of every ten flight-test missiles exploded on the launch pad or failed in mid-flight. The V-2 was not fired operationally by German troops until September 1944—after the Allies' D-Day invasion at Normandy.

Under the fascist dictatorship, Wernher von Braun was a member of the Nazi party, having waited almost five years after Hitler came to power before signing up. Under heavy pressure, he later accepted an officer's commission—essentially honorary—in Heinrich Himmler's brutal SS corps. Without question, von Braun was a prominent member of the Third Reich at least peripherally connected with the underground, SS-run, forced-labor, main V-2 factory, with its atrociously high mortality rate. Yet this living, breathing paradox soon became America's perennial "Patriot of the Year" and "Scientist of the Year," although certainly not in everyone's minds.

It had not hurt von Braun's case, after he and about 120 of his fellow German rocketeers transferred to the United States in 1945–46, that he had been arrested early in 1944 by Himmler's Gestapo secret police, imprisoned on political charges of treason, and placed on trial for his life.

Spies had reported the rocket-*meister* saying he was more interested in exploring space than developing weapons; they had also overheard him denigrating certain Nazi big-wigs. He had further been accused of keeping his fast, four-seat, personal Messerschmidt aircraft gassed up at Peenemünde and handy for an escape to England with all the V-2 secrets. He was sprung in mid-trial by direct order of Hitler, thanks to intercession by the rocket *Wunderkind's* commanding general, Walter Dornberger, and one of his patrons in the Nazi hierarchy, Albert Speer, archenemy of Himmler. Hitler acted on the probably questionable grounds that the V-2 program would collapse without von Braun.

As with the R&D problems of the V-2 and its predecessor, test-bed German rockets, the U.S. Army's Redstone missile endured a less-than-perfect performance record early on in its history. This 200-mile, nuclear-capable weapon was the first major new development project assigned to the von Braun team in this country in the early 1950s. Launch-pad failure followed launch-pad failure after three years of work.

Witnessing one catastrophic Redstone explosion at Cape Canaveral, the scientist's boss, Major General H.N. Toftoy, asked, "Wernher, *why* did that rocket explode?" Von Braun said the answer must await analysis of data. Toftoy persisted, finally questioning whether the German had "*any* idea why it exploded?" Von Braun fired back: "Yes. It exploded because the s.o.b. *blew up*!"

Von Braun had learned long before that close-knit teamwork and honest communication were the keys to eventual success. A classic example occurred with another Redstone mid-flight test failure. Telemetry data showed all systems had performed well until a precise point. This enabled troubleshooters to localize the probable source. The suspected area had been checked and rechecked during lab tests. Finally, the likeliest explanation was accepted, and corrective action ordered.

Then an engineer with the firing group asked to see him. The engineer explained that during pre-launch preps, he had tightened a certain connection for good measure. In so doing, he had touched a contact and drawn a spark. But since the system later checked out well, he had not paid any attention to it. Now that everybody was talking about that apparatus, he just wanted von Braun to know. A quick study showed that this was indeed the answer, and the planned "remedial action" was canceled. Von Braun sent a bottle of good champagne to the engineer. He wanted *everyone* to know that honesty pays off, even at the risk of incriminating oneself.

In America, aerospace leader von Braun was competitive and aggressive in seeking programs, projects, and budget dollars for his agency. He tended to seize the moment. The very night that Sputnik went up, Eisenhower administration Secretary of Defense-designate Neil McElroy was visiting at Redstone Arsenal with von Braun, his commanding general, John Bruce Medaris, and other Army brass. Within a month, the von Braun team and its partners got the go-ahead to prepare and launch America's first satellite. They did so in less than ninety days, having earlier made under-the-table preparations.

When NASA was being created, von Braun sought to have the lion's share of responsibilities based in Huntsville. And when Agency roles and missions for the space shuttle effort were being considered by Headquarters, he proposed that Marshall be lead center for almost everything, including central program management.

Two brief stories shed more light on aspects of von Braun's management style and philosophy. One involves Marshall Center's old "neutral buoyancy simulator." Von Braun had the 33-by-35-foot water tank built on the sly and on the cheap in the 1960s, using in-house welders and funds borrowed from various accounts. It had its own "temporary" building. It proved a valuable tool for space flight hardware engineering design, evaluation, and eventually astronaut EVA training. It was also a great public-relations boon—a prime visitor attraction. Von Braun had not wanted to go through Congress and endure the inevitable restrictions on its use, so he called this huge structure a piece of "equipment," not a "facility." Eventually he was found out, and Congress did apply restrictions. The ploy reflected his philosophy of "better to ask forgiveness than permission." As he told his inner circle at Marshall: "You build the facility first, then take the slap on the wrist. But you *have* the facility. They are *not* going to *burn* it."

Von Braun tended to be a decisive, action-oriented manager. He detested bureaucratic indecision. When Hurricane Camille ravaged the Gulf of Mexico Coast and the Marshall-managed Mississippi Test Facility in 1969, its manager called urgently for help. A Marshall management staffer suggested the center send down a team to survey the critical needs. Von Braun said, "They don't need a survey! They *know* what they need. We're going to get a relief convoy together in the morning, and we are going down there and help!" The Marshall Center convoy arrived on the scene before the National Guard.

Von Braun was far from a perfect manager. He tended to hold overlong meetings, was considered too compassionate to reprimand or discipline wayward staffers (and usually had his chief longtime deputy, Eberhard Rees, do it for him), and was loathe to deny his management hierarchy unlimited access to him.

At one point, *thirty-eight* managers at Marshall had direct access to him between the weekly "board" meetings. An American-born insider finally persuaded him to appoint an R&D overlord to whom the majority would routinely report. After heated debate, von Braun directed the group to choose one from its number as the *Uber*-boss. The director was going on a holiday trip with his wife, and he said, "I won't come back until I see the 'white smoke' of agreement." The team acquiesced, selecting Hermann Weidner for the superchief's role. Thereafter, von Braun would introduce him as "my pope," chosen by his cardinals, the lab bosses.

The engineer-scientist could not, or would not, operate a dictation machine or a VCR, or learn how to adjust a color television set. A retainer of virtually all the knowledge he was ever exposed to, von Braun sometimes had trouble remembering to pick up his car-pool riders, buy the groceries his wife Maria told him to get at the market, or put on a belt or matching socks. When traveling, he never carried money, credit cards, or checks, leaving it to others, usually his assistants, to pay the bills and tips.

When the V-2 finally flew successfully on October 3, 1942, Hitler made the paradoxical von Braun an honorary "Research Professor," a title he proudly emblazoned on his stationery at Peenemünde. He liked his colleagues there to address him as "Professor," yet he never formally taught anywhere, aside from occasional guest lectures on campuses in America and abroad. But he was a teacher most of his adult life. When a Marshall

Center delegation visited the Palomar Observatory in the late 1960s, a California university astronomer gave a lecture on the subject of white dwarfs. This inspired von Braun later that evening to give an all-night lecture on astronomy to his associates back in his quarters.

And once in the mid-1960s, a Marshall contingent traveling by Lear jet across Kansas at 41,000 feet had to fly around the giant meteorological phenomenon known as an anvil cloud. Von Braun left the cockpit and proceeded to give a young engineer a learned discourse on anvil clouds.

As a space leader, von Braun was quite the political operative, and he had warm relationships with national political figures ranging from President John F. Kennedy to NASA Administrator Tom Paine to Texas Congressman Olin "Tiger" Teague, longtime chair of the House space subcommittee. The rocket scientist worked at cultivating personal political relationships. He was a willing, popular, enthusiastic, but straight-shooting congressional witness. He went on countless hunting trips with politicians. He rolled out the red carpet for them at Marshall Center.

Given his past in Nazi Germany, it was unknown how the image of this human paradox would fare in the twenty-first century. *Aviation Week & Space Technology* coordinated a worldwide survey in 2003 for the centennial of man's first powered flight, to determine the "Top 100 Stars of Aerospace" history. More than a million ballots came in from industry professionals in 180 countries. The results put him first among world space figures. In the overall category, he came in second, behind the Wright brothers. Walter Cronkite compared von Braun to Columbus. He said that, just as 500 years afterward we remember Columbus's voyages of discovery as the supreme events of that time, so, too, will people 500 years hence remember the Apollo missions to the Moon as the crowning human achievement of the twentieth century. Cronkite observed that, while earthlings of the twenty-fifth century will undoubtedly fixate on the daring exploits of Armstrong, Aldrin, Collins, and their successor lunarnauts, Apollo's engineers would also be prominently remembered: "[People then] will recognize it as an *engineering* feat. And when they do, they will fix on von Braun as certainly one of the greatest space engineering pioneers." ●

A RETAINER OF VIRTUALLY ALL THE KNOWLEDGE HE WAS EVER EXPOSED TO, VON BRAUN SOMETIMES HAD TROUBLE REMEMBERING TO PICK UP HIS CAR-POOL RIDERS, BUY THE GROCERIES HIS WIFE MARIA TOLD HIM TO GET AT THE MARKET, OR PUT ON A BELT OR MATCHING SOCKS.

BOB WARD, a former managing editor and editor-in-chief of *The Huntsville (Alabama) Times*, is the author of the 2005 biography *Dr. Space: The Life of Wernher von Braun*, published by the Naval Press Institute.


Photo by Michael Mercier

Cancelled Project, Continuing Relationships

BY THE *ASK* EDITORIAL STAFF

The HyTEx team stands with a llama in southeast Huntsville, Alabama, at a farm owned by Tony O'Neil, a member of the Marshall project management group.

In March 2003, a team from five NASA centers, two Air Force groups, the Army, and Sandia National Laboratories began work on a hypersonic re-entry vehicle intended to serve as a flying technology test bed for thermal protection systems, flight controls, sensors, communications, and other vehicle systems that need to withstand the rigors of high-speed re-entry. They developed plans for a 750-lb. vehicle that would be launched on a suborbital rocket from Wallops Island and achieve speeds ranging from Mach seven in early tests to Mach twelve and beyond. It was designed to then be slowed by parachutes and retrieved in mid-air by helicopter. The project was known as the Hypersonic Technology Experiment, or HyTEx. Working quickly, the team had a Preliminary Requirements Review in July, just four months after their start date, and a successful Preliminary Design Review (PDR) eight months later, in March 2004. Almost immediately after that PDR, however, the project was cancelled as a result of changing NASA priorities and budget pressures.

