

Tracking greenhouse gases from above

By Mark Whalen



Carol Lachata / JPL Photo Lab

Orbiting Carbon Observatory prepares for Vandenberg launch

The Orbiting Carbon Observatory, the latest mission in NASA's ongoing study of the global carbon cycle, is being prepared for a Feb. 23 launch from Vandenberg Air Force Base. The observatory is the first spacecraft dedicated to studying atmospheric carbon dioxide, the most significant human-produced greenhouse gas and the principal human-produced driver of climate change. This experimental Earth System Science Pathfinder Program mission will map the globe once every 16 days for at least two years with the accuracy, resolution and coverage needed to provide the first complete picture of the regional-scale geographic distribution and seasonal variations of both human and natural sources of carbon dioxide emissions.

Principal Investigator David Crisp discusses the mission with Universe.

WHY ARE PRECISE MEASUREMENTS OF ATMOSPHERIC CARBON DIOXIDE SO IMPORTANT? WHAT WILL BE LEARNED FROM THE DATA?

The primary purpose of the mission is to help us understand the processes that are controlling carbon dioxide in our atmosphere today. About 85 percent of the carbon dioxide emitted into the atmosphere by human activities is coming from fossil fuels. However, many people don't realize that almost 60 percent of this carbon dioxide is disappearing somewhere—it's being reabsorbed by oceans and plants on land.

As we've learned from a very early age, we breathe in oxygen and exhale carbon dioxide, while plants breathe in carbon dioxide and exhale oxygen. That's what is called a "carbon dioxide sink"—it absorbs carbon dioxide from out of the atmosphere.

The issue is that we don't know exactly which plants are absorbing the carbon dioxide and where they're located. And we don't even know whether land plants are more effective carbon dioxide sinks than the oceans. We don't understand those things because the current methods for measuring carbon dioxide consist of about 100 ground stations scattered around the world; they make very precise measurements but there just aren't enough measurements to resolve where the sinks are that are absorbing 60 percent of the carbon dioxide.

HOW DOES THE INSTRUMENT OPERATE?

It's an optical spectrometer that observes reflected sunlight from Earth, mostly in the near infrared. At those wavelengths, gases such as oxygen, carbon dioxide and water vapor absorb very strongly, and absorb only certain colors of light. With our measurements of those specific colors absorbed by carbon dioxide, we can monitor the amount of carbon dioxide in the atmosphere. While ours isn't the first space-based instrument to measure carbon dioxide in reflected sunlight, it will make those measurements with unprecedented accuracy.

WHAT IS THE HISTORY OF MEASURING CARBON DIOXIDE FROM SPACE?

JPL's Atmospheric Infrared Sounder instrument (on the Aqua satellite) has been measuring carbon dioxide for the last several years—but those measurements are from high levels in the atmosphere, 5 to 15 kilometers (3 to 10 miles) up, where carbon dioxide is most effective as a greenhouse gas, trapping the thermal radiation

the Earth is trying to re-emit into space. And that is a climate instrument, so it's a very relevant measurement to make. But we need a measurement that's much more sensitive, very close to the Earth.

Also, there are two other instruments that have been making measurements of carbon dioxide in the upper atmosphere, but they're not as precise. One is a National Oceanic and Atmospheric Administration instrument, Tiros Operational Vertical Sounder, that makes measurements in the thermal infrared like the Atmospheric Infrared Sounder does, but only in a few narrow channels, and it's nowhere near as sensitive.

The other is the European instrument Sciamachy, which is on the European Space Agency's Envisat, the closest thing Europe has to an Earth Observing System-type platform. Sciamachy takes a series of measurements, mainly for studying atmospheric chemistry, but also makes measurements in the near infrared, much like our mission will.

There are two fundamental differences. Sciamachy has low spectral resolution, so that it isn't very sensitive to variations in carbon dioxide, and it has a very large measurement footprint, about 1,800 square kilometers in size. The problem with such a large footprint is that you always get a cloud. So it's very difficult to analyze the Sciamachy data with the kind of accuracies needed to look for the very subtle variations in carbon dioxide that we know exist today.

