Researchers develop what may be world's smallest robot

Robot described as being able to 'turn on a dime and park on a nickel'

By Chris Burroughs

What may be the world's smallest robot — it "turns on a dime and parks on a nickel" — is being developed by Sandia researchers.

At 1/4 cubic inch and weighing less than an ounce, it is possibly the smallest autonomous untethered robot ever created. Powered by three watch batteries, it rides on track wheels and consists of an 8K ROM processor, temperature sensor, and two motors that drive the wheels. Future enhancements being considered include a miniature camera, microphone, communication device, and chemical micro-sensor.

"This could be the robot of the future," says Ed Heller (1763), one of the project's researchers. "It may eventually be capable of performing difficult tasks that are done with much larger robots today — such as locating and disabling land mines or detecting chemical and biological weapons."

He says it could, for example, scramble through pipes or prowl around buildings looking for chemical plumes or human movement. The robots may be capable of relaying information to a human-manned station and communicating with each other. They will be able to work together in swarms like insects.

The mini-robot has already successfully maneuvered its way through a field of dimes and nickels and travels at about 20 inches a minute. It can sit comfortably on a nickel.

The newest mini-robot research continues work started in Intelligent Systems Sensors & Controls Dept. 15211 by Perry Molley (now 2331), Tom Webber, and others. In 1996 the department unveiled a Mini Autonomous Robot Vehicle (MARV), a one-cubic-inch robot that contained all the necessary power, sensors, computers, and controls on

(Continued on page 4)

MINI-ROBOT RESEARCH — Doug Adkins (1763) takes a close-up view of the mini-robots he and Ed Heller (1763) are developing. At 1/4 cubic inch and weighing less than an ounce, they are possibly the smallest autonomous untethered robots ever created. (Photo by Randy Montoya)

Sandia LabNews

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Sandia National Laboratories

Domenici upbeat on Sandia, budget, future, concerned about energy crisis

Senator's colloquium gets appreciative, standing-room-only audience

By Ken Frazier

Sen. Pete Domenici had only to walk down the aisle of Sandia's Steve Schiff Auditorium Monday afternoon, Jan. 15, to get his first burst of applause from the overflow crowd of Sandia employees.

PETE DOMENICI makes a point at the colloquium.

Perhaps it was merely relief that he was back on his busy schedule and feeling good after spending the previous Friday night in the hospital for observation. Perhaps it was in gratitude for Domenici's strong support for Sandia and the national labs. Whatever the reason, it set the tone for an upbeat, at times even boisterous, colloquium by the Republican senator from New Mexico.

Domenici spoke with pride of "the very powerful budget bill" that has brought the highest-ever budget to DOE's defense programs (and Sandia). He praised Sandia and its long-time leadership ("51 years at Sandia! What a wonderful thing to say!"). He said he wanted to make sure Sandians were happy in their jobs and that morale is good. He pledged to help work around an eleventh-hour-passed legislative measure to have even larger numbers of national labs employees take annual polygraph tests.

He also called for massive new investments in infrastructure at the national labs. He praised Sandia's future MESA facility for advancing cutting-edge microsystems and microelectronics. He pledged to keep pushing DOE to improve Sandia's pension plan. He called Sandia's work in establishing new spin-off compa-

(Continued on page 4)

Special Labs Accomplishments issue

In a special 16-page center pull-out section following page 4, the *Lab News* presents its annual Labs Accomplishments issue, featuring key achievements submitted especially for this publication by division VP offices.

The accomplishments presented here represent work completed during the fiscal year ending Sept. 30, 2000. In the photograph at left Kevin Krenz (8420) looks at the chamber of an extreme ultraviolet lithography device, one of the key new technologies mentioned in the section.

Endeavour space mission

Last month's space shuttle Endeavour mission to the International Space Station used an experimental Sandia camera. Read about the mission and Sandia's involvement in John German's story on the back page.

Sandia, Celera, Compaq join forces to create superdupercomputer for biotech applications

Goal is 100 TeraOPS, with possibility of 1,000 TeraOPS

By Howard Kercheval

DOE announced in Washington Jan. 19 that Sandia, Celera Genomics, and Compaq have entered into a cooperative research and development agreement (CRADA) to develop the next generation software and computer hardware solutions specifically designed for computational biology and a full range of life sciences applications.

Labs Director C. Paul Robinson signed the agreement with Celera in a ceremony at DOE headquarters. Compaq will provide the project technology.

The goal is to increase computing capability to 100 trillion operations per second (100 TeraOPS). By sharing some computing technology developed by Sandia, Celera and Compaq may ultimately reach the "petacruncher" (1,000 TeraOPS) level.

This level of cooperation is necessary to meet the dramatic increases in performance required for emerging genomics and proteomics applications at affordable prices and brings together the capabilities of three leaders in bioinformatics, high-performance computing, and massively parallel systems.

Proteomics is the study of the function, structure, and interactions of proteins in cells, including humans and other organisms.

"The next stage of the biotechnology revolution that was started by the Human Genome Program will be fueled by the successful marriage of molecular biology with high-performance comput-

(Continued on page 6)

This & That

Colorful braggin' — This issue contains our annual Labs Accomplishments special insert — in full color — summarizing our top technical and administrative accomplishments. It is in effect Sandia's "annual report" and is well worth your reading time if you want to know what this great laboratory accomplished in FY2000. It's an impressive collection, as usual.

It takes the cooperation of many Sandians to produce this insert, and we thank everyone involved. *Lab News* writer Bill Murphy did most of the work on our part. If you need a few extra copies to share with your customers or friends, call Iris Aboytes (12640) at 844-2282.

And, how can we afford the color printing? We've arranged for all Sandia VPs to forgo a salary increase this year to cover our increased printing costs, but we haven't yet determined who's going to tell them.

* * *

No flogging, though — Imagine my surprise when I read in the Dec. 31 *Parade Magazine* that a Michigan judge had ordered a teenager to listen to two hours of Wayne Newton songs as punishment for blasting rap music from his car. Here, reprinted from the June 16, 2000, *Lab News* is my own (original) suggestion for punishing people who play rap or rock music loud enough for me to hear if my car window is rolled up: "Public flogging while listening to Wayne Newton singing *Danke Schoen* at full volume ...." Maybe I could sue him for judicial plagiarism or some such high offense.

* * *

Sandy the singing Sandia retiree — Speaking of music, Sandia retiree Sanders (Sandy) Dolce recently brought me a copy of a CD he recorded after some encouragement by his wife, Kay. Sandy, who worked for most of his 27-year Sandia career in the weapons area and retired in 1994, has been writing songs and singing since the early 1950s, and Kay gave him a surprise gift several years ago — arrangements for him to record many of his songs. Sandy and Kay live in Albuquerque, and I'll bet he'd be glad to tell you more about his 30-song CD, "Sandy Dolce Sings His Songs." After listening go it, I'm not sure he will become a major threat to Wayne Newton or Puff Daddy, but it's obvious Sandy loves his musical hobby and had a real blast recording his songs. His phone number: 505-299-8801.

* * *

Family car wars — Several years ago, I sponsored a "crummiest work car" contest for Sandians who are proud of driving their "extended-life vehicles." Jerry Hanks (12141) didn't have it then, but he thinks he may have a contender in his 1982 Subaru if we have another contest soon. He says he avoids driving it on roads with salvage yards for fear that a giant arm may come over the fence and try to capture it.

Jerry says he's the third family member to own the oxidized little yellow jewel, which he lovingly calls "pigpen." "The deal is whoever gets it has to keep it running for another year before the next poor family member has their turn," he says. Brother Ken Hanks (12142) may inherit pigpen next year, Jerry notes. The car recently passed the county emissions test on the fourth try after a "minor $426 tune-up," he adds.

— Larry Perrine (845-8511, MS 0165, lgperri@sandia.gov)

Sandia LabNews

Sandia National Laboratories

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LOCKHEED MARTIN

Flu shot clinic Feb. 9 for Sandia retirees, spouses, contractors, children

It's not too late to get your flu shot! Lovelace will offer flu shots to Sandia retirees, spouses, contractors, and children age nine and older at the Coronado Club on Friday, Feb. 9, from 1 to 4 p.m. The vaccinations are free to Lovelace HMO and TOP members but you must show your ID card to receive the free vaccination. The cost to all others is $10

Retiree deaths

Dorothy E. Holloman (age 76).....Aug. 10
Nelle Satathite (84).....Oct. 12
Gordon C. Gaskill (78).....Oct. 16
Gabriel M. Baca (87).....Oct. 18
Frank A. Maestas (75).....Oct. 18
George W. Stohner (77).....Oct. 18
Thomas J. Brooks (83).....Nov. 1
Betty M. Sterling (75).....Nov. 9
Charles I. Westmark (71).....Nov. 10
Patricia A. Carothers (60).....Nov. 11
Robert G. Fleming (73).....Nov. 11
Joe M. Holcomb (77).....Nov. 12
Paul E. Matson (78).....Nov. 19
Ricarda Gallegos (78).....Nov. 20
L. K. Renfro (81).....Nov. 23
Vernon L. Barcafar (85).....Nov. 28
Charles J. Kaspar (88).....Nov. 30
Henry F. Bacon (89).....Nov. 23

SCN InfoDay shows off classified networking capabilities at Labs

An e-mail message sent from Sandia/California and received at Sandia/New Mexico isn't usually an occasion for applause. At the Sandia Classified Network (SCN) InfoDay sessions last month, however, many audience members clapped when they saw the brief message get through.