Despite that disappointment, project participants remain extremely positive about the experience, citing outstanding cooperation among the multiple centers and organizations involved and the speed and quality of the work accomplished. Rich Nelson, Kennedy Space Center Advanced System Division Chief, a NASA employee for thirty-four years and part of the Kennedy Space Center group involved in HyTEx, says, "The PDR was one of the best I've been through. It went the way things *should* go." Susan Spencer, deputy on the Marshall project management team, thinks of HyTEx as the project she is proudest of.

Project manager Jimmy Lee believes that the relationships of trust and mutual understanding established during the work will persist and have lasting value for NASA and the participants. "The success of the project is relationships," he says. "The sense of trust sets you up for future engagements. You're not making a cold call; you've got an existing relationship, and people will go out of their way to help you." Nelson agrees, noting that the connections he established with colleagues at Wallops continue and provide a foundation for future cooperation. He says, "HyTEx showed that NASA centers can work in close collaboration without competing for resources."

Ron Walsh, the Wallops project manager for HyTEx, attributes that successful collaboration in part to Lee's clarity about the work to be done. "He had a very clear definition of system boundaries," he says. "No one felt other people would encroach; they had a space to work in." Because people were confident that these boundaries would be respected, they did not feel they had to protect their territories by limiting the information they shared or devote attention and energy to fending off attempts to grab part of their work. Thanks to what Walsh describes as "a sense of safety," they were open to offering and asking for help.

At least as important as this clarity about boundaries and responsibilities was the atmosphere of openness, trust, and respect that Lee fostered. Part of that came from leading by example. "He's a straightforward and trustworthy guy," says Nelson, and Ron Walsh remarks that Lee's positive and cooperative spirit was "contagious." For Lee, an essential contributor to developing trust among team members was for him to trust them. He did not micromanage the project. Instead, he says, "I tried to give the vision and direction and let folks go off and do what they did best." Characteristically, he underplays his role, saying, "If you've got people engaged in doing something they like to do, it's easy."

Lee also took concrete steps to build relationships with the team. He organized frequent face-to-face meetings with project leaders and other team members—as many as thirty or forty people at a time at meetings held at different NASA centers and at Sandia National Laboratory. Varying the location helped create a sense of equality and partnership that would have been lacking if meetings had been held only at Marshall, where Lee and his project management group were located. (Unusually, Marshall had no technical role in the project, only management responsibility.)

HyTEx Team

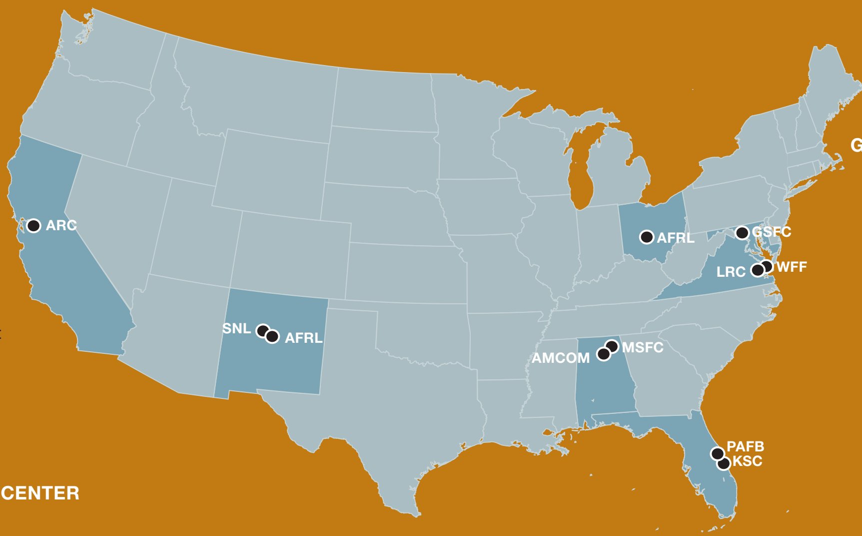
AMES RESEARCH CENTER
Thermal Protection System Experiments
Vehicle Health Management Technology

SANDIA NATIONAL LABORATORIES
Re-Entry Vehicle

AIR FORCE RESEARCH LAB (NEW MEXICO HQ)
Re-Entry Structures Experiment

ARMY AVIATION AND MISSLE COMMAND
Aerothermal Analysis
Ground Testing

MARSHALL SPACE FLIGHT CENTER
Mission Management



AIR FORCE RESEARCH LAB (OHIO HQ)
Thermal Protection System Technology

GODDARD SPACE FLIGHT CENTER/ WALLOPS FLIGHT FACILITY
Booster
Range and Launch Operations
Recovery

LANGLEY RESEARCH CENTER
Aeroscience
Thermal Protection System
Wind Tunnel Testing

KENNEDY SPACE CENTER
Experiment Management System
Experiment Processing
Vehicle Health Management Technology

PATRICK AIR FORCE BASE
Recovery Operations

These work sessions were followed by social times that helped team members get to know one another better and deepen their sense of connection. Often, the whole group went out for dinner together. Once, during the HyTEx Preliminary Requirements Review, the team met at the Cozy Cove Farm for a cookout. Tony O'Neil, a member of the Marshall project management group who owns the farm in Southeast Huntsville, graciously hosted the traditional southern cookout. In addition to the outstanding food and the opportunity to socialize with friends, Tony's farm gave team members the experience of a "petting zoo" within the city limits complete with miniature donkeys, horses, llamas, and alpacas. After dinner that night, the hosts paraded several of their favorite llamas into the barn to mingle with the team and be admired.

Shortly after the project was cancelled, Jimmy presented a framed certificate with a group photo with one of the llamas to each person in recognition of their individual contributions to the team. The photo remains a prized souvenir of the project and exemplifies the team's chemistry and unity. This was a fast-track project with a demanding work schedule, but Lee and his colleagues understood that taking time for social connection could help produce good results faster, not delay them.

Along with these meetings, frequent teleconferences kept team members in contact. Walsh remembers the calls as notably inclusive, saying, "Jimmy invited everyone in." One result, says Nelson, was "enjoyable and knowledgeable" discussions and productive outcomes. He cites the example of work on the Experiment Management Unit that would be designed to transmit data from the flight experiments on board, one of the Kennedy Space Center responsibilities. Sandia had developed a similar system but one built for a specific, different payload. Rather than getting caught up in rivalry between Sandia and Kennedy, Nelson experienced a cooperative sharing of expertise.

None of this diminishes the real disappointment team members felt when HyTEx was cancelled. While they recognize that such changes in direction are a fact of life at NASA, they continue to believe in the value of the work. Their belief in the importance of the project—their shared sense of mission—was one of the things that supported their outstanding collaboration in the first place. (Some related work continues at Sandia.) Still, they see HyTEx as a model of how collaborations among multiple centers and organizations should happen. The approaches used, the spirit of the project, and the relationships that have survived it are all part of the lasting legacy of that intense year of work. ●

Improving Lessons Learned

BY DAVID OBERHETTINGER

The engineering and operation of extremely complex and technically advanced systems pose significant risks, and we must accept the likelihood of design errors throughout the life cycle. Expensive mistakes and lost opportunities become less acceptable, however, when it is discovered that the enterprise already knew how to avoid them. Lessons learned can be an effective medium for communicating proven mission success factors and warning of especially risky engineering and procurement practices.

Establishing a Formal NASA Lessons Learned Process

The NASA Office of the Chief Engineer is taking steps to establish a formal lessons learned process to supplant largely ad hoc efforts by the field centers. The impetus for process improvements stems from findings by the General Accounting Office that NASA lessons learned were not being effectively used and findings from the Columbia Accident Investigation Board report that NASA "has not demonstrated the characteristics of a learning organization." NASA is turning to a formal lessons learned process that has been used by the NASA/Caltech Jet Propulsion Laboratory for twenty years. Based on this model, NASA issued NPR 7120.6, *The NASA Lessons Learned Process,* in March 2005. It calls for each NASA field center to establish a Lessons Learned Committee and *infuse* lesson learned recommendations into center business practices.

Jet Propulsion Laboratory Experience

In 1984 Jet Propulsion Laboratory (JPL) demonstrated enterprise-wide commitment to a formal lessons learned process through the establishment of the JPL Lessons Learned Committee (LLC). The JPL LLC includes representatives of the major technical and mission assurance organizations and is charged with real-time "wordsmithing" of draft lessons. The LLC meets weekly to review anomaly reports, mishap investigation reports, and informal communications to identify lesson learned candidates, and to rank the candidates according to the following criteria:

- Potential impact on mission success
- Applicability to other current and planned space flight projects
- Lack of coverage of the underlying issues in previous lessons

Authors are assigned to high-priority topics. When a draft is received, the LLC revalidates the topic as a suitable lesson learned, verifies the stated facts, and edits the draft during one of its regular meetings. The committee gives particular attention to ensuring that the lesson learned recommendation is readily "actionable" within the JPL engineering culture. An "actionable" lesson learned recommendation is neither too broad to be applied nor so detailed that it tells an expert how to do his or her job.

The LLC-approved lesson is then sent to the NASA Headquarters Data Manager for review and posting. This formal JPL process has been resource intensive, and it does not generate large numbers of lessons learned, but it provides credible alerts of proven threats to mission success.

Lessons Learned Infusion

Verifying space flight project compliance with the published lesson learned recommendations has grown to be a daunting task due to the sheer size of the NASA lesson learned compendium. With more than 1,500 lessons learned in the NASA system,

Frames from the Mars Exploration Rover landing video simulation.

THE JPL LLC INCLUDES REPRESENTATIVES OF THE MAJOR TECHNICAL AND MISSION ASSURANCE ORGANIZATIONS AND IS CHARGED WITH REAL-TIME "WORDSMITHING" OF DRAFT LESSONS.

iterative review by project personnel at major project milestones may be impractical. Nor can JPL rely on a passive system in which technical specialists within the JPL line organization elect to consult lessons learned for alerts.