We sometimes refer to Sciamachy as our engineering model. The principal investigator of that instrument, John Burrows, is on my team. We've learned a lot from them, and we've tried to design our instrument to address all the issues they have faced.

WHAT PART OF EARTH WILL BE COVERED?

The mission can measure carbon dioxide everywhere the sky is clear over Earth's sunlit hemisphere. Because the sun doesn't shine north of the Arctic Circle in the winter hemisphere, we can only measure carbon dioxide over the poles in the spring, summer and fall.

It is not a mapping mission; it actually makes measurements along a narrow swath, very much like the CloudSat instrument does. Carbon dioxide is mixed from the surface of the Earth up into the atmosphere and is dispersed over a fairly large plume, which we will sample by making measurements along our orbit track. Each measurement covers an area of about 3 square kilometers or less (about 1 square mile); typical ground tracks are about 2.25 kilometers (about 1.3 miles) long, and a tenth of a mile to a mile wide. We'll get two or three swaths across the United States every day.

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Orbiting Carbon Observatory

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WHO PROVIDED THE SPACECRAFT AND INSTRUMENTS?

Our primary partners are Orbital Sciences Corp. of Dulles, Va., who provided the standard spacecraft bus, a Leostar 2. Hamilton Sundstrand Sensor Systems of Pomona provided the instrument. In late 2006 we brought the instrument in house, mainly because we could build more parts of it in parallel here at JPL, to complete the job more quickly than at Hamilton Sundstrand's facility. Our main task here was the integration and testing of the instrument.

OVERALL, WHAT ARE JPL'S ROLES IN THE MISSION?

The science team, which was, at least initially, largely homegrown here at JPL, is international in nature. Our algorithm development team is centered at Colorado State University and is doing an excellent job for us. Our algorithm implementation team, also part of the science team, is here at JPL, along with the ground data system team.

There are about 30 full-time equivalents from JPL, with the total counting about 50 when part-timers are included.

WILL YOU BE ABLE TO MAKE CONCLUSIONS THAT WILL LEAD TO MITIGATION OF SOME SOLVABLE ENVIRONMENTAL ISSUES IN THE SHORT TERM? OR ARE THERE ONLY LONG-TERM SOLUTIONS TO THE PROBLEMS?

There are things that could be done quickly. For example, certain types of crops and trees absorb carbon dioxide very strongly; at least you could change policy right away to implement that as a sequestration source.

The countries that have signed the Kyoto protocol already have caps on carbon, and one of the interesting things about those caps and the trading system that was built up around them is that you get penalized for sources of carbon dioxide and get credited for sinks. So as we starting identifying sources and sinks, one of the first beneficiaries of that information will be countries that have signed up for treaties like Kyoto and will be able to directly determine whether or not they have an asset to sell. We might see some activity in that direction that's very short-term.

However, it's important for people to recognize that even though carbon dioxide is a very policy-relevant gas to measure in the atmosphere, this is not a monitoring mission designed to ensure treaty compliance or something like that.

We are looking for the most efficient and effective methods of limiting the buildup of carbon dioxide in the atmosphere from fossil fuel burning and we may find that there are some relatively low-hanging fruit that we can work on. For example, natural gas flaring is a major input to the system and it wouldn't take much for people to instead capture the gas and start selling it rather than burning it to the atmosphere, essentially wasting it.

IS THERE A LOT OF WORLDWIDE INTEREST IN THE MISSION?

Absolutely. I get inquiries weekly from around the world. I see a lot of interest in Europe, and a tremendous amount of interest from Japan, but that's partly because they're flying their own carbon dioxide mission, the Greenhouse Gases Observing Satellite, which launched Jan. 23. We're working as closely as possible with their team and we're hoping that by having both

satellites up at the same time we can cross-calibrate and cross-validate the measurements of both to ensure their accuracy and reliability. But also, by combining the data from ours and Japan's mission, we'll double the coverage that the satellites would individually provide for the science community.