"Part of the audience was obviously skeptical about how well classified e-mail works," says Fran Current (8935), project lead for InfoDay planning.

New, improved classified computing

Classified e-mail was just one of the capabilities demonstrated at three SCN InfoDay sessions in December. More than 360 Sandia scientists, engineers, and managers at the New Mexico and California sites had a chance to look at new and improved classified computing services ranging from the Technical Library's classified online catalog to engineering applications to Classified Web FileShare.

The video- and computer-linked connection between New Mexico and California during SCN InfoDay made use of classified videoconferencing and a secured version of NetMeeting, a popular desktop collaboration tool. "Besides the demonstrations themselves, the fact that we had presenters and audience members participating fully at both sites helped show what can be done in the classified world now," says Fran, who served as emcee during the three half-day sessions.

Among other topics covered were access to several classified information resources, the use of "thin clients" (small diskless desktop devices) to connect to the SCN, and modeling and simulation tools. Many of the SCN-based services have existed for some time but are now available through faster or more convenient interfaces.

Nuclear Weapons Program Senior VP Tom Hunter (9000) and other managers representing the Nuclear Weapons Strategic Business Unit and Integrated Information Services also spoke, stressing the importance of the SCN for carrying out Sandia's core missions.

A better, more productive environment

The SCN Infrastructure Integration Project, led by Robyn Hartley (9336), is working to create a production-quality environment for the Sandians doing classified computing. "Some of what the team is doing, such as a new SCN home page, is immediately visible to users," says Robyn. "Other aspects are not directly visible but are resulting in more reliable service and well-defined processes that make the SCN a better, more productive environment."

Another visible — or audible — change is that the Corporate Computing Help Desk (CCHD) now takes calls for assistance with many SCN requests and problems. Coverage of the SCN, though not yet as comprehensive as for the unclassified networks, is steadily broadening and provides a one-number (845-2243) contact point. Customers must be careful not to mention any classified information when they call for help.

To give a boost to potential SCN users in getting on the network and benefiting from its services, an unclassified SCN Jumpstart Web site is available on the Sandia Restricted Network. From the internal home page, click the "S" index button and scroll down to "SCN Jumpstart."

— Charles Shirley

Recent Patents

John Torczynski (9113): Spin Coating Apparatus.

James Allen (1749), Ernest Garcia, and Marc Polosky (both 2614): Surface Micromachined Counter-Meshing Gears Discrimination Device.

Ronald Manginell and Gregory Frye-Mason (both 1764): Chemical Preconcentrator.

Jonathan Weiss (1739): Fluorescent Optical Liquid Level Sensor.

Unique instrument completes climate study comparison

Lidar automatically profiles water vapor in atmosphere at 120-foot increments

By Nancy Garcia

Imagine being able to watch moist air gather and dissipate in Paradise Hills from Albuquerque, or from Livermore to Dublin, through night and day, for more than a decade.

Climate scientists are receiving a heady long-range data stream from the lower atmosphere thanks to a unique instrument created by Sandia scientists and installed at a DOE weather research station in Oklahoma. The device, recently rigorously compared with other weather research instruments, measures water vapor up to the upper edge of the troposphere, some eight miles above ground.

Since humidity traps the sun's warmth and shifts over time, this understanding will assist predictions of the greenhouse effect and global warming. "Water vapor is the primary greenhouse gas," explains John Goldsmith, Manager of Combustion Chemistry Dept. 8353, who counts the time he spent developing this instrument as among the most satisfying in his 20 years at Sandia.

Sandia CaliforniaNews

A laser spectroscopist by training, John had created combustion diagnostic devices using similar technology prior to this project, installed in 1995 after a preceding Sandia/NASA collaboration that focused on developing the necessary technology.

'Neat research opportunities'

The instrument identifies water vapor by pulsing laser light for billionths of a second, then recording the light that is scattered back, some of it slightly shifted in wavelength by the molecules of water and nitrogen in the atmosphere. This technique, called Raman lidar, "opened up a lot of neat research opportunities," says instrument mentor Tim Tooman (8120), who estimates he's spent seven months at the Oklahoma site over the last five years. "It's a very useful thing." For instance, the surface of the moon was mapped with a backscatter lidar by NASA's Clementine spacecraft.

The lidar system at the Oklahoma site actually profiles the atmosphere, bracketing readings every 120 feet (as if someone could climb a ladder with rungs 120 feet apart and record water vapor at each layer). Being able to reach the upper levels of the troposphere is important, because this is where sunlight first encounters climatologically significant quantities of atmospheric water.

"LAB IN A BOX" — The moisture-monitoring lidar system resides in Oklahoma in a re-fitted cargo container, customized with heating, cooling, power, and an instrument table so the sensor can operate automatically around the clock.

Aside from being able to provide valuable data, the instrument has also been subject to three studies that compared water vapor measurement techniques. "At the moment," says Tim, "we've taken essentially every important, fieldable instrument that measures water vapor and compared them to each other."

Tim and John each spent a week in Oklahoma in December during the last phase of the third study, along with researchers who supported the other instruments and met daily for discussion of scientific issues. In this phase, two more lidars were used. One was taken aloft on the NASA DC-8 jet to study water vapor above and below the aircraft, which was piloted in a column of airspace above the site at night (when sunlight does not reduce the maximum altitude that can be measured by the Raman lidar). John, a pilot, enjoyed coming along in the cockpit jump seat.

Multiple simultaneous measurements

The objective was to have the instruments all measuring the same atmosphere at the same time, Tim said, since every instrument has measurement errors and intercomparisons help show how accurate each is.

"In a sense," he says, "we're the one to beat." The lidar, housed in a revamped cargo container, has been optimized to now operate continuously more than 90 percent of the time and is being improved even further. For instance, in this rural setting, every day or so the voltage would falter for a few thousandths of a second, which used to cause the laser to shut off until power-conditioning units were added.

John wrote the software that runs the instrument and is helping improve software that analyzes the data. Measurements obtained during the fall Intensive Observation Period will be evaluated over the next couple of years, and DOE has extended the initial 10-year Atmospheric Radiative Monitoring project another 10 years due to the promise and complexity of the overall research. After an interval leading a team on another project, John was excited to get back involved with the lidar and pleased with the way the unique instrument operates itself. Says Tim, "You'd just come and watch it run."

Dec's diesel research paper earns SAE honor

Society of Automotive Engineers announces award

John Dec (8362) essentially rewrote textbooks when his diesel engine studies revealed a new conceptual model for how diesel combustion occurs. Now a research paper that expands on that model and points to promising directions for reducing soot emissions has received a merit award from the Society of Automotive Engineers (SAE) for making an original contribution to the subject of diesel combustion.

John and his co-authors received one of 14 Arch T. Colwell merit awards out of more than 2,160 papers published for SAE meetings in 1999, and will receive a certificate at an honors convocation March 6 in Detroit.

John's paper was co-authored by Cummins Engine Co. colleagues Patrick Flynn, Russell Durrett, Gary Hunter, Axel zur Loye, and O. C. Akinyemi, and Charles Westbrook, a chemical kinetics modeler at Lawrence Livermore National Laboratory. It is titled, "Diesel Combustion: An Integrated View Combining Laser Diagnostics, Chemical Kinetics, and Empirical Validation."

The paper combines John's conceptual model of a reacting diesel fuel jet with Westbrook's chemical-kinetics models to show how the soot-formation zone stabilizes. It then goes on to show how, in this combustion environment, adding oxygenates to the fuel reduces soot formation. Their results explain the main mechanism for the soot reduction that has generally been observed with oxygenated fuels. They are also in very good agreement with experimental data in the literature about the amount of oxygenate required to eliminate soot formation. John says more development of this approach is needed before any commercial application, but the work indicates what directions to take.

Selected over a two-year period by a review committee, from a pool of papers provided by a prescreening process, the paper was presented at the SAE International Congress and Exposition in March 1999. In addition to the contributions of co-authors, John says the paper draws on the work of Dennis Siebers (8362), whose research has lead to the development of a scaling law for diesel jet penetration and the rate of air entrainment.