In 2002, JPL opted to end its passive reliance on having engineers consult the lessons learned compendium and to move toward a closed-loop system. Unless active measures are taken to infuse recommendations into enterprise-wide practices, an extensive and well-validated set of guidelines may degenerate into a "data morgue." Each JPL lesson learned recommendation was assigned to one or more JPL process owners for action—more than 600 assignments—via the closed-loop JPL Corrective Action Notice (CAN) system. When a process owner demonstrates that a recommendation has been fully incorporated into JPL procedures and training, the infusion is complete and the CAN is closed.

A JPL lesson learned published in March 2006 (http://www.nasa.gov/offices/oce/llis/imported_content/lesson_1712.html) pointed out the need for substantial design margin to encompass a poorly understood environment. Mars Exploration Rover designers had responded to a high level of uncertainty regarding Martian winds by providing the lander with a set of small, sideways-pointing (transverse) rockets and adding a small camera to directly sense horizontal drift. This redesign to reduce the risk that the descending lander would graze Martian terrain was implemented only eighteen months before launch.

A video simulation available at http://marsrovers.jpl.nasa.gov/gallery/video/movies/spirit/AMA_Hi_Res_Animation.mpg is based on actual Mars landing data; it looks north and shows the main rockets decelerating the craft, and the transverse rockets canceling the ground drift from a westerly wind. Without this capability from the redesign, the lateral motion across the rugged incline of the Gusev Crater would likely have damaged the now-operating Spirit rover. To infuse this lesson, JPL design guidelines for future planetary missions will call for countering significant environmental risks at the upper bounds of their probable severity, with substantial margin.

AN "ACTIONABLE" LESSON LEARNED RECOMMENDATION IS NEITHER TOO BROAD TO BE APPLIED NOR SO DETAILED THAT IT TELLS AN EXPERT HOW TO DO HIS OR HER JOB.

Due to the backlog of published lessons extending back to the Voyager era, only half the JPL contributions to the NASA system have been fully infused. But after an independent assessment confirms the adequacy of the disposition of a given lesson learned, JPL will no longer have to fully depend on periodic review of that lesson.




UNLESS ACTIVE MEASURES ARE TAKEN TO INFUSE RECOMMENDATIONS INTO ENTERPRISE-WIDE PRACTICES, AN EXTENSIVE AND WELL-VALIDATED SET OF GUIDELINES MAY DEGENERATE INTO A “DATA MORGUE.”

Status of the NASA Initiative

The NASA field centers have responded positively to the Headquarters lessons learned initiative. The NASA Office of the Chief Engineer has conducted rollouts of NPR 7120.6 at each of the field centers, and the centers are organizing their Lessons Learned Committees and infusion processes.

To complement these efforts, NASA has recently transferred its collection of lessons learned from the previous Lessons Learned Information System to the NASA Engineering Network (NEN). The NEN offers expanded search capabilities, and planned enhancements will include advanced data mining capabilities. ●

DAVID OBERHETTINGER works for the Chief Engineer of the NASA/Caltech Jet Propulsion Laboratory (JPL), and he chairs the JPL Lessons Learned Committee. He also serves as a vice-chair of the annual Reliability and Maintainability Symposium (http://www.rams.org) and on an AIAA Committee on Standards.

“An expert is someone who knows some of the worst mistakes that can be made in his subject and how to avoid them.”

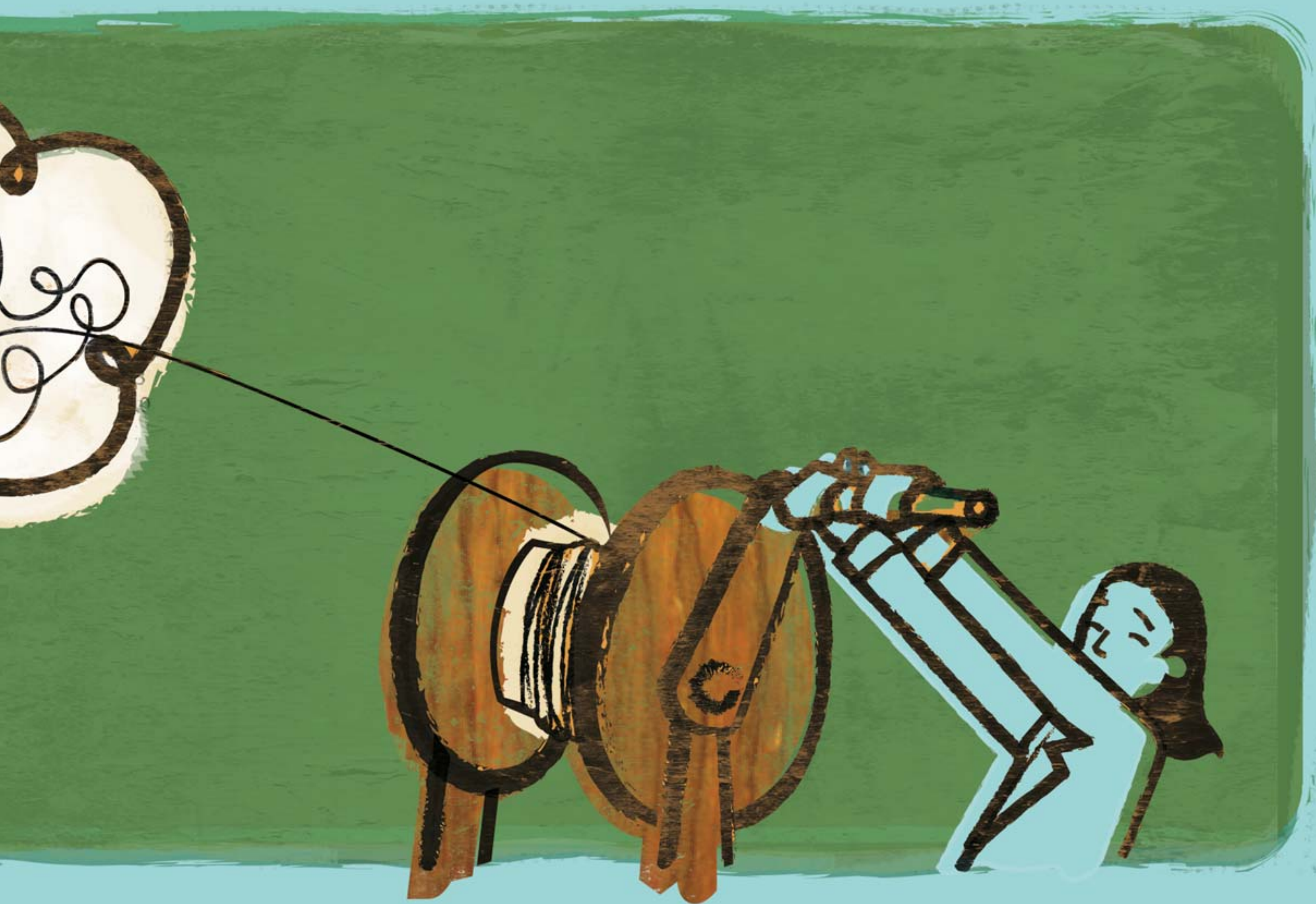
WERNER KARL HEISENBERG
AWARDED NOBEL PRIZE FOR PHYSICS FOR 1932

“We don’t invent new mistakes; we just repeat the old ones.”

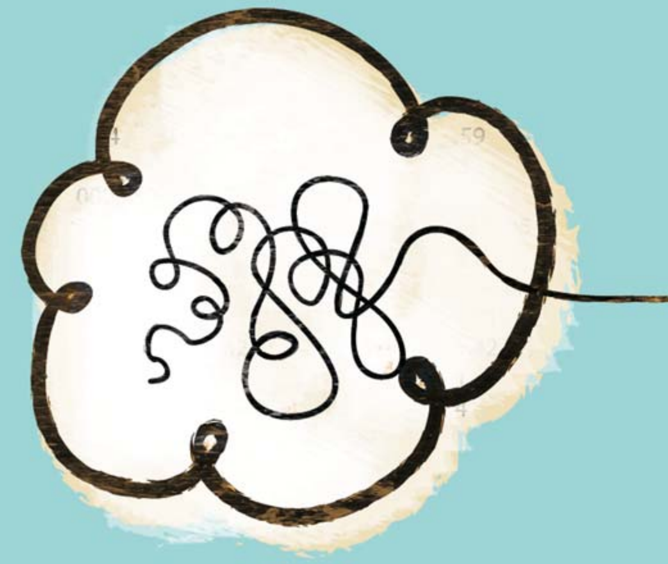
BILL BALLHAUS
PRESIDENT AND CEO OF THE AEROSPACE CORPORATION

From Chaos to Order

BY MIKE ZAMBRUSKI AND DON COHEN



In 2005, I was asked to assume project management responsibilities for an Internet portal project designed to improve relationships between a large company and its customers by giving customers convenient electronic access to company services. Compared with most NASA projects, the work and the resources needed to accomplish it were modest. Technicians, leads, and project managers from ten organizations responsible for design, construction, testing, and implementation contributed a total of fifty-seven staff-months of labor. The scope and relatively short duration of the project—six months—did not, however, save it from uncertainty that verged on chaos. When I was called in, there was no project team in place and the statement of business requirements consisted only of vague ideas and anecdotes, the product of some informal meetings and e-mail exchanges. To further complicate matters, the project had only a high-level promise of funding to cover the anticipated scope and a completion date that could not be postponed.



My first and primary job was to replace vagueness with clarity, to confront the chaos that threatened the success of the project and begin to establish order. I achieved those goals with the help of a simple project management tool that served as an essential part of a deliberative, collaborative process to clarify goals, tasks, resources, and responsibilities.

The tool itself is in Microsoft Excel and therefore readily available to all project participants. It provides a place to define and communicate project phases and tasks, to match tasks with the groups that would be responsible for them, to calculate needed resources of time and money, and to make explicit the assumptions underlying the plans and budgets.