WHAT IS THE BEST OUTCOME TO THE MISSION YOU COULD HOPE FOR?

We expect the mission to completely revolutionize our understanding of the carbon cycle of the Earth. It will do this by helping us understand spatial distribution of sources and sinks of carbon dioxide on at least regional scales. We might be able to do a lot better than that in some regions, on much finer scales. For example, if we could learn more about sources and sinks within California, that would be a great advantage.

I want to emphasize that this is an exploratory science experiment. We've never tried to make a measurement of a trace gas in Earth's atmosphere with this accuracy before.

We need to understand where in the oceans carbon dioxide is being absorbed, because that would tell us whether or not it'll stay absorbed for a long time or a short time, and that's absolutely critical to understanding how rapidly carbon dioxide will be building up in our atmosphere.

WITH THE OBAMA ADMINISTRATION NOW IN THE WHITE HOUSE, DO YOU EXPECT SCIENTISTS TO BE SOUGHT OUT FOR THEIR OPINIONS ON MITIGATING CLIMATE-RELATED ISSUES?

Yes. I do anticipate that the new administration will be making a very quick and active use of scientific information from satellites such as ours.

Dawn to swing by Mars for gravity assist

By Mark Whalen

JPL's rovers and orbiters on and around Mars will soon have some company, at least for a while.

The Dawn mission, on its way to visit two asteroids, is being readied for a Feb. 17 flyby of the Red Planet for a gravity assist to the asteroid belt. Dawn will fly to within 500 to 600 kilometers (about 310 to 370 miles) of the Martian surface to help it on its 2.8-billion-kilometer journey (1.8 billion miles) from Earth to Vesta.

"We launched in September 2007, started thrusting with our ion propulsion system in December of that year, and had a long thrust period that ended Oct. 31, 2008," said Marc Rayman, Dawn's project system engineer. "That was 10½ months of ion thrusting that put us on a trajectory to fly by Mars at the right time and at the correct angle in order to help boost us on our way.

"Ion propulsion is essential for completing such an ambitious mission," Rayman added. "Even with the extraordinary effectiveness of ion propulsion, Dawn needs the extra boost from Mars. Within NASA's constraints, it wouldn't even be possible to send a spacecraft just to orbit Vesta without ion propulsion," he said. "And we're going beyond that—we'll orbit Vesta, leave it, and then orbit Ceres."

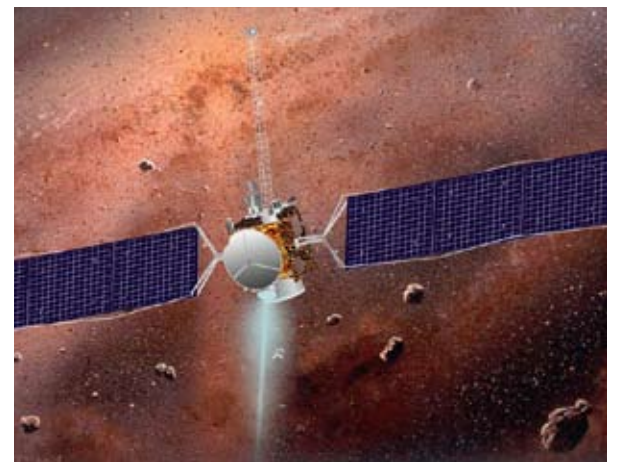
Several trajectory correction maneuvers were planned after thrusting was completed, but when the team executed the first one that was scheduled, on Nov. 20, it was so accurate that they decided not to do the second one, which would have been on Jan. 15.

There are a couple of reasons the spacecraft won't need any further such maneuvers, Rayman said. "First, we have a great navigation team that got the spacecraft correctly on course. Second, the ion propulsion system affords the mission so much flexibility that we don't have to hit the kind of narrow target at Mars that a typical mission might have for a gravity assist."

Rayman said that despite the benefit of the Mars gravity assist, a rendezvous with Vesta and Ceres requires the ion propulsion system to do most of the work. For comparison, he noted that the Messenger spacecraft, which is on its way to Mercury, needs six gravity assists before it gets into orbit. Part of that is to tip the plane of its orbit.

