Inside Sandia

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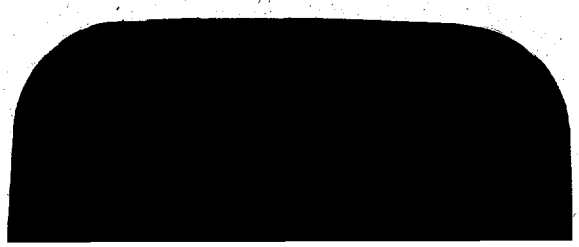
Sandia is a multiprogram engineering and science laboratory operated by Sandia Corporation, a Lockheed Martin company, for the Department of Energy, with major facilities at Albuquerque, New Mexico, and Livermore, California. Sandia has major research and development responsibilities for nuclear weapons, arms control, energy, the environment, economic competitiveness, and other areas of importance to the needs of the nation. The Laboratories' principal mission is to support national defense policies by ensuring that the nuclear weapon stockpile meets the highest standards of safety, reliability, security, use control, and military performance.



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DISCLAIMER

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Inside **Sandia**

Contents

A Sandia-developed technique for producing aerogels — the world's lightest solids — at room temperature and pressure has opened tremendous commercial possibilities in areas such as super-insulators, ultrasensitive molecular recognition sensors, and antireflective coatings on optical devices. See Newsbrief on page 12.

New testing techniques, textiles on the information superhighway, and knowledge preservation

Our third issue focuses on the future and the past

Inside Sandia looks at two very different types of testing in this issue. The first assesses the health of cervical tissue. The optical probe, based on the science of tissue spectroscopy, detects abnormal cervical cells in just seconds by analyzing the characteristics of light absorbed and emitted by cervical tissue. This device could cut weeks off the anxious wait for cervical cancer test results and treatment.

Also discussed is the testing of contaminated landfills. The SEAMIST™ Instrumentation/Sampling System features a coated fabric liner that everts directly into a borehole when gentle air pressure is applied, comparable to an inverted rubber glove finger blown right-side-out. Sampling devices and monitoring sensors, attached to the liner, are positioned into the borehole as the liner is installed.

Preserving Sandia National Laboratories' nuclear weapons expertise is the subject of another article. The RePAV process starts with taped interviews of Sandia engineers to capture nuclear weapon design, testing, and manufacturing information. After the tapes are processed, information is easily accessed by properly cleared users — an invaluable resource to those involved with the nuclear stockpile or weapon systems repair and replacement.

The Demand Activated Manufacturing Architecture (DAMA) project is also discussed. Sandia hopes to link the entire textile complex through the information superhighway to boost the national textile industry's competitiveness in the global market.

Newsbriefs cover VCSELs, a new class of semiconductor laser diode that could revolutionize the laser diode industry; Sandia's Basic Energy Sciences award for sustained achievement in sol-gel films research; and Sandia's structural health monitoring techniques for assessing aging and damaged structures.

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Structural Health Monitoring techniques and robust analysis tools assess aging and damaged structures

Sandia leads the nation in the monitoring, testing, and modeling of aging and damaged structures such as bridges, aircraft, and wind turbines, according to George James of Sandia's Experimental Structural Dynamics Department. This group leads Sandia's Structural Health Monitoring project, dedicated to monitoring and analyzing structures over a period of time using periodically spaced measurements. Many structures in the U.S. are nearing the end of their design lifetime. Sandia has developed new noncontact, nondestructive techniques to collect diagnostic measurements from these structures using specially designed vibration sensors. Robust data-analysis methods grew out of the project, as well, allowing researchers to determine the location and extent of damage. The next step is to predict how damage affects a structure's life and to suggest inspection and repair strategies, particularly for Sandia hardware in aging weapon systems.

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Sandia's VCSELs: sparking a laser diode revolution?

Vertical-cavity surface-emitting lasers (VCSELs) are a new class of semiconductor laser diode that could revolutionize the industry. Unlike conventional laser diodes, which emit light out of the side of the semiconductor wafer, VCSELs emit light straight up out of the wafer, providing numerous application advantages. Although VCSELs typically emit infrared radiation in the 850-nm or 980-nm wavelength range, Sandia has pioneered the development of VCSELs that emit visible light in the red (650-nm to 690-nm) region of the spectrum. Sandia is now partnering with Xerox Corporation to develop red VCSEL technology for high-density laser printhead arrays and with Honeywell Inc. to develop lasers for plastic-fiber communications systems. Industry's specific interests include fabricating the device in dense, two-dimensional arrays to significantly enhance the speed and performance of high-resolution laser printers. In addition, the 650-nm emission wavelength of red VCSELs coincides with the transmission peak of currently available plastic fiber, so these devices can become the source for plastic-fiber links used in automotive and avionics control systems and a host of other applications. VCSELs can be fabricated using conventional microelectronics fabrication methods, and the novel VCSEL geometry enables many cost-saving manufacturing advantages.