I began development of the tool by defining the key phases of the project, using recommended practices from the Project Management Institute, my book *The Business Analyzer & Planner*, and prevalent Systems Development Life Cycle protocols. The phases are as follows:

1. Gathering, documenting, and validating business requirements
2. Establishing technical design and system requirements
3. Construction and individual module testing
4. Systems testing
5. Business acceptance and end-to-end testing
6. Production coordination

Phases one and five were then assigned to the business unit; the others were the responsibility of the technology unit. Although this overall work distribution was familiar to the project team, it was complicated by the number of contributing organizations that we had to involve for each phase. Many coordination and negotiation sessions with various technical units were required to coordinate our needs with their existing priorities and arrive at a balance that was equitable but still supported the project scope.

Populating the tool with accurate information was an iterative, collaborative process. Over the course of the first month, several two-hour meetings with the technical leads and project managers were held to clarify the project's statement of work and build shared commitment to achieving it. Specific task descriptions, responsibilities, and resources were subject to discussion, debate, and revision.

Some version of this discussion process is or should be part of the planning for any project. The tool provided a structured, consistent way for the team to develop successively deeper and more detailed insight into the project scope and confirm the time and labor that would be needed. It makes the project's requirements, tasks, and expectations clear and definite, replacing the vagueness and uncertainty of conversation with explicit, visible, unambiguous statement. Vagueness about requirements, resources, responsibilities, or schedules is the enemy of project success. The tool helps participants move from a subjective "sense" of what needs to be done to a set of objective statements that can be discussed, debated, modified, and agreed on. The purpose of the tool and a major part of my job as project manager is to replace an "analog" view of the project (a continuous and therefore ambiguous range of values or choices), which can persist for a long time if all you have is discussion, with a "digital" or binary one—a clear either/or choice that shows precisely what is expected and committed to.

In many project management engagements where I use this process and tool, clients are at first impatient about what they see as "a lot of process" (by which they mean "too much process"). Especially when projects are on tight schedules or late getting started—which, of course, describes most of them—the teams that watch the clock tick toward the project deadline as we meet repeatedly to discuss requirements and responsibilities often ask, "Why aren't we getting down to work?" The answer is that we are doing essential work. Taking time to eliminate misunderstanding about the project and establish commitment to carrying out unambiguous tasks increases the chances of meeting our target date. Once this becomes clear, the complaints about too much process stop. In fact, many of the skeptics have adopted the process and tool for use in their other project work.

Project management is typically done in a cross-functional or matrix environment, so it is no accident that the tool I developed makes it possible to see those connections. In the case of the portal project, it helped all participating disciplines plan and monitor staffing levels, interdependencies, and final deliverables in a closely coordinated fashion. It also enabled us to respond quickly to the ever-changing dynamics of a highly technical environment, and thus helped ensure that the final project was deployed when it was needed at a cost that was acceptable. ●

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Collaborative Community

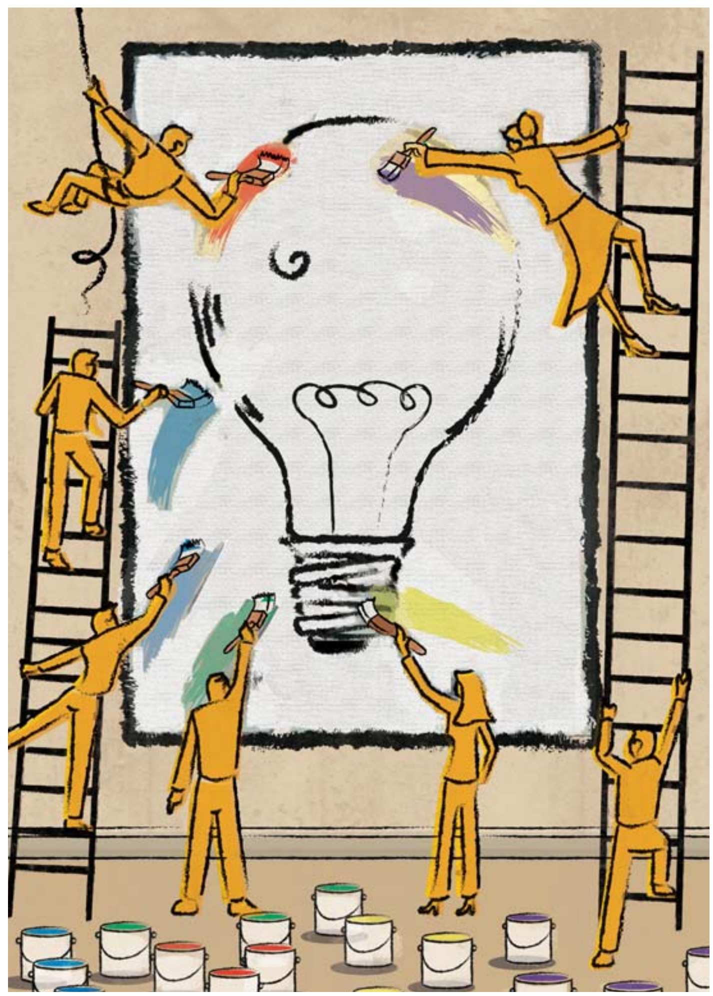
BY PAUL ADLER AND CHARLES HECKSCHER

Work is increasingly a matter of knowledgeable experts cooperating on projects in rapidly changing environments. Our research has attempted to identify the form of organization best equipped to support such work. We have reached two conclusions. First, this kind of work requires a strong sense of community that allows contributors to trust each other. The two other main "tools" of organization, financial incentives and bureaucratic authority and procedures, are useful but ineffectual without a backdrop of community. Second, the kind of community needed today is very different from the traditional community based on loyalty; it takes a new form we call "collaborative."

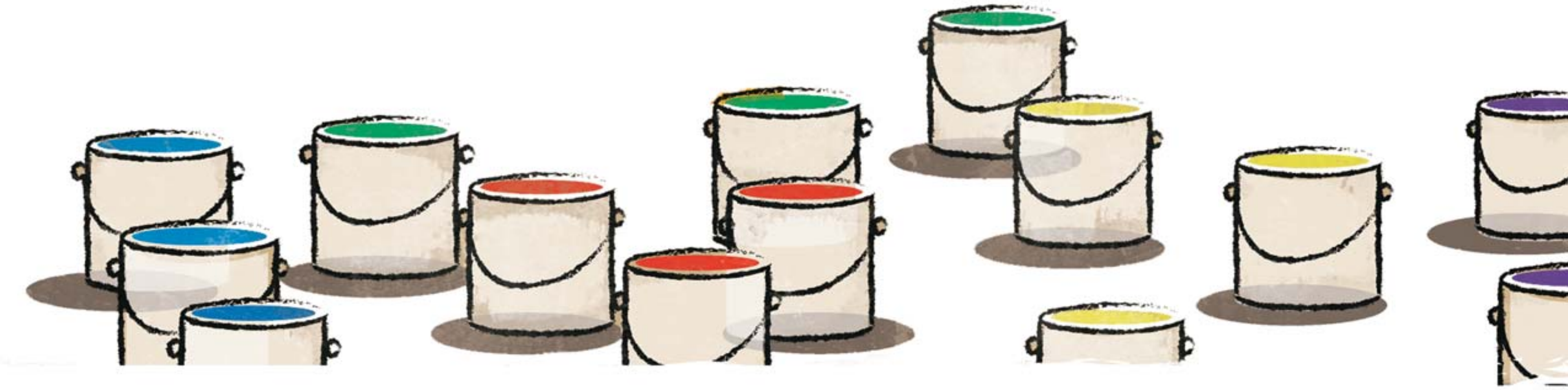
Throughout human history people have cooperated with others who were like them and were part of shared long-term communities where personal reputations were well known. For many decades, many of our most effective organizations fostered this kind of community, clothing the skeleton provided by the formal bureaucratic structure in a tissue of strong loyalty. Loyalty similarly added robustness to market relations with key suppliers and customers.

Recent trends have seriously compromised the effectiveness of these arrangements. Within organizations, people are asked constantly to cross boundaries—to work with people they don't know well and who are very different from themselves. Increasingly, work requires flexible cooperation across functions, divisions, and levels within organizations. Moreover, the network of inter-organizational ties is changing ever more rapidly and broadening to encompass new organizations often based in different national cultures.

Many business organizations in recent years have reacted to these challenges by ignoring or casting aside community. They have tried to meet their performance challenges by restructuring to strengthen bureaucratic controls and by sharpening financial incentives. In the process, they have destroyed trust. These approaches tend to generate fear and competition rather than cooperation and openness. When such organizations attempt to bring different kinds of knowledge and skill together to solve problems, the absence of trust undercuts the knowledge sharing that the work demands.



Our research suggests that successful businesses meet these new challenges not by abandoning community but by reconstructing it along more "collaborative" lines. This new form is more flexible and less insular than loyalty-based



community, and trust is established more quickly. This new form is distinguished by its *organization*, which supports horizontal interdependence rather than relying on top-down control or autonomous self-interest guided by financial incentives; by its *values*, which emphasize interdependent contribution to a collective purpose rather than loyalty or reliability; and by the *social character* of its members, which is tolerant of ambiguity and conflict rather than comfortable with fixed roles and status.

IBM Creates a Collaborative Community*

An interesting case in point is IBM's effort to overcome its bureaucratic past in order to create a flexible services capability. By the late 1970s, it became apparent to many in the company that the long tradition of proprietary mainframe products—"big iron"—was losing ground. Many leaders tried to spur innovation by attacking the traditional IBM culture based on strong expectations of loyalty and conformity to company values (right down to the IBM dress code). The IBM PC was thus developed in an autonomous division set up in Florida, far from headquarters, and kept separate from the rest of the company. The PC was a great product, but the price of the division's autonomy was that it never overcame the resistance of other divisions and power bases, and as a result IBM lost the opportunity to dominate a new market.

By the early 1990s insiders knew that a crisis was coming. John Akers, the first CEO brought in from outside the company, tried hard to break down traditional loyalties and shake up the company, relying mainly on stronger lines of authority and sharper financial incentives. He restructured, created new divisions, and instituted tough performance standards. These efforts hit a wall of incomprehension and resistance. When their failure became obvious, Akers went into a tirade at a senior management meeting: "Everyone is too damn comfortable. [We have] too many people standing around the water cooler waiting to be told what to do." He was gone shortly afterwards, and the company nearly went bankrupt within a year.