"We don't have enough bodies in the vicinity of the asteroid belt to do multiple gravity assists; Messenger has Earth, Venus and Mercury," he said. "We're flying by Mars mainly to change the plane of Dawn's orbit, but still a large part of the burden of reaching our targets is on the ion propulsion system. A chemical propulsion mission really would be at a significant disadvantage because it's so difficult to reach Vesta's orbit.

"Then, when it leaves Vesta, Dawn is completely on its own—we don't get to take a big rocket out there to launch it from Vesta to Ceres—there's nothing else to help us in the asteroid belt. All that maneuvering is the responsibility of the spacecraft. And the tremendous capability of ion propulsion is what allows that."



Rayman also noted that thanks to the work of many previous missions to study Mars, the planet is so well characterized that it provides a good reference target for Dawn's instruments during the brief flyby.

"We've mostly been coasting since Oct. 31," Rayman said. "Beyond Mars, we'll resume thrusting in mid-June of this year, and then we will be in powered flight for most of the subsequent 2¼ years.

"This spacecraft propels itself during much of the mission. Some spacecraft have months or years of coasting to their next target, while we have years with this gentle, whisper-like thrust gradually reshaping our orbit until we nudge up to Vesta."

For more information on the mission, visit <http://dawn.jpl.nasa.gov>.

Mars rovers celebrate five years

The young man who fell in love with Mars in the 1930s while reading Edgar Rice Burroughs novels about the planet and later grew to be one of the world's great science-fiction writers was on hand to celebrate the Mars Exploration Rovers' five years of exploration Jan. 15.

Ray Bradbury, who said at age 12 he couldn't afford the sequel to Burroughs' novel "The Gods of Mars" so he wrote it himself—his first writing project—told the von Kármán Auditorium crowd, "My life has been spent on Mars from the very first."

Bradbury related what "Brave New World" author Aldous Huxley told him following the publication of "The Martian Chronicles" in 1950.

"He said, 'Do you know what you've done, Mr. Bradbury? Do you know what you are? You're a poet. You've written about Mars, but it's poetry, for god's sake. This book is going to be around forever.'"

"I didn't realize that in my 30s I was writing about the future," Bradbury said.

The event also included a congratulatory video from International Space Station astronaut Mike Finke as well as proclamations commemorating the anniversary from local, state and federal politicians. In attendance were La Cañada-Flintridge Mayor Stephen Del Guercio, Pasadena Mayor Bill Bogaard and Los Angeles County Supervisor Mike Antonovich, along with representatives of congressmen Adam Schiff and David Dreier, State Senator Carol Liu and Assemblyman Anthony Portantino.

For more information about the rovers' fifth anniversary, visit <http://www.jpl.nasa.gov/news/features.cfm?feature=2006>.



Carol Lachata / JPL Photo Lab

Science-fiction author Ray Bradbury addresses the Mars Exploration Rovers team.

Reporter's notebook: public loves the rovers

By Mark Whalen

On the occasion of the fifth anniversary of the landing of JPL's Mars Exploration Rovers in January, former CNN correspondent Miles O'Brien stopped by the Laboratory to deliver the keynote address to a gathering of the rover team. Universe caught up with O'Brien—whose tenure at CNN ended in December—for his impressions of how the mission has resonated with the American public.

IN YOUR EXPERIENCE, WHERE DOES THE MARS ROVER MISSION RANK IN TERMS OF BOTH POPULARITY AND SCIENTIFIC SIGNIFICANCE?

This is the gold standard; this is what people want to hear about. The average person probably has inch-deep, mile-wide interest in NASA in general. But these are the missions—the ones that transform them and take them to another world—that really get the juices flowing. People see a picture of Spirit or Opportunity, or Victoria Crater, and they can see themselves there in hiking boots.

We take for granted the flood of images we have at our fingertips that take us to Mars or other planets. It's amazing to be alive at this time, and I think people get that, and really respond to the mission and in a sense have a bit of fondness for robots. It's like Wall-E.