This is the ninth recognition John has received from the SAE, including fellowship in the society, two other awards for outstanding papers, and five awards for presentations. The latest presentation award, announced last month, is an "Excellence in Oral Presentation" award for the March 2000 presentation of his SAE paper entitled, "The Effects of Injection Timing and Diluent Addition on Late-Combustion Soot Burnout in a DI Engine Based on Simultaneous Imaging of OH and Soot." — *Nancy Garcia*

New fiber-optic classified video system recognized at Pantex plant site

A team of Sandia/Californians and the Pantex TriLab Sandia Office manager were recognized by Mason & Hanger recently for their efforts in developing and fielding a new fiber-optic classified video system. The system is a product of Sandia's recent efforts to provide systems engineering solutions in response to Pantex plant needs. It was developed because of the need for close monitoring of critical classified operations under potentially hazardous conditions.

According to Pantex Deputy General Manager Jim Angelo, "The success of this demonstration was exceptionally noteworthy in that it reduced the number of required visitors [in the operations bay], improved the visual access to the [W88 DOE readiness assessment/nuclear explosive safety study], and provided a playback capability. As a result, the quality of readiness reviews in the future will be greatly enhanced." Pantex is currently evaluating the use of this system for W56 war reserve activities.

The concept for the secure video system, dubbed COViS, for Classified Operations Video System, was researched and managed by Bill Wilson (2250) and Sandia TriLab Office manager John Duncan (2252), who also coordinated the safety approval process. Robert Kinzel (8415, formerly 2253) was responsible for technical design, fabrication, and personnel training for the portable system. Additional management oversight was provided by Anton West (2253). All four team members were awarded Individual Performance Awards by Mason & Hangar in recognition of their "personal commitment, dedication, and outstanding performance."

Domenici upbeat

(Continued from page 1)

nies and in creating cooperative research and development agreements with existing companies a "shining light." And he spoke urgently of the new energy crisis and the need for straight talk to Americans about priorities, including the need to resume mining coal to reduce over-consumption of natural gas and the necessity of getting Americans to overcome their fears of nuclear power.

And he said he planned to work closely with Spencer Abraham, the new secretary of energy, and Gen. John Gordon, head of the semi-autonomous National Nuclear Security Administration within DOE, to help them carry out their responsibilities. "He [Gordon] will literally manage the science-based stockpile stewardship program and the nuclear weapons program separately from the rest of DOE."

And in answer to a question at the end, Domenici said he intended to run again for another six-year term as US senator in 2002.

Afterward, Labs Director C. Paul Robinson, who introduced Domenici at the colloquium as "our very good friend" and the prototype of a "uniter not a divider," told local media that Domenici had put on a "terrific colloquium" and been "in rare form."

Domenici himself said it had been "an exciting day." He marveled that when he speaks to "all these serious Sandians" he gets more laughs than from any other audiences.

Some elaborations and additional points:

Budget: "I am proud that we put out a very powerful budget bill, especially for science-based stockpile stewardship," Domenici told the colloquium audience. "We ended up with a very good and energetic budget, the best we've had for Sandia for many years," he added at the subsequent news briefing. "And we broke the $5 billion barrier for defense DOE work' [for the whole nuclear weapons complex].

Pensions: He knows Sandia's pension plan is not as good as that of the other two national weapons labs. "We're not up to snuff on it. We are pushing them [DOE] very hard. I'm going to say we are going to get that done. We've got to fix this too." He noted that "we've fixed it a bit" — the pensions for retirees were increased on a sliding scale from 3 to 18 percent (those who retired in 1983 or earlier getting the largest increase) in late October (*Lab News*, Nov. 3), but he said he will continue to work on improvements that will affect current employees.

Polygraph tests: "We don't need so many of you to get annual polygraph tests," he said, to another round of applause. He said he is familiar with all the evidence about the problems with polygraphy. Nevertheless, a new legislative requirement expanding polygraph tests at the national labs was added onto a popular amendment on another topic and passed with little notice in the last Congress. "We have to fix that in our own little way," he said. "I hope we can put some common sense into that issue very quickly. Let's hope."

HIGH-POWERED DUO — Sen. Pete Domenici and Sandia President Paul Robinson brief local news media in the lobby of the Steve Schiff Auditorium following Domenici's Jan. 15 Sandia colloquium. (Photo by Bill Doty)

Tax surpluses: The projected huge budget surpluses are real and provide new opportunities to pay down the Social Security debt, provide more defense funding, pay for Medicare and prescription drugs, and increase federal funding for education from the current 8 percent share to around 9 percent. "It [the projected surplus] is a brand new event, but a big one."

National labs' infrastructure: "When we see the size of the surplus," he said, "I'm for building the infrastructure of the United States laboratories quickly." At the news conference he said he has talked with NNSA's Gordon about the need for investment in new infrastructure at the labs. "He [Gordon] is convinced that there is a desperate need for a five-year program to replenish, rebuild, and modernize the infrastructure."

Testing, recruiting: The continued absence of underground testing makes it difficult for weapons scientists and engineers to carry out their responsibilities, Domenici noted. "What everyone needs to understand is, that is not simple," said Domenici. "We didn't do [underground testing] for fun. So we need the best we can hire from the best in America, and we need to make sure they think they are doing important work."

The new energy secretary: "Spence Abraham. . . I know a lot about him. He served on my Budget Committee. He was one of my trusted allies. He's a quick learner. He wants to do things right. He's not an expert on energy, but we're all going to help. Also, he is going to get some wonderfully smart people to work for him. I think he's going to be OK. I've already pledged to work with him."

The new US energy crisis: "The country is in a serious energy crisis," Domenici said. He described the current severe problems in California as a crisis in electricity generation and a consequence of too much demand for and reliance on natural gas. The utilities have been rocked by a 9-times increase in the cost of their raw materials. Domenici criticized Californians for wanting continued economic and population expansion while rejecting all new energy-generating sources. "They're frightened to death of nuclear. What are they going to do for electricity? They don't know who to blame. Somebody has got to do something."

Coal and nuclear energy: "It is time for straight talk," said Domenici. "We've got to find ways to use more coal. We've got to change our fear of nuclear power. We need to tell people that it is safer than any others." He noted that nuclear power reactors in the US are now functioning at their highest levels ever, "as safe as can be," and they're "finally generating profits." The nation needs to consider building new nuclear power reactors, with new designs that are inherently safe, and some of the many proposed solutions to nuclear waste need to be implemented. "We're just going to have to move full speed ahead. It is going to be exciting."

Energy and the world: The poor countries of the world need new sources of energy as well. "We want the poor people of the world to become free," but we also want them to gain "a glimpse and the reality of prosperity." For that they need more energy. He raised the specter of China vastly increasing its energy production without new technology or environmental safeguards "They will pollute the world to do it. They won't care what we say."

Sandia, industry, and pride: "When it comes to labs like Sandia, they do some startling things to help the private sector. . . . Sandia is so great that the great computing and electronics companies come to it" for technological assistance. "You've got to know, I am very proud of this laboratory."

Mini-robots

(Continued from page 1)

board. It was made primarily from commercial parts using conventional machining techniques.

Over the next several years the department improved the original MARV and in September 1999 delivered 36 mini-robots to the Defense Advanced Research Projects Agency (DARPA). The robots' bodies were made of printed circuit boards, and each had an obstacle detector sensor, radio, temperature sensor, and batteries. At 1.6 x 0.75 x 0.71 inches, they were much larger than the mini-robots being developed now.

MINI-ROBOT "turns on a dime and parks on a nickel."

Ray Byrne (15211), who was involved in the DARPA project, says about three years ago Intelligent Systems and Robotics Center 15200 teamed with Sandia's Sensor Technologies Dept. 1744 to further miniaturize the robots. They sought out Dept. 1744's help because of its expertise in building sensors and other devices on miniature scales.

By trying new techniques in packaging electronics, wheel design, and body material, the new team of researchers has already shrunk the robots to 1/4 cubic inch.

Ed, who developed the device's microelectronics, says one significant innovation that permitted the shrinkage was the use of commercially available unpackaged electronics parts.

"Previous small robots consisted of packaged electronic parts which were more bulky and took up valuable space. By eliminating the packaging and using electronic components in die form, we reduced the size of the robots' electronics considerably," Ed says. "This was a first major step."

The unpackaged parts are assembled onto a simple multi-chip module on a glass substrate. The assembly was done at Sandia's Compound Semiconductor Research Laboratory.

Doug Adkins (1763), who developed the mechanical design for the new mini-robot, says the robot's size was further reduced by using a new rapid prototyping technique to form the device's body. Called stereolithography, the material-building method lays down a very thin polymer deposit that is cured by a laser. The material, which "grows" as each layer is added, is lightweight, strong, and can be formed in complex shapes. The robot bodies, which were manufactured by Daryl Reckaway in Dept. 14184, have cavities for the batteries, the electronics-embedded glass substrate, axles, tiny motors, switches, and other parts.