Like many top managers in troubled companies, Akers put the blame on "the frozen middle" as the principal obstacle to change. This diagnosis hid the inability of top leadership to create a sense of shared community around a new direction, as it does in many other organizations we have studied. In pushing for change, Akers created uncertainty and fear rather than unified commitment. For people to go beyond their narrow jobs and embrace the new challenges and opportunities, they need to have a vision of a positive future, to believe that others will respond positively, and to be convinced that by contributing to a larger whole they will be part of something meaningful. IBM in this first phase destroyed the stifling bonds of traditional loyalties but did little to build a new, more effective community.

The solution for IBM—and, we believe, for many other organizations—was not simply to return to a familiar community, to re-knit broken bonds of loyalty. The old community of twentieth-century corporations was secure and stable, but it was also hierarchical, conformist, and conflict-averse. Trust relied on the assumption—now obsolete—that employees felt they shared a common identity and that their roles were basically stable. The traditional form of community had many strengths but one big flaw: it was insular. The new context requires a new form of trust that fosters open discussion and debate, that not only tolerates but also encourages diversity of views and capabilities.

Collaborative Community: Structure

The new collaborative form of community requires a new structure built around horizontal processes—supplementing, though not replacing, traditional vertical controls. People need to orient their actions not just to what the boss wants and thinks but also to process mechanisms that cross divisional

SOME PEOPLE ARE JUST CONTENT WITH JUST MANAGING THEIR PIECE OF TURF AND DON'T WANT ANYONE MUCKING AROUND IN IT. [HERE YOU NEED] SOMEONE WHO WOULD BE OPEN TO CRITICISM OR SUGGESTIONS AS OPPOSED TO SOMEONE WHO WOULD GET DEFENSIVE, BE SCARED BY PEOPLE MEDDLING AROUND.

boundaries and are constantly updated and adapted to changing circumstances. We call this *structural* element of collaboration "interdependent process management."

IBM has worked hard to create effective processes. Current CEO Sam Palmisano has defined his goal as "an enterprise whose business processes—integrated end-to-end across the company and with key partners, suppliers, and customers—can respond with speed to any customer demand, market opportunity, or external threat." As a result, we see within the company fewer traditional organization charts of hierarchical boxes and more process maps that define roles and responsibilities in horizontal flows. Whereas the traditional organization chart focuses on upward responsibility and downward authority, these process-focused representations are tools that help people coordinate horizontally with their peers.

IBM has gradually built processes that link parts of the company horizontally toward the customer, crossing from technology development and manufacturing to sales and marketing. Employees have had to change their orientation: instead of looking for a rule to follow and settling into a stable routine taken from their boss or a handbook, they must continually redefine roles and responsibilities through discussion with their project colleagues.

A traditional bureaucratic structure creates clarity by ensuring that each person has a defined realm of authority that matches accountability. The new IBM embodies the collaborative approach in breaking this traditional rule: it is expected that people will take responsibility for things they can't fully control and that they will move outside the zone of their formal accountability. Moreover, in a traditional bureaucracy, power and influence flow downward. Procedures that specify horizontal processes are typically defined by a centralized staff and imposed on the rest of the organization. The new IBM embodies the collaborative approach: it still relies on standardized, formalized processes, but this centralization is combined with high levels of participation, because the processes are defined and refined over time by input from all levels and units.

Collaborative Community: Values

The second pillar of collaborative community is a set of shared values that give priority to interdependent contribution. A traditional bureaucracy emphasizes doing a good job; it values conscientiousness, reliability, loyalty, and devotion to duty. In a collaborative community, this orientation is no longer enough: people must look beyond their jobs and take larger initiatives. The main question becomes not, "Did you do a good job?" but "Did you contribute to the mission?" We call this *value* dimension of collaborative community "the ethic of interdependent contribution."

Lou Gerstner's first actions when he became CEO in 1993 advanced just such an ethic. As one of our interviewees noted, he immediately took dramatic action to focus everyone on the customer:

"Lou turned the thing way upside down—[he said] the most important thing a CEO does, or any executive in this company does, is meet with customers. That was like a rocket through the company."

The move was revolutionary because it shifted attention from internal tasks and relationships to "customer solutions" as the common objective that united everyone. Contribution to that shared, external objective could now serve as the common yardstick. IBM has engaged in a major effort to define this concept of contribution to make it real for managers and employees. A significant portion of variable pay is now based on assessments of the individual's "contribution to IBM," which attempts to account for hard-to-measure dimensions of performance like teamwork and helping out a colleague.

This is a profound shift in orientation. People focused on contribution are scornful of bureaucrats, and vice versa. The former see the latter as narrow and timid; the latter see the former as undisciplined and overly aggressive. Building a true ethic

of contribution requires a great deal of trial and error, during which people learn what kinds of challenges and risks are really constructive and which are destructive; which kinds of conflicts create stronger results and which divide and weaken. Above all, it requires that everyone gain a richly detailed picture of the shared purpose toward which they are all working, a shared understanding of the strategic challenges and opportunities that they are addressing.

Collaborative Community: Character

Finally, there is the dimension of character. People who are dependent on authority and seek security and clarity are not well adapted to collaborative systems. What is increasingly required is the ability to tolerate ambiguity and manage multiple conflicting commitments. In a unit of Citibank we have studied, collaborative community had become the norm, and one of our interviewees described the difference between his new organization and the older, more bureaucratic Citibank in these terms:

"Some people are just content with just managing their piece of turf and don't want anyone mucking around in it. [Here you need] someone who would be open to criticism or suggestions as opposed to someone who would get defensive, be scared by people meddling around."

Nor is collaborative community a hospitable environment for the "cowboy" types who value autonomy above all. What is increasingly required is a more "interdependent" sense of one's self: a habit of caring and heedfulness. In a unit of a large software services company that had also made considerable headway in forging a collaborative community, one of our interviewees described the contrast between the old world of cowboy hackers and the new one in these terms:

"It's a bit like streetball versus NBA basketball. Streetball is roughhousing, showing off. You play for yourself rather than the team, and you do it for the love of the game. In professional basketball, you're part of a team, and you practice a lot together, doing drills and playing practice games. You aren't doing it just for yourself or even just for your team: there are other people involved—managers, lawyers, agents, advertisers. It's a business, not just a game. You have to take responsibility for other people—your teammates—and for mentoring other players coming up."

Collaborative systems need people with *interactive character* and identities that embrace the complexity of interdependence rather than seeking refuge in either dependence or autonomy. This capacity requires considerable ego-strength and has roots in early socialization and education. We have found that in the shift to collaborative community, many people rise to the challenge and embrace this new self-concept. However, there also seems to be a minority who are incapable of dealing with the inevitable lack of clarity or who are frightened by the questioning of all-powerful authority.

Collaborative Community: The Process of Change

So how has IBM navigated this change from ponderous bureaucracy to relatively nimble, solutions-oriented company? There has certainly been a great deal of internal dissent and conflict, but for the most part they have been successfully overcome because the company has done some crucial things right. Not only have they oriented themselves toward promising, distinctively collaborative types of structure, values, and character, but IBM's leadership has shown itself committed to a collaborative process for getting from here to there.

All too often, leaders propound a promising model but then pursue that goal with a process that dooms it to failure. For example, the last couple of decades have seen numerous CEOs propound "empowerment" goals, which they tried to implement by autocratic command. By contrast, IBM's leadership has been courageous in adopting a more collaborative path toward collaborative community.

Sam Palmisano, who took over from Gerstner, felt that IBM's key problem at that time was a lack of clarity on

IT'S A BIT LIKE STREETBALL VERSUS NBA BASKETBALL. STREETBALL IS ROUGHHOUSING, SHOWING OFF. YOU PLAY FOR YOURSELF RATHER THAN THE TEAM, AND YOU DO IT FOR THE LOVE OF THE GAME. IN PROFESSIONAL BASKETBALL, YOU'RE PART OF A TEAM, AND YOU PRACTICE A LOT TOGETHER, DOING DRILLS AND PLAYING PRACTICE GAMES. YOU AREN'T DOING IT JUST FOR YOURSELF OR EVEN JUST FOR YOUR TEAM: THERE ARE OTHER PEOPLE INVOLVED—MANAGERS, LAWYERS, AGENTS, ADVERTISERS. IT'S A BUSINESS, NOT JUST A GAME. YOU HAVE TO TAKE RESPONSIBILITY FOR OTHER PEOPLE—YOUR TEAMMATES—AND FOR MENTORING OTHER PLAYERS COMING UP.

the core values of the company: the old expectations set by the founders were clearly inappropriate to the fast-moving, customer-centric business model being developed. Palmisano took the extraordinary step of starting a companywide, open conversation—a "values jam," starting with an intranet-based free-for-all in 2003 and continuing through more focused dialogues in subsequent years. The jam deliberately broke the rules of hierarchical deference: top executives participated as equals in heated debates with lower-level managers, shop floor workers, and clerical staff. At the start, the discussion was dominated by expressions of anger and mistrust at the changes in the company, so strongly voiced that some top managers felt the discussion was getting out of hand and should be cut off. But Palmisano persisted, and the tone soon shifted to a positive collective effort to build a shared orientation to the new environment.

These moves have laid the foundation for a kind of trust that is more flexible than in the old IBM community. People relate successfully not only within the old IBM boundaries but also to the PricewaterhouseCoopers consultants acquired in 2002 and increasingly to a web of allies and contractors. They work together across these boundaries to bring integrated and flexible solutions to their customers. There is now wide agreement that traditional values that gave such prominence to loyalty are untenable, but this has not meant a turn toward individualistic cynicism. Commitment to the mission holds people together and provides the foundation for internal innovation that would have been inconceivable in the past.