DO YOU GET A SENSE THAT THE AUDIENCE APPRECIATES NOT JUST WHAT WE'RE DISCOVERING ON MARS, BUT ALSO THE INCREDIBLE EFFORT JPL FOLKS PUT IN TO DESIGN THE MISSION, BUILD IT, TEST IT AND GET IT THERE SAFELY ... DO PEOPLE THINK ABOUT THAT?

Whenever I have done a story, I do my best to tell that part of it. What's interesting is that JPL doesn't try to soft-pedal the risks; I admire that. Maybe it's because they're unmanned missions, but I think there's a little more intellectual honesty about telling people how difficult it is. And in so doing, you bring people into the tent; they're more a part of it, because they're part of the suspense.

FOR THE MEDIA IN GENERAL, IS SCIENCE FROM PLACES LIKE JPL AND NASA UNDERREPORTED? IF SO, WHY? IS IT LACK OF AUDIENCE OR SPONSORS AROUND YOUR SEGMENTS?

Well, that's interesting because at CNN we never had difficulty getting a sponsor for our content, which is science and technology. You can imagine how easy it is to



Carol Lachata / JPL Photo Lab

sell this stuff to a potential advertiser. The problem is complicated. One of the issues is these newsrooms are run by a bunch of science-phobics—these are all the political science and history and English majors, who didn't do well in science; that's why they're in the news business.

This has something to do with the way we're taught science and the way people perceive science. Think of scientists depicted in white lab coats and all the other nonsense associated with science, and what we venerate in our culture.

That spills into the editorial consciousness, so as a result, you're starting in a hole every time you come to them with a science story and they say, "You have to convince me that it's interesting." Whereas, when you come to them with a political story they're predisposed to run it anyway. It's a deep cultural thing.

Couple that with a business that is crumbling right beneath their feet. And all the business models they have risen on are being questioned; frankly, every person with a blog or Twitter account and a digital camera and a Macintosh is actually able to compete. It's really amazing and exciting. There's an army of citizen journalists out there who are changing the whole world.

That has management panicked, and they're retrenching in many respects; certainly this is very true with newspapers right now.

So I think it's a combination of a cultural bias against science, along with some financial realities.

CNN WAS CONSIDERED BY MANY TO BE THE CLEAR LEADER IN SCIENCE AND TECHNOLOGY REPORTING. WHAT'S YOUR UNDERSTANDING OF THEIR DECISION TO LET YOU GO? DID IT SURPRISE YOU AT ALL?

No. When they eliminated our show Science and Technology Week we knew that was a bad sign. The current management, for whatever reason, has decided that this is not a priority. It's their pop stand, I understand.

I think it's unfortunate timing because, frankly, we have had eight years of an administration that has done everything it could to minimize and ignore science and scientists. Now there's a new administration that actually sees advancement in this realm—the environment, green technology, space—as a way of weaning ourselves from fossil fuels, retooling our economy and getting us out of this recession.

It's interesting that at a time when it's finally ripe for renaissance, the decision is made to cut. But we're not the only ones.

So in that sense I'm a bit perplexed by it, but I had seen for a long time how difficult it was for us to get our stories on the air. So I knew there was trouble brewing.

HAVE YOU LANDED ON YOUR FEET? WHAT'S NEXT FOR YOU?

First of all, they've got to pay me for two years, which is nice—that's like hitting the Lotto, right? But I've been overwhelmed with interesting, intriguing, flattering, sometimes off-the-wall offers. It's been great.

I just signed a deal with PBS to do a documentary on rebuilding America's infrastructure; I'm going to start shooting that very soon. I've been talking to other networks, and I've been considering ideas on Internet streaming; I may just go to the next launch and stream it out myself.

It's a different world and it's really exciting in many ways. The hardest part has been figuring out what I want to do the most.

It's weird, with the plane crash in the Hudson River in New York today [Jan. 15] ... it's hard to kind of disengage that itch to call my buddies and get this thing going. But, you know, it's also nice to be here visiting at JPL.