Doug also redesigned the wheel structure of the device. Earlier models had standard four wheels. However, the mobility was limited due to the small size of the wheels.

"I thought of how tanks with their track wheels can maneuver over many large objects and realized the mini-robots could benefit from the same type of wheels," Doug says. With the addition of tracks, the robot can now move easily on carpet.

The ultimate size of the miniature robots is primarily limited by the size of the power source — the three watch batteries. The body must be large enough to hold the batteries to support the power requirements of the robot.

"Batteries — both the physical size and battery life — have been one of our biggest issues," Ed says. "The batteries need to run longer and be smaller."

Over the next few years, with additional help from other groups in 1700, Ed and Doug expect to add to the mini-robots either infrared or radio wireless two-way communication capability, as well as miniature video cameras, microphones, and chemical micro-sensors.

Sandia technology part of Raton company's bid to improve oil, coal extraction, landmine detection

Technology developed by Sandia and a Russian nuclear weapons lab and adapted by a Raton, N.M., company to improve coal mining, oil exploration, and landmine detection has attracted a $20 million investment by Credit Suisse First Boston.

The investment was announced Jan. 15 at a United States Industry Coalition (USIC) news conference and demonstration of the equipment developed by Stolar Horizon Inc. at the offices of Technology Ventures Corporation in Albuquerque.

After greeting Stolar President and Chairman Larry Stolarczyk with a bear hug, Sen. Pete Domenici, R-N.M., decried the "energy crisis" that just a couple of days later would bring the first of rolling blackouts in California. "We have literally done nothing to head off this crisis," he said, criticizing the just-ended Clinton Administration, "and we are in big, big trouble."

The technology refined at Stolar Horizon will allow petroleum exploration companies to produce better maps of oil and gas deposits by providing long-vision mapping of underground fractures. The company also plans to commercialize a radar device for continuous coal mining equipment.

The radar equipment would fit inside huge continuous mining drums that grind through coal and rock. It would provide feedback to miners operating the equipment, identifying for them, among other things, the rough edges of coal seams, which are often low-grade coal because of higher content of ash and mercury.

"If we mine coal cleaner it's going to burn cleaner," Stolarczyk told Sandians and others attending the event. "And if we mine coal cleaner, we're going to have a cleaner environment. No question about it."

The adaptation work was performed under the aegis of the Initiatives for Proliferation Prevention program, created in 1994 "largely through the efforts of Sen. Pete Domenici, R-N.M., with strong support from Sen. Jeff Bingaman, D-N.M.," according to a USIC news release. It finds projects that allow scientists and engineers formerly engaged in the Soviet nuclear weapons program to continue to work in their own country. They work on nondefense-related projects with US counterparts.

Stolar Horizon worked with scientists and engineers from the Institute for Measuring Systems Research (NIIIS), a Russian nuclear weapons facility located in Nizhny Novgorod, about 460 miles east of Moscow.

Sandia is providing Stolar with scientific expertise on the borehole radar and related technology the company is using to develop landmine detection equipment, including the robot that will provide the moving platform for the landmine detection equipment. DOE's Kansas City Plant is providing technical and manufacturing help on the coal seam application.

Information provided by USIC says more than 100 million landmines in 70 countries maim and kill some 27,000 people each year — mostly women and children.

Labs Director C. Paul Robinson recalled that following the collapse of the Soviet Union, there was "another threat growing, and we were wondering, 'What can we do about it?' We needed to find ways to encourage Soviet scientists to find work outside their defense-related fields so they wouldn't be pressured to immigrate to other parts of the world and, perhaps, use their expertise in weapons proliferation."

The IPP program was conceived with that concern in mind, he said.

Stolar Horizon, which currently employs 17 people in Raton, expects to add about 50 to its payroll by the end of the year and still more in the coming years. The project could eventually add as many as 350 jobs in New Mexico and perhaps twice as many in Russia. *— Howard Kercheval*

EMCORE opens expanded New Mexico facility

EMCORE hosted a ribbon-cutting Jan. 19 to mark the opening of its expanded facility in the Sandia Science & Technology Park (SSTP) east of the Kirtland AFB Eubank Gate.

The expansion — adding 36,000 square feet to the existing 50,000-square-foot building — triples the Somerset, N.J., company's cleanroom manufacturing capacity. The building houses solar cell, optical component, and networking products.

"The additional cleanroom capacity is critical for us to serve our growing customer base, and provides an opportunity for EMCORE to continually develop new product technologies for the rapidly increasing global communication markets," said EMCORE President and CEO Reuben Richards. "I expect this expansion to help us achieve our aggressive product development and production goals for the remainder of the year and beyond."

The company's Solar Cell division manufactures advanced triple junction solar cells for satellite applications. The Optical Device division provides the building blocks for high-speed telecom and data communications applications, including the Internet infrastructure.

"EMCORE is one of a handful of strategic industrial partners that we treasure," says Al Romig, VP for science, technology and partnerships (1000). "The core product of EMCORE's western division in Albuquerque grew out of technology co-developed at and licensed from Sandia, and we continue to work with them. We're happy to see that technology in the marketplace, and happy to have EMCORE in the park."

Jackie Kerby Moore (14004), project manager for development of the park, says EMCORE is an exemplary SS&TP tenant. "Their success as a company is one of our biggest selling points," she says. "Companies move here to co-locate with other successful businesses, and we're gratified that EMCORE Optical Devices chose to build its new facility in the park."

The newly expanded facility will house 285 employees, and company officials expect to add employees this year.

Job Shadow Day coming up

JOB SHADOW DAY — Children and guests of Sandians will be able to "shadow" their sponsors at work on Groundhog Day, Feb. 2. Here Ryan Cook (right), a Cibola High School senior, shadows Rusty Escapule (15414) during National Shadow Day last year. More information about this year's event can be obtained by calling Amy Tapia (12650) at 250-1111. (Photo by Randy Montoya)

Consortium to develop Cold Spray™ technology

Sandia and 10 companies have formed a consortium and signed a cooperative research and development agreement (CRADA) to develop and commercialize Cold Spray™ technology.

The consortium includes Alcoa, ASB Industries, DaimlerChrysler, Ford Motor Company, The Jacobs Chuck Manufacturing Company, Johnson Manufacturing, Ktech Corporation, Pratt & Whitney, Praxair, and Siemens/Westinghouse. The first experiments performed for the consortium were conducted shortly before the holidays.

The group expects to complete Cold Spray development activities in three years, enabling broad commercial use of the technology.

Cold Spray™ is a rapidly emerging technology in which metal or composite powders are accelerated to supersonic velocities in a stream of compressed gas, usually helium, and used to coat a substrate by plastic deformation and bonding.

"This is an especially exciting technology because of its fundamental simplicity," says Rich Neiser (1833). "It allows us, for the first time, to fabricate dense, oxide-free deposits of ductile metals at high rates in air with equipment no more complicated than a nozzle and compressed gas."

Unlike thermal spray coatings, where the coating material undergoes melting, Cold Spray powders do not change phase or state during deposition and thus offer high deposition rates, very low oxide content, minimal heat input to the substrate, and faster and more efficient coatings without masking. Coatings also can be applied to many materials that cannot tolerate the higher temperatures of thermal sprays.

When developed and commercialized, the Cold Spray technology is expected to benefit industries as diverse as aerospace, petrochemicals, automotive, paper and printing, electronics, computers, biomedical, and primary metals, and have a number of applications ranging from electronic components to satellite structures.

"These industries are looking closely at cold spray as an economical means to fabricate, repair, and protect their expensive components," says Rich. And he adds, with a chuckle, "Cold spray was originally developed in the Former Soviet Union; and where else but Siberia."

Endeavour

(Continued from back page)

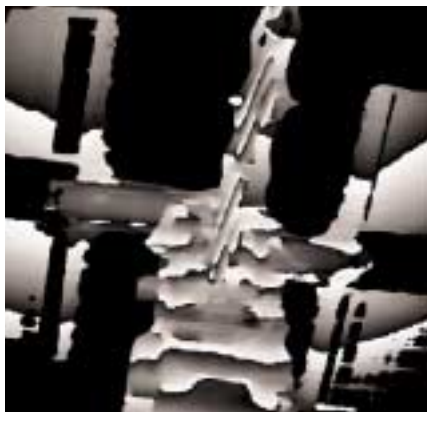
advantage."

The next DTO-261 test will involve moving the P6 truss to its final ISS destination, out to the end of the 300-foot truss assembly. NASA officials plan to use LDRI during that operation and have expressed an interest in LDRI for future navigation, guidance, docking, and inspection applications.