The Challenges Ahead

IBM represents just one case that shows a way out of the dilemmas facing many organizations today. But we cannot afford naiveté. In the harsh world of business today, there are many forces that undermine any form of community and that frustrate the emergence of this new, collaborative form. Indeed, the dominant tendencies in industry over the past couple of decades have been toward reliance on command rather than collaboration, and on transient market relations rather than partnership.

Nevertheless, we remain optimistic. The old, cozy world of loyalty-based bonds seems lost for good, but the harsh world of market individualism and hierarchical command cannot build the constructive collaboration among different specialties that is increasingly essential to business. The only way out is to forge a new type of community that encourages people to work together toward a shared sense of purpose. Organizations that master this new form will have a huge advantage in our increasingly knowledge-intensive world. ●

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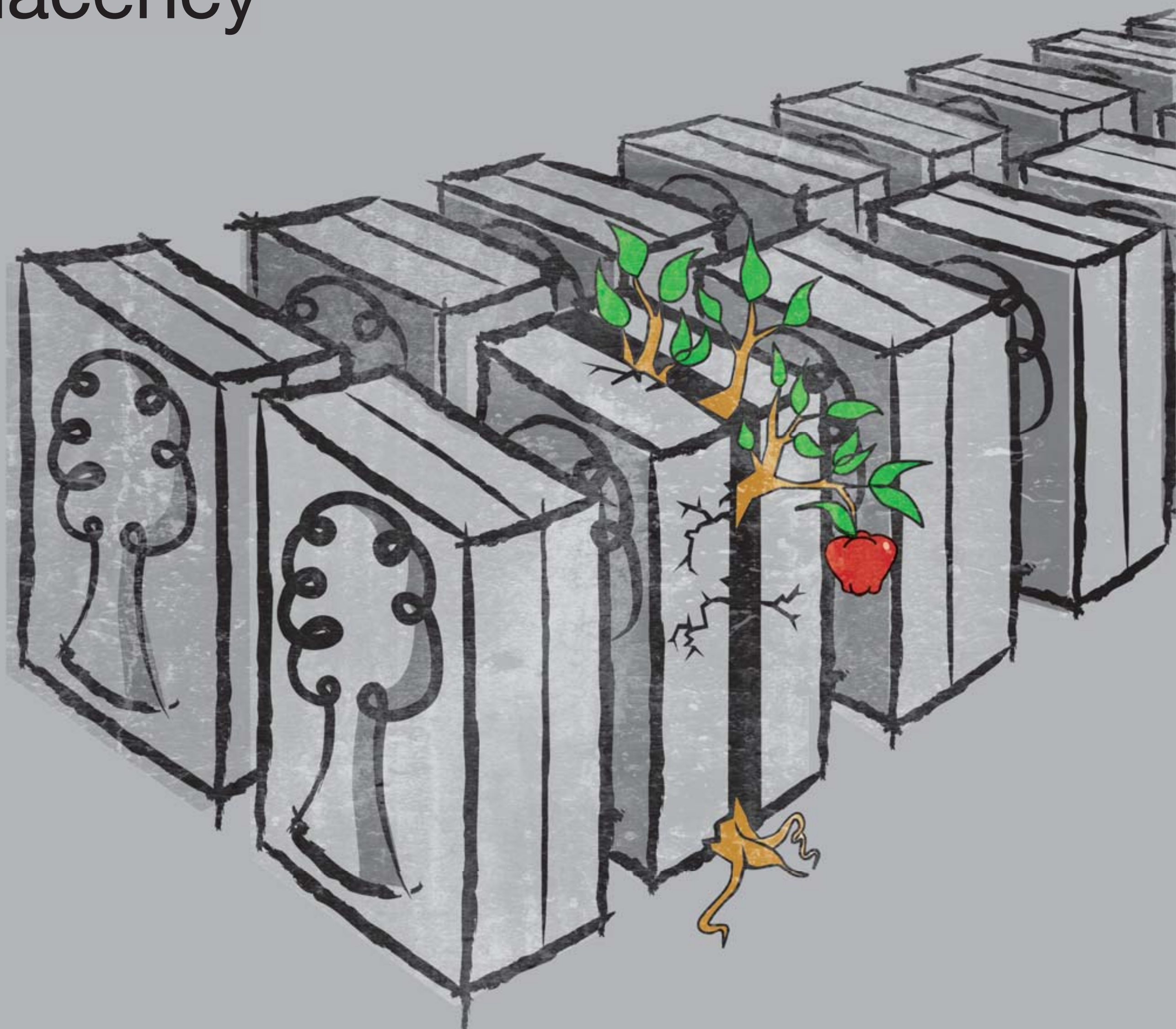
* The following information on IBM is based in large part on Lynda M. Applegate, Charles Heckscher, Boniface Michael, and Elizabeth L Collins, "IBM: Uniting Vision and Values," Harvard Business School case # N9-805-116 (2006); see also Lynda M. Applegate, Rob Austin, and Elizabeth Collins, "IBM's Decade of Transformation: A Vision for On Demand," Harvard Business School case # N9-805-018 (July 21, 2004).

Challenging Complacency

BY STEPHEN DENNING



When the minority report of the group monitoring NASA's progress in making the space shuttle fleet safer after the loss of the Columbia said in August 2005 that NASA "must break [the] cycle of smugness substituting for knowledge," it put its finger on a challenge that afflicts all successful organizations: how to avoid the complacency that inevitably accompanies success and how to use knowledge to reduce the risks that complacency brings with it.[1] Whether or not NASA itself suffers from smugness—the majority of the monitoring group didn't address the question—the issue of complacency is endemic in all large organizations. Various strategies have been used by organizations wishing to retain their edge. This article reviews the strengths and weaknesses of different approaches, including several for dealing with situations where knowledge is no help.

Root Causes of Organizational Complacency

The first step in dealing with the problem is to recognize how deep-rooted and intractable it is. Many common assumptions and behaviors promote complacency. These are the most important:

- **EXCESSIVE RELIANCE ON PRIOR SUCCESS:** The more often a particular routine achieves a successful outcome, the more likely people are to develop an unwarranted belief that success is assured.[2] The reality is that the opposite is true where random risks are involved: the probability of risk materializing increases over time.
- **ARROGANCE OF EXPERTS:** Disdain for laymen or for experts in other fields is a perennial tendency of the expert. The fact that the expert is right more often than the laymen can lead to the illusion that he is always right.
- **OVER-ACCENTUATION OF THE POSITIVE:** Management is an action-oriented activity. The can-do mind-set that is necessary for getting things done may discourage listening to nay-sayers and skeptics, even when their viewpoints have merit. Nevertheless, most high-value knowledge lies in negative narratives that reveal the pitfalls, difficulties, and obstacles that lie in the way of success.[3] Because such narratives can be seen as a threat to management plans and objectives, fear of negative career consequences can hamper their dissemination.
- **OVER-RELIANCE ON TECHNOLOGY:** Technical specialists have a tendency to believe in the infallibility of their technology, particularly in areas where they have some knowledge and control. This can be a serious problem for computerized safety systems, which can generate a false sense of infallibility.[4]
- **THE "BLACK SWAN" BIAS:** People tend to discount the possibility of unprecedented risks. Because all the swans they have seen are white, they assume black swans do not exist. A black-swan event is beyond the realm of normal expectations and tends to be discounted, even by experts. The difficulty of learning from black-swan events is compounded by the fact that they rarely repeat. Learning from the discovery of one black swan that black swans are possible doesn't prepare us for, say, a platypus.[5]
- **GROUPTHINK:** Groupthink occurs when people are deeply involved in a cohesive group whose striving for unanimity overrides a realistic appraisal of alternative courses of action.[6] Large organizations often exhibit symptoms of groupthink, including illusions of invulnerability and a sense of superiority; collective rationalization and stereotyping of outsiders as uninformed; ignoring contrary data; suppressing alternative viewpoints; and shielding leadership from dissent.

Strategies for Dealing with Complacency

Because the root causes of organizational complacency lie deep in the human psyche, there is no known cure. Various organizational strategies for reducing the impact of complacency have been adopted, including changing the organizational structure, adjusting the discourse, enhancing organizational values, getting ready for the unexpected, and aiming for radical innovation. The different approaches have varying strengths and weaknesses.

Changing the Organizational Structure

One set of strategies concerns adjusting the organizational structure, forcing attention on important issues that are often ignored.

- **GIVE ORGANIZATIONAL INDEPENDENCE TO ANALYSTS:** One approach to resolving the tension between negative knowledge and management's positive can-do attitude is to give analysts formal independence from the managers. In the World Bank, the Operations Evaluation Department (OED) reports to the board of directors rather than to the president of the organization. This enables the OED to be fearless in presenting its findings. Where the approach results in confrontation, however, organizational learning may be retarded.

- **ESTABLISH FORMAL PROCESSES FOR PROFESSIONAL DISSENT:** In high-stakes decisions, such as in the management of nuclear energy facilities, where a mistake could mean disaster, formal processes are established to allow professionals to express "differing professional opinions," or DPO. The hope is that such a channel allows heterodox opinions to be shared. The risk is that using the DPO can have the same negative career consequences for critics as when no such channel exists.
- **INTRODUCE STRUCTURED APPROACHES TO MANAGING RISK:** Recently, risk management programs have become popular. They set up systematic processes for describing, cataloging, evaluating, and taking measures to prevent, reduce, or compensate for risk, with specific accountabilities for accomplishing these tasks. Such programs promise to give managers a handle on intangible risk factors.[7] They also may create costly bureaucracy, giving a semblance of protection against risk while stifling the creativity needed to deal with significant risk.
- **CREATE OASES OF SAFETY THROUGH COMMUNITIES OF PRACTICE:** A more flexible approach, growing out of knowledge management, gives communities of practice organizational blessing and support. Communities constitute "safe spaces" where experts can establish levels of trust needed to discuss even difficult, institution-threatening issues. The approach is low cost and flexible and builds on the natural tendency of experts to learn by sharing experience. But communities can be fragile as they depend on the forbearance of hierarchical managers. In the absence of active efforts to cross-fertilize from other disciplines or groups, they are also vulnerable to groupthink.[8]

Structural solutions are attractive because, apart from communities of practice, they can be implemented by managerial fiat. They generate explicit and consistent approaches to knowledge issues and create clear accountabilities. None of the structural solutions is guaranteed to work, however, because the results depend on the quality of the discourse taking place within the various structures.