News Briefs



Rosaly Lopes



Tom May



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Phoenix wins exploration award

The Mars Phoenix lander team has been named to receive the Space Foundation's 2009 John "Jack" Swigert Jr. Award for Space Exploration.

The Phoenix team, which includes members from NASA, Lockheed Martin and the University of Arizona, will receive the award in March at the National Space Symposium in Colorado for the design, development, launch, landing and operation of the Mars lander.

The award honors Apollo 13 astronaut Swigert and is presented annually to the person or organization that has made the most significant accomplishments in advancing space exploration.

Women's group honors Lopes

Rosaly Lopes, a volcanologist in the Geophysics & Planetary Geosciences Group, has been honored by Wings WorldQuest, a not-for-profit organization dedicated to promoting the contributions of women explorers.

At the organization's recent Women of Discovery awards ceremony, Lopes won the Wings WorldQuest Award for Air & Space. The citation noted "Lopes has led the NASA teams exploring Jupiter's volcanic moon, Io, and has become a specialist on the hazards from lava flows, traveling to erupting volcanoes all

over the globe." The awards acknowledge excellence in fields related to international exploration, honoring research, adventures and pioneering discoveries of women that have led to global and scientific advancement.

Kudos to Naderi, Casani

The American Institute of Aeronautics and Astronautics recently announced 2009 honors to Firouz Naderi, JPL's associate director for project formulation and strategy, and John Casani, special assistant in the Office of the Director.

Naderi was designated a fellow, an honor bestowed to members who have made notable and valuable contributions to the arts, sciences or technology of aeronautics and astronautics. Casani was named honorary fellow, granted only to "preeminent individuals who have had long and highly contributory careers in aerospace."

Presentation of the honors will take place May 13 in Washington.

JPL prominent at museum

"Data + Art: Science and Art in the Age of Information," which explores the hidden stories revealed in data through emerging forms of expression, and "Eye in the Sky," an exhibition about JPL's Mars Reconnaissance Orbiter, are currently featured exhibits

Remembering Dr. King



Dutch Slagter / JPL Photo Lab

Martin Luther King Jr. and President Obama are reflected on the screen in von Kármán Auditorium during JPL's annual tribute to the civil rights leader, held Jan. 12. At the podium is Dana Howard, a subcontracts manager in Section 2622, who spoke at the event. Featured was an art gallery that paid tribute to heroes and heroines who contributed to positive change in the United States, as did members of JPL's affinity groups: the Advisory Council for Women, African American Resource Team, Amigos Unidos, Asian American Council and Spectrum. The presentation will be posted on the Diversity & Inclusion Oversight Committee site at <http://br.jpl.nasa.gov/diversity>.

at the Pasadena Museum of California Art through April 12.

Curated by JPL's Dan Goods and David Delgado, "Data + Art" challenges viewers' assumptions by exploring the beauty inherent in data, asking them to see complexity in a new light. "Eye

in the Sky" showcases the JPL spacecraft that launched in 2005 and has the most powerful telescopic camera ever sent to another planet.

For more information, visit www.pmcaonline.org.

Passings

Tom May, 63, manager of JPL's Business Opportunities Office, died Jan. 12.

May, who joined JPL in 1976, had managed the Business Opportunities Office since 1978. Among the honors for his professional excellence and leadership were the U.S. Small Business Administration's Procurement Advocate Award, Prime Contract Advocate Award and Lifetime Achievement Award. He was also recognized as one of the Minority Business & Professionals Network's Fifty Most Influential Minorities in Business. In 2007, May earned his second NASA Exceptional Service Medal and was the recipient of the U.S. Small Business Administration Legacy Award. He was also credited with JPL receiving the Small Business Administration's Eisenhower Award for Excellence—the SBA's most prestigious award—in 1996, 2003 and 2008.

May is survived by his wife, Diane, sons Augustine and Thomas Jr., and three grandchildren. A memorial service was held Jan. 24. In lieu of flowers, the May family has asked that donations be made to the Pasadena Humane Society or any local K-12 school.