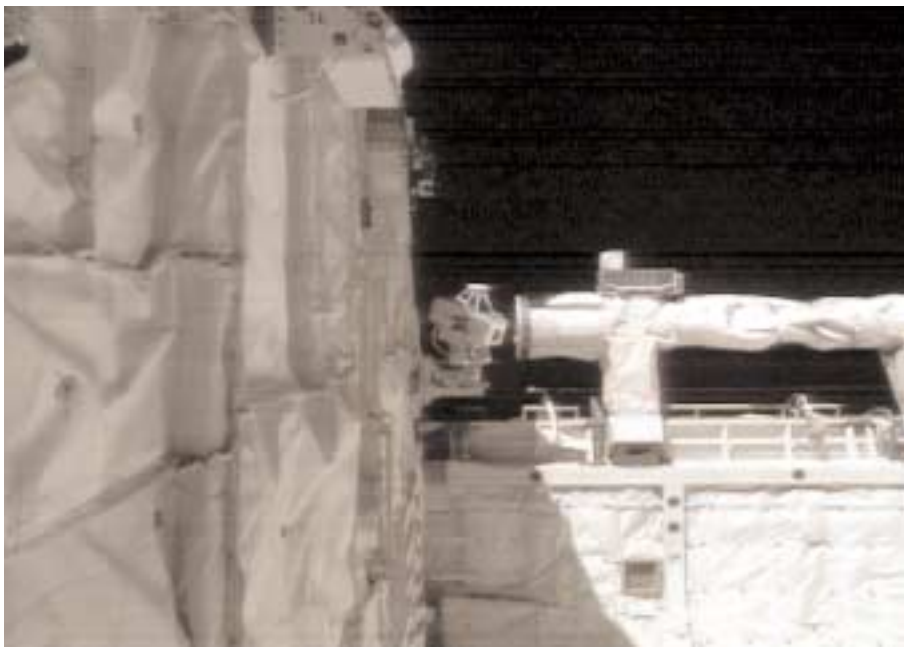
Sandians at Johnson Space Center at various times during the Endeavour mission included Bob, Steve Lebien, Ed Hoover, T.J. Cook, Colin Smithpeter (all 2618), and Mark Heying (15351).

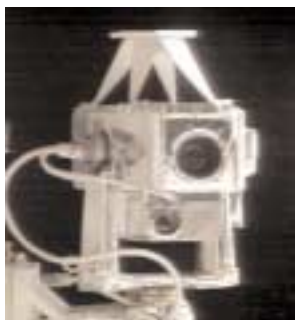
"It was like being in a beehive," says Bob. "It's a big place with a lot of people doing diverse things in a highly structured manner. There's a fevered pitch all the time, with hundreds of radio loops to listen in on. There's a new interruption every 30 seconds. A lot more care and feeding was involved in making the mission a success than we anticipated."

Other people who directly contributed include Dave Armistead (2664), Jack Martinez (15415), Ron Akau (9117), Irene Bentz, Kate Olsberg (both 5711), Tim Dubay (5712), Tom Casaus (2618), Ken Reaves (2991), Sid Gutierrez (5932), John Sackos (2612), Marion Scott (1707), Howard Arris (14172), Cory Ottesen (2346), Ed Jones (ret.), and Frank McMullan (contractor).



RANGE IMAGES taken with Sandia's Laser Dynamic Range Imager, looking up the space station's P6 mast from the Endeavour's cargo hold, with the solar array panels extending left and right. In the left image, white represents 50 feet away and black represents 110 feet away from the camera. In the right image, each cycle from full black to full white represents 3.5 feet of range. (See "Tricks of light . . ." below.)





TWO VIEWS OF THE LDRI, mounted to a camera pan-tilt assembly in the port side of Endeavour's aft payload bay (left photo, center), just left of the orbiter's parked manipulator arm. The LDRI is the box with the small lens (top photo) mounted underneath the black-and-white camera with the larger lens.

Tricks of light, timing allow LDRI to measure vibes in 3D

The strength of Sandia's Laser Dynamic Range Imager (LDRI) for structural vibration measurements, says Bob Nellums (2618), is its ability to measure "near-far" movements very precisely, as slight as fractions of an inch, and to take such measurements many times per second.

"2-D cameras can measure cross-axis movement," he says. "But something vibrating in complex, three-dimensional fashion is difficult to measure remotely."

The LDRI works by illuminating a scene with wide-angle pulses of laser light many times per second, then measuring the intensities of light that reflect off objects in the scene. Light reflected by an object that is close to the LDRI will return to the system's camera billionths of a second sooner than light reflected by an object that is farther away.

Meanwhile, the camera's eye is blinking many times per second as well, collecting images of the scene while the eye is open, while it's squinting, while it's closed, and while it's squinting again. Surfaces of the scene that reflected light back to the system while the eye is near fully open appear brightest; surfaces closer to or farther away from the camera appear more dim because the eye was squinting or near-closed when the reflected light returned. The result is in an intensity image containing many light and dark bands that contain information about the light's time of flight to and back from each surface.

At least four such intensity images of the scene are collected while precisely varying the timing of the laser pulses and the blinking rate of the camera's eye. By mathematically comparing information about how the intensity of each pixel varies in the four images, the LDRI computes distance to each pixel to create a 3D range image.

Other laser radar systems transmit a pinpoint of light that is mechanically scanned across the scene and imaged pixel by pixel.

The "scannerless" technology employed in the LDRI takes in the whole scene simultaneously, which allows many more images to be collected — as many as $7\text{-}^{1}/_{2}$ 3D range images per second, fast enough to analyze vibration frequencies in large structures such as the space station — with resolutions down to 1/20th of an inch.

Superdupercomputer

(Continued from page 1)

ing science," Bill Richardson, in his last full day in office as energy secretary, said at the ceremony. "The Department of Energy, as it helped develop the technology that made the human genome project possible, once again is forging ahead to provide the tools to bring the genome to life."

The goal is to increase computing capability to 100 trillion operations per second (100 TeraOPS).

Bill Blake, vice president of High Performance Technical Computing at Compaq, said the outstanding aspect of the CRADA relationship is "the simultaneous provision of algorithmic support, design of actual application software, and development of the system platform by three organizations with world-class competence in their respective areas. . . . Our intent with this alliance is to apply the same full system modeling approach to bioscience that has been so successfully applied to physical sciences in the DOE/NNSA [National Nuclear Security Administration] Stockpile Stewardship program."

Celera President J. Craig Venter said even the most powerful of today's supercomputers do not meet the needs of his company's work in genomics. "Just three years ago, the computational needs of biology were thought to be minor and irrelevant to the computing industry. Today, biologists are setting the pace of development for the industry." But, he said, "As Compaq and the Department of Energy move toward creation of the next generation of supercomputers for defense purposes, we look forward to helping both groups develop the new machines, software, and algorithms to advance life sciences."

Bill Camp, Director of Sandia's Computation, Computers, and Mathematics Center 9200, said delivering affordable and scalable supercomputer architectures has been the focus of Sandia research for more than a decade.

"Our knowledge will be useful because understanding the complexity of the human genome requires manipulating ever vaster amounts of information, using more advanced computing technologies than was required even for the assembly of the human genome itself.

"We . . . look forward to providing world-class expertise in parallel algorithms and systems software in the cause of human health, and welcome the opportunity to play a role in developing what may be some of the most exciting science in recent human history," he said.

Sandia, Compaq combine experience

The alliance will use Compaq Alpha processors connected in massively parallel configuration with extremely high bandwidth, and low latency mesh interconnects. Compaq and Sandia will collaborate on developing system hardware and software. Both have extensive experience with supercomputers based on Alpha.

Compaq already manufactures a line of supercomputers, the AlphaServer SC series, that was recently selected by NNSA as the architecture for the world's most powerful computer, the ASCI Q system, which will deliver 30 trillion operations per second when delivered in 2002.

ASCI, the Accelerated Strategic Computing Initiative, is a key component of the stockpile stewardship program to ensure the safety and reliability of the nation's nuclear weapons stockpile in the absence of nuclear testing.

Sandia currently operates the most powerful Linux-based supercomputer in existence, Cplant™, which employs more than 1,600 Alpha processors. Sandia also is home to ASCI Red, the first TeraOp supercomputer, until very recently the fastest supercomputer in the world.

The full news release can be found at http://www.energy.gov/HQPress/releases01/janpr/pr01022.htm.

Congratulations

To Tom and Laura (15312) Swiler, a son, Eric Wallace, Oct. 10.

Sandia Classified Ads Sandia Classified Ads Sandia Classified Ads Sandia Classified Ads

MISCELLANEOUS

COMPAQ PRESARIO COMPUTER P120, 32M RAM, 56K modem, color monitor, great for school/home. Mounho, 299-0883.

ROSENTHAL "JAPANESE BLOSSOM" CHINA, 6-piece place setting, w/some serving dishes, gorgeous, modern/traditional. Wagner, 823-9323.