Upgrading the Quality of the Discourse

Explicit efforts can be made to upgrade the quality of the discourse that takes place within organizational structures.

- **USE ANALYSIS TO GET THE BEST POSSIBLE HANDLE ON KNOWN ISSUES:** Statisticians and data can be used to get the *best rational take on probabilities*, based on past experience, while recognizing that past experience is not a guaranteed guide to the future. Expert judgments can also be supplemented with techniques that draw on the *"the wisdom of crowds"*—large numbers of people, acting independently, engaged to assess probabilities.[9] Managers also need to wrestle with the data, continually reassessing its significance and reliability, focusing discussion on areas of *doubt* and *uncertainty*, and paying particular attention to anomalies and *dissenting viewpoints*. It is also important to *learn systematically from mistakes*. Without systematic tracking of risk-related decisions and their effectiveness and training to correct for known biases, learning is likely to be limited.
- **USE NARRATIVE TECHNIQUES TO EXPAND THE RANGE OF ISSUES TO BE ADDRESSED:** While analysis is good for dealing with known issues, it is impotent for evaluating issues that have not yet been formulated. Narrative techniques can help open up previously unimagined risks and reveal the nuances and interconnections of apparently unconnected risks. One technique is *pre-mortems*. In a pre-mortem, planners are asked to imagine that their plan has been carried out and that it has failed and to think about what might have caused the failure.[10] Where the issues involve human behavior, *role-playing* and *simulations* can help overcome the problem of the time-lag in learning from real-life experience in complex situations.[11] Research shows that role-playing can yield more accurate predictions than expert forecasts.[12]

APPROACHES FOR FIGHTING ORGANIZATIONAL COMPLACENCY	STRENGTHS	WEAKNESSES
CHANGING THE ORGANIZATIONAL STRUCTURE	**CAN** usually be implemented by organizational fiat; generate consistent and explicit exposure of the issues with clear accountabilities	**CAN** be rigid, as the efficacy depends on the quality of the discourse that takes place within the structures
UPGRADING THE QUALITY OF THE DISCOURSE	**FLEXIBLE** and generally low cost	**HARD** to institutionalize; efficacy depends on organizational values
ESTABLISHING AND DISSEMINATING ORGANIZATIONAL VALUES	**INCULCATES** capability to deal with issues throughout the organization	**VALUES** may no longer be relevant in a radically different environment
PREPARING FOR THE UNEXPECTED	**GENERATES** flexibility and creativity, leading to efficient solutions to seemingly insoluble problems	**ASSUMES** that reliable knowledge is not available; may encourage excessive use of improvisation
TRANSFORMATIONAL INNOVATION	**CAN** save an organization from irrelevance and death; requires courage, imagination, smarts, and strong leadership	**RELIABLE** knowledge is not available; involves high risk

- **TAKE ACTIVE STEPS TO ENHANCE THE FLOW OF DEBATE:** The quality of discussion can be improved and the chances of defining and mitigating risk can be increased by *encouraging open discussions*, having group leaders solicit and receive feedback and criticism from others; *ensuring a mix of disciplines*, and getting outsiders involved in the discussion, so as to generate potentially creative tension; *taking time out* to give individuals room to re-think, re-formulate, gather further data and re-present; *having non-participants explicitly assess the group's dynamics* to help flag phenomena that may be stifling debate.

Efforts to upgrade the flow of professional dialogue comprise an array of tools and techniques, none of which is "the solution," but all of which can make a contribution. The tools are flexible and generally low cost. They are, however, hard to institutionalize. Moreover, these approaches will lack robustness unless supported by strong organizational values.

Establishing and Disseminating Organizational Values

Neither structural approaches nor steps to enhance dialogue are likely to be effective unless they are aligned with organizational values. An organization may declare that innovation or safety is a top priority, but if the actions of the top management show that its real priority is meeting short-term production goals, then its declarations will have little impact.

ORGANIZATIONS NEED TO PREPARE FOR UNANTICIPATED RISKS. AFTER ALL KNOWN RISKS HAVE BEEN PLANNED FOR AND THE RIGHT STRUCTURES, DISCOURSES, AND VALUES PUT IN PLACE, THEY NEED TO BE PREPARED FOR ISSUES THAT HAVEN'T BEEN ANTICIPATED.

Values are usually established in situations where leaders have to deal with adversity. For instance, General Electric has a detailed set of policies specifying what is meant by unyielding integrity and backs them up with energetic managerial action. In 1991, for instance, when a single GE employee was found to have been involved in bribery related to the sale of airplane engines to Israel, GE swiftly disciplined twenty-one otherwise-excellent executives, including several top managers, whose only flaw was that they had not been watchful enough to detect and prevent the fraud. This GE story of principles and actions sends a clear signal about the value of integrity. Repeating the story helps establish integrity as a core value of the company.[13]

Establishing and disseminating organizational values is a powerful way of inculcating a capability to deal with difficult issues throughout the organization. However, some values may no longer be relevant when the totally unexpected happens.

Preparing for the Unexpected

Organizations need to prepare for unanticipated risks. After all known risks have been planned for and the right structures, discourses, and values put in place, they need to be prepared for issues that haven't been anticipated. Because knowledge of such events is by definition lacking, specific plans cannot be formulated, but steps can be taken to enhance the capability to deal with the unexpected.

- **DEVELOP A CAPABILITY TO SWARM:** The military has learned that top-down centralized decision makers can not deal as resiliently with uncertain battlefield conditions as decentralized units on the ground, which can respond to risks and seize opportunities as the situation evolves.[14] The same tactic can be applied in non-military settings, as NASA showed in response to the Apollo 13 problem and as a Toyota group demonstrated when it rebuilt a burned-down factory in a week.[15]
- **INVEST IN REDUNDANCY:** Super-efficient, just-in-time game plans may be good for getting results in smooth seas, but when the going gets rough, survival may depend on having extra capacity and backup. In the aftermath of both 9/11 and Katrina, cell-phone systems designed to handle normal traffic failed, greatly hampering rescue efforts.[16]

A capacity to improvise can generate flexibility and creativity, leading to efficient solutions to seemingly insoluble problems, even where advance knowledge is not available. Too much reliance on improvisation, however, can encourage ad hoc approaches to risks that should have been predicted and prepared for. And it is little help when the overall mission of the organization is in question.

Transformational Innovation

Management often involves trying doing "more of the same" but doing it better, more quickly, and more economically. Innovation is about doing something completely different. In a sense, innovation is the opposite of management and requires dissimilar techniques.[17]

Thus much of the activity that currently goes by the name of innovation hardly warrants the term. Henry Ford once said that if he had asked clients what they wanted, they would have said "faster horses." Much so-called innovation in organizations is about searching for "faster horses," that is, tame, incremental improvements that don't fundamentally change the situation, when what is really needed is something radically different—a car.

When organizations face fundamental challenges to their mission as a result of shifts in the external environment, they may need to innovate radically in order to survive. Digital Equipment Corporation had great strengths in minicomputers and kept making marginal improvements to them but was unable to adjust to a fundamental shift in the external environment—the advent of the PC. It did not survive. By contrast, Nokia began life as a collection of firms specializing in foresting, rubber, and cable manufacture; it successfully transformed itself to become a global giant in mobile phones.

Public sector organizations face similar challenges when the external environment changes or when the consensus supporting the mission unravels. They may not die abruptly like private sector firms if they fail to adjust to the new situation and transform themselves, but they will slowly decline into irrelevance.

When it comes to transformational innovation, knowledge is often the problem, not the solution. All available knowledge concerns the past and typically indicates that radical new strategies will fail, because there is no market, or existing organizational capability, or tested technology, or all of the above. Transformational innovation concerns the future about which there is no reliable knowledge. When the future is very different from the past, courage, imagination, and smarts become at least as important as knowledge.

For organizations that are in synch with their environments, transformational innovation is a matter of choice. Where the external environment has shifted significantly, transformational innovation becomes a necessity. In such cases, complacency is not an option, but neither is knowledge. Private sector organizations may face the necessity of generating a new market with radically different products, services, clients, or business models. Public sector organizations may need to face the stark reality that unless they can forge a new consensus with stakeholders, transformational innovation will be a requirement of survival.

Attacking Complacency on All Fronts

In any large organization, the struggle against complacency is an unending battle. All avenues reviewed in this article need to be exploited, including structural approaches to enhancing the sharing of knowledge, steps to enhance the quality of the dialogue that takes place within those structures, strenuous efforts to establish and transmit appropriate organizational values, explicitly preparing for the unexpected, and creating a capability to undertake transformational innovation. Organizations cannot entirely eliminate risk or complacency, but serious and thoughtful efforts to counter complacency can help bring dangers to light and reduce the likelihood of failure. ●

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Knowledge in Brief

Three Reflections on Meeting Face to Face

E-mail and virtual workspaces are important contributors to knowledge exchange in large, dispersed organizations, but face-to-face conversation adds essential depth and richness to collaboration, knowledge sharing, and trust creation. Here are three brief examples of how these conversations can be encouraged.

Gathering Under the Marula Tree (Courtesy of Rob Weare)

Namdeb Diamond Corporation of Namibia supports the creation of a knowledge-sharing culture by engaging in culturally based activities that encourage the flow of experiential knowledge and the development of cooperative relationships.

At Namdeb, the operational senior management team conducts a monthly knowledge-sharing café with all managers. They call their meeting an "Omugongo." Commonly known as the Marula, the Omugongo tree plays a central role in the community. Thanks to its thick foliage and cool shade, it has long served as the location for important community gatherings, where important issues are fully and openly discussed.

By choosing the name Omungongo for this management community gathering at Namdeb, and by insisting that the meetings be conducted in keeping with the deep cultural traditions surrounding this tree, the senior management team ensures that conversation will be rich and candid. Relevant strategic objectives and initiatives are shared, and an open and free exchange of ideas is encouraged. The lively and open discussion helps create valuable trust relationships that encourage further knowledge exchange and collaboration.