Eleanor Helin, 76, an astronomer renowned for discovering hundreds of asteroids and comets and leading programs in ground-based astronomy, died Jan. 26.

Helin was credited with discovering or co-discovering more than 800 asteroids and comets, many of which she named in honor of JPL employees.

During her JPL career of more than three decades, Helin in the 1970s initiated the Palomar Planet-Crossing Asteroid Survey from Palomar Observatory, which has uncovered thousands of asteroids; organized the



Eleanor Helin

International Near-Earth Asteroid Survey during the 1980s, stimulating worldwide interest in asteroids; and led the Near-Earth Asteroid Program at JPL, for which she received JPL's Award for Excellence in recognition of her leadership. She also earned NASA's Exceptional Service Medal. Services were pending.

Reynaldo (Phil) Salazar, a metal cutter in the Technical Inventory Management Section, died Nov. 25.

Salazar had worked as a contractor at JPL since 1995 before becoming a JPL employee in April 2008. Memorial services were held in December.

George Gale, 92, a retired Deep Space Network staff member, died Dec. 12.

Gale joined JPL in 1967 and retired in 1981. He worked at the communications complexes at Goldstone, Calif., Madrid, Spain and Canberra, Australia, and was recognized by NASA for developing a flow rate switch during his years at JPL.

He is survived by children Maryanne, Frank, Donald and Shirley, 10 grandchildren and two great grandchildren. Services were held in Portland, Ore.

Lloyd Adams, 74, a retired senior optical engineer, died Jan. 10.

Adams worked at JPL from 1961 to 1998. He worked on many of the imaging cameras developed at JPL from Mariner '64 through the Cassini Imaging Science Subsystem. He is survived by his brother Jack and sister Gail.

Salvatore Rocci, 85, a retired Deep Space Network antenna designer/builder, died Jan. 14.

Before joining JPL, Rocci was an engineering manager for antenna builders Blaw-Knox and Rohr Industries, companies that designed and built JPL's 26-meter and 64-meter antennas.

Rocci worked at JPL from 1979 to 1993 as supervisor of the Antenna Mechanical Engineering Group, and was responsible for the 70-meter expansion of the 64-meter antennas at Goldstone, Madrid and Canberra. He also managed the installation of the new generation of 34-meter antennas at all three sites.

Rocci is survived by children Carmine, Maria, Anthony, Ron, Susie and Mike, and 23 grandchildren. Services were held in San Diego.

nary. His spirit will always be with us. I apologize for this delayed thank-you note. I hope you understand. Happy holidays! In Christ's love,

Jean

I'd like to thank Section 335 and Division 33 for the lovely plants and expressions of sympathy on the losses of both my father and my mother. They are together now and at peace. Thank you all so very much for your kindness and understanding during their illnesses and the weeks and months that followed after their deaths. I'm truly blessed to have such wonderful friends and co-workers. Thank you again.

Joanne Nakayama

We would like to thank our JPL colleagues and friends in the Transportation Office, mailroom and Ethics Office for their support and condolence messages on the recent passing of our beautiful baby granddaughter. On behalf of our entire family we appreciate all the flowers, cards and the beautiful plant from JPL in her memory. Jasmine will be sorely missed and forever in our hearts!

Enrique and Martha Avina

I would like to express my sincere thanks to my friends and colleagues in the Astronomy and Physics Directorate for their expressions of support on the passing of my mother. I was humbled by the kind and comforting words sent my way, and touched by the beautiful plant.

David A. Imel

I would like to thank my JPL family for the lovely ficus tree sent on the recent passing of my father-in-law, Bob Cloud. He was a wonderful, kind man who will be missed by all. Special thanks to my colleagues in Section 26 for their support and words of encouragement.

Debbie Cloud

Letters

To JPL/JPL colleagues: Thank you very much for attending Guy Man's memorial service, sending sympathy cards and the beautiful plant. It has been more than six months since Guy went to heaven. We've never been parted for that long. Knowing that he is not coming back physically is very hard for me to accept. Guy had accomplished what he was sent down here to accomplish beyond the ordi-