BRIAN URLACHER TRADING CARDS (Donruss, UD-Ionix, PressPass autograph, etc.), selling for 75% of book value. Leong, 892-1564.

WASHER/DRYER, Maytag, white, excellent condition, $150, firm; TV, Hitachi, 24-in., excellent picture, $75. Petersen, 275-7467.

3-PIECE SECTIONAL, w/full sleeper & recliner, neutral colors, southwest design, $800 OBO. Lippert, 299-6594.

DELL LAPTOP COMPUTER, 600MHz, 15.1-in. screen, 6.1GB hard drive, 64MB RAM, DVD drive, carrying case, paid $2,300, asking $1,900. Gore, 836-7477 Mon.-Tue. only.

HP CD-RW WRITER PLUS, 8110i 4X/2X/24X, new in opened box, plus 16 CD-R & 1 CD-RW blank disks, $110. Simmons, 281-3590.

FRENCH SCREEN DOORS, bronze, 72" x 80", excellent condition, $100. Anderson, 232-2167.

EXTENSION LADDER, 40-ft., $300; rotary darkroom door, $100; large dog igloo, $40. Shelmidine, 281-8413.

TI-82 CALCULATOR, working all right, $40. Goel, 845-4692.

COUCHES, 1 blue & white, 72"W x 24"H x 30"D, $150; 1 med.- blue, 4-seat velvet, 110"L x 28"H x 36"D, $300. Wadell, 821-0276.

CHILTON'S REPAIR MANUALS, for Olds Cierra, Pontiac 6000, Buick Century, Chevy Celebrity, '82-'88, $10; Chrysler front-wheel drive, '81-'91, $5. Ewen, 836-3563.

RELOADING EQUIPMENT, turret press, bench, scale, powder measure, dies, etc. Marder, 291-8140.

TV, Hitachi, 24-in., excellent picture, $75. Petersen, 275-7467.

4 TIRES, 16-in., Goodrich Wilderness AT, (not on recalled list), 30K miles, $85. Locher, 266-2021.

NORDICTRACK PRO, variable elevation, w/pulse, calorie count, timer, excellent condition, $200. Stromberg, 299-8591.

NATIONAL GEOGRAPHIC, eighteen-year collection,'80-'98, free to good home or school. Keener, 294-1919.

TWIN BEDSETS, boy's wood headboard, frame, box spring, mattress, $60; girl's metal headboard, frame, box spring, $35; frame & box spring, $25. Gruetzner, 237-2966.

GOLF BAG, SporttrekUFO, partioned, putter holster, rain hood, $30; brown-leather scoop chair (rocks/swivels), $125. Letz, 293-4525.

FISHER VACUUM-TUBE RADIO, w/phonograph, $60; '40's New Home sewing machine, w/wooden flip-top cabinet & attachments, $110. Lewis, 268-5025.

COUCH, Ethan Allen print, sage-green, dusty-rose, blue colors, excellent condition, cost new $1,200, asking $550. Biffle, 293-0330.

COINS: US proof & mint sets, '60 through '00, sell at 65% of dealer prices, all or part. Hollister, 323-1659.

WEDDING DRESS, w/headpiece, "fluffy" train, beautiful, white organza over satin, short sleeves, size 8-10, $100 OBO. Lauben, 275-7466.

JOGGER STROLLER, $100; twin bed/box/frame, $40; Broyhill, 5-piece black-lacquer bedroom set. Lebien, 822-8851.

FORMAL DINING ROOM SET, all glass, w/4 chairs, Sony surround system, VHS movies: "Top Gun," "Jurrasic Park," etc. Garcia, 292-6930.

SKIS, boots, & bindings for child of about 60 lbs. or 8-yrs., used twice, $60. Dobranich, 298-4547.

MAN'S ROLEX, diamond dial; beautiful brass crib; nice rabbit- fur jacket, small; Beanie babies/bears. Dawn, 298-5868.

GENERATOR, Generac 5KW 6250 surge, wheels, still in box, $500. Baney, 294-8970.

WESLO CARDIOGLIDE & Weslo AirStrider, both in excellent condition, $60 each or $100 for both. Hubbard, 293-2819.

JENN-AIR RANGE/OVEN, w/4 removable burners & 1 grill, approximately 6-yrs. old, works great, $110. Swahlan, 286-2808.

1/4-CORD FIREWOOD, approximately, already cut, free, you haul. Holzrichter, 298-5695.

ANTIQUE DINING ROOM SET, 6 upholstered chairs, expandable, pad, light wood finish, good condition, $350. Tucker, 822-5560.

PC, 700MHz, AMD, 64MB RAM, 4GB HD, 48 x CD ROM, 56K modem, 10/100 netcard, RageFuryMaxx 2-processor videocard, w/64MB VidRAM, 17-in. monitor, $850. Crow, 821-0956.

SADDLE, beautiful, tan, barrel-racing w/forest green seat, silver conchos, saddle pad, $650 firm. Southward, 286-5676.

3-PIECE SECTIONAL, w/sofa sleeper & recliner, brown, good condition, $350 OBO. Gallegos, 332-3821.

BAND SAW, 10-in., 1/3-hp., Craftsman, dado heads & groover blades, moulding heads & blades; chains tire reinforced snow, P215/R15. Pitti, 256-1629.

REPTILE CAGE, new, large 3' x 3' x 4', heat rock, UV light, many extras, paid over $300, sell for $150. Dempsey, 281-9101.

SCHWINN AIRDYNE, steel frame, very good condition, gelfoam seat, minimal use, $200. Rockwell, 884-4206.

WHIRLPOOL REFRIGERATOR, 23 cu. ft., side-by-side, white, icemaker, 15 yrs. old, works well, $115. Van Den Avyle, 898-6474.

BABY MONITOR, Fisher-Price, w/AC adapter, $15; computer hardware, video cards, 4MB/$10, 16MB/$25; 32X CD drive, $25. Cocain, 281-2282.

GE OVEN, 27-in., $125; Kenmore upright freezer, $75; Amana refrigerator/freezer, $75. American Standard "Americast" bathtub, $75. Ambabo, 266-2383.

UPRIGHT FREEZER, $100, queen-size waterbed, $60; coffee/end tables, $90; carpet shampooer, $125, curio cabinet, $30. Strader, 296-0209.

KENMORE SOLID-STATE MICROWAVE, excellent condition, $40. Carroll, 298-2827.

METAL LATHE, 12" x 36", Sears/Atlas, w/3-&-4 jaw chucks, faceplate, 4-way tool post holder, and miscellaneous tooling, $1,200. Rosborough, 865-8490.

REFRIGERATOR, 21.6 cu. ft., w/ice-maker, 6 yrs. old, $300 OBO; sofa bed, chair & coffee table, $150/3 pieces. Hebert, 294-8182.

ADORABLE COCKER SPANIEL, female, black, 5-mos.-old. Spinello, 292-5681.

OWNER'S HANDBOOK, Sprite, MG Midget, '62, rally tables. Beegle, 298-0330.

MICROWAVE OVEN, Sharp Carousel, model R310AW, white, $65. Laguna, 856-0777.

MIRRORS, 3' x 5' & 3' x 6', w/hardware, white aluminum storm door, 30"RH, $20 each; Intrepid spare, $10. Mooney, 294-5161.

DINING TABLE, dark oak, 48-in. pedestal, 4 chairs, $200; 3 dark rattan 24-in. bar stools, $150. Kepler, 296-0402.

WHIRLPOOL REFRIGERATOR, w/ice-maker, 19.5 cu. ft., $95; Sears 10-in. table saw, $150. Williams, 344-9276.

FREE to an Atari 2600/5200 enthusiast: parts & some game cartridges. Lunsford, 299-5187, ask for Gwen.

How to submit classified ads

DEADLINE: Friday noon before week of publication unless changed by holiday. Submit by one of these methods:

- **E-MAIL: Sandy Smallwood, (sksmall@sandia. gov)**
- **FAX: 844-0645**
- **MAIL: MS 0165 (Dept. 12640)**
- **DELIVER: Bldg. 811 Lobby**
- **INTERNAL WEB: On Internal Web homepage, click on News Center, then on Lab News frame, and then on the very top of Lab News homepage " Submit a Classified Ad." If you have questions, call Sandy at 284-3704. Because of space constraints, ads will be printed on a first-come basis.**

Ad rules

1. Limit 18 words, including last name and home phone (We will edit longer ads).
2. Include organization and full name with the ad submission.
3. Submit the ad in writing. No phone-ins.
4. Type or print ad legibly; use accepted abbreviations.
5. **One ad per issue.**
6. We will not run the same ad more than twice.
7. No "for rent" ads except for employees on temporary assignment.
8. No commercial ads.
9. For active and retired Sandians and DOE employees.
10. Housing listed for sale is available without regard to race, creed, color, or national origin.
11. Work Wanted ads limited to student-aged children of employees.
12. **We reserve the right not to publish an ad.**

VIOLIN, ideal for student, case, no bow, $175. DiPrima, 275-3479.