Japanese Talk Rooms

Many Japanese pharmaceutical firms have "talk rooms." These are attractive lounges where tea is served all day and researchers sit down and discuss their projects with fellow scientists in an informal, relaxed setting. People speak to different people every day, most of them strangers to each other's research. The rooms facilitate knowledge exchange and invite serendipitous creative blending of ideas at very low costs.

These pharmaceutical firms have also taken to displaying posters outside their laboratory doors that tell passers-by what the scientists are working on. This is meant to encourage any and all to stop by and chat about the work, a technique that costs nothing and can have a great pay-off.

The Wired Coffee Pot

Believing strongly in the creative value of chance conversations, managers of Xerox's Palo Alto Research Center devised a way to enhance the already powerful drawing power of free coffee. They connected the center's coffee pot

to the center's computer network so researchers would get a message on their desktops whenever a fresh pot had been brewed. That electronic announcement usually brought several of them to the coffee lounge, where they often stayed to chat about their work.

Managers put white boards around the lounge so researchers could jot down ideas and calculations. A camera automatically captured these sometimes-valuable notes and sketches, and the images were made available on the center's intranet, inviting others to comment and contribute. ●

ASK Bookshelf

From time to time, the editors will offer brief reviews of books they believe will especially interest ASK *readers. Here are descriptions of two books, very different from one another, that we admire.*

The Business of Projects: Managing Innovation in Complex Products and Systems, by Andrew Davies and Michael Hobday (Cambridge, UK: Cambridge University Press, 2006)

It is no secret or surprise that much innovative and collaborative work in organizations these days happens through projects. What is surprising is just how little has been written about the nature, structure, and economics of projects. Much of the best work in this area (some by NASA employees) has been cases and stories about successful projects. These efforts are invaluable, but there is more to be said, especially as projects become more and more common in organizations that tackle complex and innovative tasks.

Written by academics who have experience working outside the academy, *The Business of Projects* fills this need very, very well. One of the book's appealing distinctions is that it is solidly grounded in organizational learning and strategy literature of the past few decades that can be summed up as the "resource-based theory of the firm." Simply put, this stream of research focuses on organizations' capabilities, capacities, and knowledge and their appropriateness to specific tasks and environments. It shows that no organization can do everything, or even close to everything, so executives need to focus on what needs to be done and the human and social capital required for that particular work.

Using examples from high-technology, aerospace, and petroleum firms—all relevant to *ASK* readers—this book discusses exactly what project capabilities are and how they are to be understood, developed, and accurately measured.

The Business of Projects includes something too often missing in management texts: a chapter on the subject of learning. "Learning in the Project Business" is original and important. It uses some new-ish constructs from the emerging discipline of knowledge management and builds on Stanford Professor James March's distinction between exploitative and explorative learning. It would be a fine place for any newcomer to project learning systems to start their own adventures in project-land, and it would also serve veterans of project wars who have never really put in the time to figure out how best to learn from successful and failed attempts.

The book concludes with some valuable rules of thumb for doing project work. Usually such concluding messages are banal, but these are realistic and valuable—another rarity in management books!

Moondust: In Search of the Men Who Fell to Earth, by Andrew Smith (New York: Harper Collins, 2005)

Moondust is the story of Andrew Smith's encounters with the Apollo astronauts who are the only human beings who have stood on the surface of the Moon. The impetus for the book comes from the wonder he felt as an eight-year-old boy when Neil Armstrong stepped onto the moon in 1969 and his disappointment (shared by many of the astronauts) that support for human space exploration waned after Apollo.

Smith's work vividly evokes what going to the Moon was like, the skill and courage required, and the sheer exhilaration of the experience. And it captures the varied ways the astronauts have been affected by their extraordinary adventure. In the decades since, some have shunned publicity and some have sought it. Some have focused on the facts of their missions, while others describe the texture and significance of their moonwalks. Alan Bean, for instance, has become a painter who tries to capture the look and feel of the Moon in his work, and Edgar Mitchell founded the Institute of Noetic Sciences as a result of his sense of a connection to the intelligence of the universe.

Some readers have complained about technical inaccuracies in *Moondust*. This is certainly not the book to read to learn about the nuts and bolts of the space program. (Many such books exist.) It is the one to read to glimpse the transformational power of space exploration and understand the lure of traveling back to the Moon and beyond it. ●

The Knowledge Notebook

How Does a Learning Organization Learn?

BY LAURENCE PRUSAK

How comfortable do you feel sitting at your desk reading a book related to your job or your area of expertise? I mean sitting in plain view, reading most of the day, and *not* answering your phone or responding to e-mail or instant messages. If the answer is "not very" or "not at all" (which would be the answer in almost any organization I know), then how can we say you work in a "learning organization?" After all, you're reading that book to increase your understanding—to learn. And yet many organizations, public and private, that would frown on a workday devoted to reading claim that they are learning organizations and that their employees are learning all the time. How do we account for this discrepancy? Does it matter? To answer those questions, let's look at what it might really mean to be a learning organization.

The term "learning organization" has been around for twenty or thirty years and was given a tremendous boost with publication of Peter Senge's *The Fifth Discipline* in 1990. This book, a surprise best-seller, popularized the ideas of organizational learning to the extent that chief learning officers were appointed in many organizations around the world. In particular, human resources departments took up Senge's cause with passion and, more relevantly, with large training budgets to try to implement a portfolio of learning practices and policies. It became a serious management movement, and while it isn't quite as popular now as it was a decade ago, the issues it raises are still with us. Indeed, many would say that learning and related issues are even more important now than they were ten or twenty years ago.

So what did this movement stand for? It tried to popularize the notion that organizations obviously learned new things all the time. If they didn't, they would quickly expire. Just how this learning occurred, who it was that learned anything, where they learned it, and how learning should be measured were the objects of much discussion and debate. But the learning processes and practices developed in most organizations reflected the same set of beliefs: namely, that more learning is always better (increasing the value of the organization's human capital), that learning is at heart an individual activity, and that the basic mechanism for learning is some form of training. So what could be wrong with that?

Well, quite a bit. It turns out that most important learning occurs not in training sessions but on the job, with workers learning from each other by participating in and telling stories about the actual work and by reflecting afterward on what has and hasn't worked. While some of this knowledge can be and often is codified, these documented learnings are usually presented by a trainer as some form of final truth that can't be questioned—a far cry from the more subtle and flexible knowledge acquired on the job. It also turns out that learning has a significant emotional component. People learn more and more richly in real-life situations where something is at stake and the process is shared with colleagues, circumstances that usually have much more emotional content than either a classroom or a computer screen. An allied issue is trust and psychological safety. One learns best when one trusts the teacher and feels safe in questioning the material.

These findings support an even more important one: that the best and most useful learning takes place in groups, in shared practices or other networks of people. The human-capital perspective, with its emphasis on individual learning, is far less valuable than the social-capital one. Most measurable changes in knowledge and skill can be shown to be social—learned within the group by adaptation or some informal mechanism. These groups rarely learn in a planned, linear, or even intentional way, and their informality—learning in the moment and from the moment—often produces the most credible and fully assimilated knowledge. Rather than try to absorb a whole body of knowledge—some useful, some not—they learn what they need to know.

So where does this leave us? The learning organization "test" I began with—reading a book at your desk—is clearly not the answer to the learning dilemma. Yes, it does reveal the level of an organization's commitment to learning in its many and varied forms, and reading the right book can provide some important knowledge, but it clearly doesn't offer the situational social learning that has so much value.

We still need to understand more about how organizational learning happens and what we can do to ensure that it is a continuous part of the work experience. We certainly need more sophisticated methods and tools than are offered in e-learning environments or in dull training sessions that no one looks forward to and few people remember. The true learning organization is still a goal to be attained, not an accomplished fact. We need organizational leaders who genuinely value learning and support wise managerial interventions and organizational policies that foster social, work- and practice-based learning. These interventions must be designed to strengthen and scale up what are now informal and sometimes accidental processes without making them mechanical, dull, and not especially relevant to people's real knowledge needs. Finding the right approach is a challenge, but one that has to be met to create learning organizations that are worthy of the name. ●

IT TURNS OUT THAT MOST IMPORTANT LEARNING OCCURS NOT IN TRAINING SESSIONS BUT ON THE JOB, WITH WORKERS LEARNING FROM EACH OTHER BY PARTICIPATING IN AND TELLING STORIES ABOUT THE ACTUAL WORK AND BY REFLECTING AFTERWARD ON WHAT HAS AND HASN'T WORKED.

ASK interactive

NASA in the News

The United States Government Accountability Office recently released a study detailing the importance of supporting a knowledge-based acquisition framework within the National Aeronautics and Space Administration.

This report evaluates whether NASA's policy currently supports a knowledge-based acquisition approach and describes how NASA centers are applying the Agency's acquisition policies and guidance.

Read the full report online at http://www.gao.gov/new.items/d06218.pdf.

Learning and Development

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IPM 220 Acquisitions and Contracting Workshop
August 21–23, Wallops Flight Facility

This three-day course provides an overview of all phases of contracting, from requirements development to closeout. It explores vital issues project managers face and highlights your roles and responsibilities to give you greater influence over how work is performed. You will also discuss actions to help ensure contractors or subcontractors perform as required under contract.

ISE 240 Decision Analysis
August 24–25, Wallops Flight Facility

This two-day course will equip you with techniques and strategies for conducting factually based decision-making activities in resolving technical issues at NASA. You will learn how to evaluate alternative solutions using established criteria and selected methods and will experience the value of trade-off analyses, modeling, simulation, decision matrices, and other tools used in decision analysis.

IPM 290 Project Management Leadership Laboratory
August 28–31, Wallops Flight Facility

This four-day course is an intensive experience aimed at building capabilities for managerial effectiveness to achieve project team objectives and to synthesize the project management practices you have learned through practice and study. This laboratory provides a unique opportunity to identify, understand, and practice effective leadership behaviors in a project team setting.

Web of Knowledge

The Academy of Program/Project & Engineering Leadership (APPEL) has a new Web site. Read about new offerings, upcoming events, and other APPEL news online: http://www.appel.nasa.gov.

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Q:

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