LANE ROCKER RECLINER, La-Z-Boy recliner, neutral colors, excellent condition, $90. White, 294-5692.

RECLINER, tan, $50; videocassette player, $25; cell phone, never used, $50. Kiro, 255-0890.

WATERBED, king-size, w/bookcase headboard, mattress & 6 drawers underneath, very good condition, see at www.mindspring.com/~grquint/for sale, $485. Quintana, 296-9155.

SOLAR COLLECTORS, 256 sq. ft., flat copper plate w/glass, frame, & pumps, $800. Iman, 856-6500.

RATTAN GLASSTOP TABLE, 4 chairs, tea cart, 2 sofa beds, chairs, foot stools, all matching. Peters, 294-0363.

NORDICTRACK TREADMILL, digital pulse, calorie count, speed, distance, timer, excellent condition, $150. Peterson, 883-8463.

DOG, to loving home, Lab mix, friendly & full of energy. Foiles, 323-4473.

CHILDCRAFT OAK CRIB, w/bedding , top-of-line, $300; REI tough traveler child-carrying backpack, both like new, $100. Hendrickson, 275-3119.

SOLID-OAK DESK, sides painted, $75; oak file cabinet, sides painted, $15; 50W Sony receiver, $40. Platzbecker, 299-6096.

SOUTHWESTERN SOFA, $150; 7-drawer dresser, $50; wicker stand, $25. Harris 821-3001.

GAS DRYER & WASHER, Amana dryer, Maytag washer (large), almond, 1 member family, slightly used, disconnected last week, $225/pair. Coe, 266-6579.

WHIRLPOOL DISHWASHER, 2 levels, $100; Badger garbage disposal, $50; small camper shell, $100. Chavez, 323-9343.

MURPHY BED, w/cabinets & doors, folds up into wall, easy up & down, little used. Heard, 877-3839.

PARABODY LEG PRESS/CALF MACHINE, compact, kick backs for thigh, weights included, $400. Jones, 293-1583.

XC SKIS, Rossingnol, waxless, 190 cm, w/poles, $20; XC boots, size 7-1/2, $8. Maloney, 299-4330.

TRANSPORTATION

'93 TOYOTA PICKUP, 4-cyl., AC, shortbed, w/bedliner, dark-green, good condition, $4,000 OBO. Lewis, 858-1360 or 237-2337.

'84 VOLVO 240DL SEDAN, 4-dr., tan, AT, overdrive, AC, PS, PB, PL, 151K miles, nice, $2,650. Ganter, 265-5007.

'90 MAZDA MIATA, 5-spd., convertible, new CD player, engine runs great, 33-mpg, $4,700, OBO. Trent, 237-8129.

'87 FORD BRONCO-II, 4x4, 5-spd., loaded, excellent condition, 120K miles, $3,950 OBO. Loescher, 299-7921.

'93 FORD EXPLORER, 4x4, Eddie Bauer Edition, 94K miles, AT, fully loaded, $8,200 OBO. Montoya, 839-1746 or 239-5278.

'97 MAZDA PROTEGE, 58K miles, standard, 4-dr, AC, stereo, excellent condition, (blue book value $9,400), $8,600. Braunbarth, 480-8719.

'89 OLDS CUTLASS SUPREME, AT, PW, PS, AC, 150K miles, $2,000 OBO; '88 Subaru GL wagon, 4-dr., AT, PW, AC, 130K miles, $1,500 OBO. Son 284-3026.

'67 CHEVELLE PROJECT CAR, 396, 4-spd., partially restored, call for details. $4,500 OBO. Meeks, 797-7814.

'98 TOYOTA COROLLA LE, 4-dr., fully loaded, 41K miles, outstanding condition. $9,500. Emery, 856-6950.

'94 CHEVY LUMINA, 73K miles, $4,500. Hudson, 821-8988.

'84 BUICK CENTURY, 4-dr., 3.0 V6, good condition, $1,500 OBO. Hill, 856-0745.

'96 CHRYSLER T&C MINIVAN, power everything, CD/tape, power-train warranty, excellent condition, book $17,500, asking $16,500. Strascina, 797-3639.

'88 JEEP CHEROKEE, 4WD, custom paint, new tires, radiator, brakes, rare off-road package, 110K highway miles, mint condition, $6,000. Ukena, 275-7275.

'53 FORD VICTORIA, 2-dr., hardtop, immaculate restoration to mild custom, show winner, sacrifice, $10,500 OBO. Buteau, 856-7705.

'94 FORD F150, 2WD XL, standard cab LB, 5-spd., V6, 54K miles, AC, shell, cruise-control, $8,366 OBO. Rhea, 878-9445.

'90 FORD MUSTANG 5.0 LX, 5-spd., runs great, fast, CD, PW, PS, AC, PW lumbar, all black, 150K miles, $3,900 OBO. Powell, 452-1885, pager 540-9335.

'77 IMPALA, one owner, $1,200 OBO. Lewin, 898-2303.

'97 TOYOTA TERCEL, AT, AC, new tires, CD, 49K miles, factory warranty, excellent condition, 43-mpg, one owner, dependable, $7,500. Brown, 262-1998.

'95 CHEVY EXT. CAB PU, white, 305 V8, lim. slip differential, AC, AT, cruise, shell, $10,500 OBO. Whitlow, 286-2591.

'93 TOYOTA 4RUNNER SR5, 4x4, fully loaded, leather, CD, moonroof, keyless entry, low mileage, 76K, $12,500. Keahbone, 250-8354.

'85 FORD BRONCO, Eddie Bauer, 302, 4x4, PL, PW, AC, rebuilt tranny, $3,500 OBO. Hesch, 284-6589.

'88 VOLVO 240DL, runs great, safe, reliable car, blue book, $3,200, asking $2,200 OBO. Nielson, 352-1167.

'90 FORD BRONCO II, standard, good condition, new upgraded tires & wheels, 150K miles, must see, $2,950. Dunivan, 296-3937.

'92 MERCURY COUGAR, 25th anniversary edition, 92K miles, 1 owner, excellent condition, $5,300. Lundgren, 281-1564.

'89 PLYMOUTH GRAND VOYAGER, white, see Monday-Thursday, north side old water tower lot, 1 owner, $2,300. Bentley, 856-7661.

'86 TOYOTA CAMRY, $1,400 OBO, Bradley, 293 9586.

'87 TAURUS GL, white, 4-dr., V6 AOD, CC, AC, 95K miles, $1,800. Wente, 299-5274.

'96 TOYOTA 4RUNNER SR-5,V6, 4x4, excellent condition, AM/FM/cassette/CD, 47K miles, dash & cargo covers, alloy wheels, privacy glass. Hassan, 822-9544.

'69 CHEVY TRUCK, flatbed, w/stake frame, 327, 4-spd., standard, $2,500 OBO. Raymond, 286-9450.

'65 FORD MUSTANG, red w/black interior, 200 cu. in., 6-cyl, runs & looks excellent, $5,500 negotiable. Lucero, 345-6420.

'97 CHRYSLER LHS, white, gray interior, 55K miles, leather interior, AT, loaded, great shape. Tomasi, 797-2661.

'85 FORD CROWN VICTORIA, all power, good tires, runs well & looks good, 104K miles, $1,800 OBO. Mounho, 299-0883.

RECREATIONAL

'99 FLEETWOOD FIFTH WHEEL, all amenities, $17,000 OBO; '99 F250SD, 4x4, crew cab, powerstroke, $28,000 OBO. Ron, 857-0503.

'89 PACE ARROW MOTORHOME, 37 ft., low mileage, 2 wall heaters, 2 AC, awning like new, generator, satellite dish, washer & dryer, all new 12V batteries. Ward, 884-9266.

REAL ESTATE

4-OR 5-BDR. CUSTOM HOME, 3-1/2 baths, 3,200 sq. ft., beautiful, on 1 acre, ranch-style brick, irrigated pasture, SW, Raymac area, market value $256,000, will consider trade, $235,000. Jobe, 877-0269.

3-BDR. BRICK HOME, corner lot, cul-de-sac, completely remodeled, new windows/roof, Berber carpet, large landscaped yards, 2-1/2 miles north of KAFB on Eubank, $5,000 down, take over payments. Lewis, 294-0766.

4-BDR. HOME, 2-1/2 baths, 2,880 sq. ft., all brick, brand-new roof, new heater & AC, Glenwood Hills neighborhood, market appraisal $239,000, asking $219,000. Dwyer 271-0741.

2-BDR. COTTAGE, Eagle Nest Lake, N.M., near Red River & Angel Fire, furnished, $75,000 or unfurnished, $69,000. Martin, 377-2244.

SWEET 2-BDR., 1 bath, 875 sq. ft., roofed patio, garage & shed, Louisiana & Copper. $79,900. Tardiff, 293-0462.

3-BDR. CUSTOM HOME, 2 baths, on golf course, 2,270 sq. ft., LG, country kitchen & more. Dahl, 864-4735.

WANTED

CONSCIENTIOUS STUDENT to sew at home, must have own machine, non-smoking, motivated, great student job. Spraggins, 256-7408.

TOTAL GYM, good condition. Veres, 797-4714.

RESPONSIBLE ROOMMATE to share 4-bdr. house w/3 female college seniors from mid March-July. Jasso, 480-1561.

HOME FOR CHOW/GERMAN SHEPHERD CROSS, 7-yrs. old, good watch dog, good w/kids, mom passed away, dog misses her, needs attention & loving owners. Armijo, 345-7385.

REFRIGERATOR from RV/trailer, good condition, new or used. Bailar, 865-1518.

HOUSEMATES to share 3-bdr., 1-1/2 baths, washer, dryer, house near UNM, ideal for UNM students, $275 +1/3 utilities. Borgman, 299-6010.

WOOD CONCERT CLARINET for high school student, good condition, new or used. Diver, 293-6596.

SWAP SAFETY-DEPOSIT BOX, at Juan Tabo for one at Kirtland. Ayers, 888-8922.

NASA sought solutions in Sandia range imager during December Endeavour mission

Slack in International Space Station's solar arrays put postponed experiment back on the fast track

By John German

During last month's space shuttle Endeavour mission that outfitted the International Space Station (ISS) with a new pair of solar wings, use of an experimental Sandia camera on board the orbiter became a mission priority after astronauts had trouble unfurling two of the ISS's four new solar blankets.

Each of the four 13- by 108-foot flexible blankets contains more than 16,000 photovoltaic cells. During deployment, the folded blankets are pulled slowly away from the solar array's main mast, called the P6 truss, along a framework.

Late in the mission's fifth day, when the two starboard solar blankets failed to tension properly, engineers at Johnson Space Center fretted that unless the tensioning mechanisms could be repaired before the end of the mission, structural uncertainties might require jettisoning the whole array into space.

Overnight, while Endeavour's crew slept, mission controllers came up with a plan to assess the structural integrity of the slack solar blankets.

First test comes early

Part of that plan was to use Sandia's Laser Dynamic Range Imager (LDRI), bolted to a camera assembly in Endeavour's cargo hold, to illuminate the ISS's solar array with infrared light during dark hours so the orbiter's cameras could examine the assembly.

Mission control's flight anomaly team also planned to take advantage of LDRI's 3D motion-measurement capabilities to assess the solar array's stability. (See "Tricks of light, timing allow LDRI to measure vibes in 3D" on page 6.)

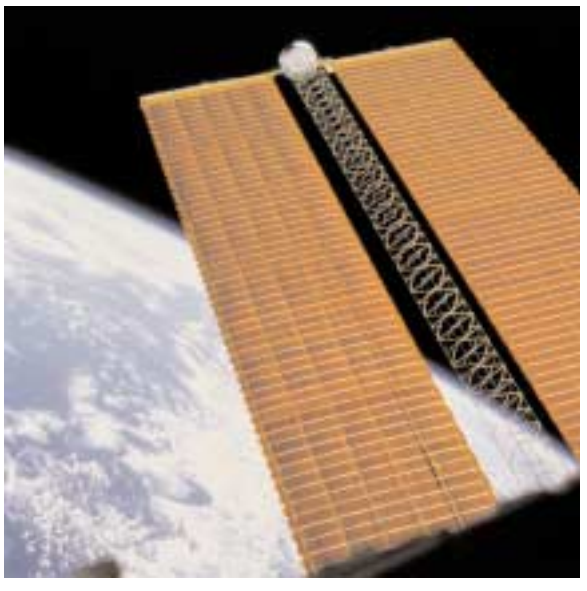
The LDRI was on board Endeavour as a component of NASA's Space Shuttle Upgrades Demonstration program. It also was scheduled to participate experimentally in the ISS On-Orbit Loads Validation Development Test Objective 261 (DTO-261), a series of tests to characterize the structures of the ISS, P6 truss, and solar arrays.

As part of DTO-261, Endeavour's crew was to repeatedly and precisely pulse-fire the orbiter's medium-sized thrusters to create vibrations in the ISS, which was mated with the orbiter during the mission. Then the vibration signatures of the station's structural elements were to be measured using a variety of cameras, accelerometers, and strain gauges.

The LDRI's role was to see whether its unique 3D imaging capabilities could improve NASA's ability to measure the vibrations.

The data collected by all the instruments are being used to validate computer models predicting the ISS's structural performance.

"You can't assemble the ISS on earth, so the only option is to check it while it's in orbit," says Bob Nellums (2618), Labs LDRI project leader for the mission, who along with several other Sandians spent two weeks at Johnson Space Center's Mission Control Center.



AN ASTRONAUT inside Endeavour's crew cabin on Dec. 3, 2000, used a handheld camera to get this photo of the International Space Station's newly deployed starboard solar array wing. (Photo courtesy of NASA)

THE BIG PICTURE — The International Space Station (ISS) following orbiter undocking on Dec. 9, 2000, one of the first images of the ISS after its new solar array had been deployed (top). When it is fully operational, the ISS's electrical power system will include a total of eight such arrays, each 38 feet wide with a wing span of 240 feet. The complete power system will generate 110 kW of total power, about as much as 55 homes would use. (Photo courtesy of NASA)

On, then off, then on again

But a glitch discovered in the LDRI's ground-control software a few days after launch had put the LDRI portion of DTO-261 on hold, much to the disappointment of the Sandians on the ground.

"NASA is always looking for ways to reduce the workload, and at that point we were a non-critical experiment with a problem," says Bob. "It was a scary moment. I thought it was over."

At the same time, he says, Sandia had a lot of commitment from a number of people at NASA, in particular from the DTO-261 project manager, George Studor.

To the Sandians' relief, the solar array crisis and the need to diagnose it quickly put the LDRI back on the fast track. A NASA ground operations controller, Grant Slusser, came up with a clever work-around to the glitch, and the LDRI was back in business.

After a night of examining the array with all sorts of instruments, including the LDRI, the astronauts were able to fix the solar array problem during a space walk the next day.

Owing in part to its emergency reprioritization, the LDRI also carried out all of its planned functions during the mission, including the DTO-261 structural integrity tests and remote monitoring and illumination during the mission's three astronaut space walks. Mission control even added a last-minute vibrometric observation of the arrays during orbiter-ISS separation to see if the shuttle thruster plumes impinged on the solar blankets.

In post-mission debriefings, crew members were favorably impressed with the LDRI's performance in its illumination mode, says Bob.

"They liked its brightness compared to the previous illuminator used with the shuttle's black-and-white camera," he adds. "Adequate illumination of the ISS out to the 400-foot range was crucial to the pilot's ability to manually undock from the ISS and fly around it at night."

(The LDRI's ability to illuminate a scene at least as well as the light it replaced on the Endeavour's camera assembly "was a prerequisite for getting a ride," he says.)

Flexibility an advantage

"One of our goals was to impress people with the usefulness of the LDRI as a general-purpose tool for future missions," says Bob. "I think we showed during the unplanned parts of the experiment that the flexibility of our system is an

(Continued on page 6)

Coronado Club

Jan. 26 — Dining, 6-9 p.m.; dancing, 7-11 p.m. Music by Midnight Magic.

Jan. 28 — Super Bowl Sunday. Tailgate buffet, 1-4 p.m. Enjoy the game on big screen TV.

Jan. 31 — Icebreaker. Meet the Coronado Club staff. Free snacks, beer, & wine, 5-7 p.m.

Sandia News Briefs

Sandian Randy Longenbaugh honored as Civilian of the Quarter while on loan to the Air Force

Randy Longenbaugh (6524) was recently honored as Civilian of the Quarter for the Technical Treaty Monitoring Division of the Air Force Technical Applications Center (AFTAC). Randy is currently on a two-year loan to AFTAC/TTA, the Atmosphere and Space portion of the Technical Treating Monitoring Division, located at Patrick AFB in Florida. "Since starting this assignment in August 1999," says Bill Richard, Manager of Mission Analysis and Simulation Dept. 6524, "Randy has provided Sandia's unique expertise and capabilities to AFTAC by performing analyses of Nuclear Detonation Detection System data originating from sensors developed at Sandia and Los Alamos national laboratories. In addition, he has been appointed as a Technical Alert Officer by AFTAC, a position currently held by only one other civilian.'

Send potential Sandia News Briefs to Janet Carpenter, Dept. 12640, jacarpe@sandia.gov, MS 0165, fax 844-0645.