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Fiber-optic instrumentation trims weeks off the wait for cervical cancer test results

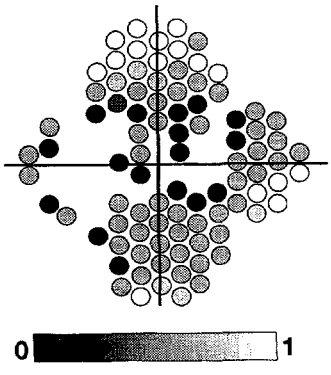
Device detects abnormal cervical cells in seconds

That anxious waiting period — from a woman's first abnormal Pap smear for cervical cancer through follow-up examinations and treatment — traditionally drags on for weeks. To greatly reduce this time, Sandia helped develop a fiberoptic device to immediately assess the health of cervical tissue; if abnormalities are detected, the patient can receive treatment during the same office visit.

Based on the science of tissue spectroscopy, the optical probe analyzes the wavelength "signature" of light absorbed and emitted by cervical tissue. Precancerous tissue fluoresces differently than healthy tissue.

Cervical cancer usually develops along a junction where two types of cervical cells meet. This junction changes during a woman's lifetime, as one cell type is transformed into another. The cells' DNA is accessed for this cellular transformation, increasing the chances for mutations that can lead to cancer. The cancer begins as a precancerous lesion; if left untreated, the lesion can deepen over a period of years to become an invasive cancer.

To detect this precancerous tissue, optical fibers at the end of a small probe illuminate the cervical tissue and collect the fluorescent light that is generated. A computer algorithm, developed by the University of Texas at Austin, analyzes the fluorescence spectrum and assesses the degree of abnormality of cervical cells. David Sandison, Sandia's project leader for instrumentation development, says that these algorithms can immediately provide the physician with tissue information that currently takes hours or even days to provide.



LEFT: A colposcopic image of the cervix.
RIGHT: A 31-fiber probe is placed on the cervix four times. Light excites molecules in the tissue to produce emissions, which the fibers bring back for analysis. Each fiber detects the fluorescence from a 2-mm-diameter area of the cervix. (Photo is courtesy of Dr. Rebecca Richards-Kortum, University of Texas at Austin.)

Conventional screening	Optical probe screening
An abnormal Pap smear leads to a follow-up Pap test. A second abnormal test prompts a colposcopic examination, in which the cervix is examined with a low-power stereo microscope. Treatment follows. This process can take weeks.	The new optical probe can detect abnormal cells on the outside of the cervix at colposcopy and would allow treatment during the same visit.
In screening for precancerous cells, Pap tests produce false results more than 25 percent of the time because of the difficulty in differentiating among normal, inflamed, or precancerous cells.	The optical probe may eventually be used to more precisely identify diseased tissue.
During colposcopy, suspect tissue is biopsied; in about half the cases, the tissue was not precancerous and did not need to be removed.	The optical probe provides a noninvasive technique for detecting precancerous cells. A biopsy of suspicious tissue is not needed if the probe provides the information that the biopsy would provide.

A comparison of conventional cervical cancer screening and the optical probe approach

The concept of the cervical probe was developed and tested by the University of Texas at Austin and M. D. Anderson Cancer Center in Houston. The first-generation prototype was too large to be marketable (about the size of a washing machine) and too expensive to become widely available. LifeSpex Corporation (who licensed the technology) asked Sandia for technical assistance to make the device smaller and more cost-effective. Sandia's systems engineering and miniaturization capabilities helped solve LifeSpex's problems. The device is being advanced through a cooperative research and development agreement between Sandia and LifeSpex, and through research agreements between LifeSpex and the University of Texas.

"Imaging and spectral analysis technologies are an integral part of Sandia's satellite and weapons nonproliferation work," says David Sandison. Besides providing the foundation for the optical probe — which can be customized to detect chemical or biological agents — these technologies are being tapped to identify explosives and to monitor the integrity of nuclear containers.

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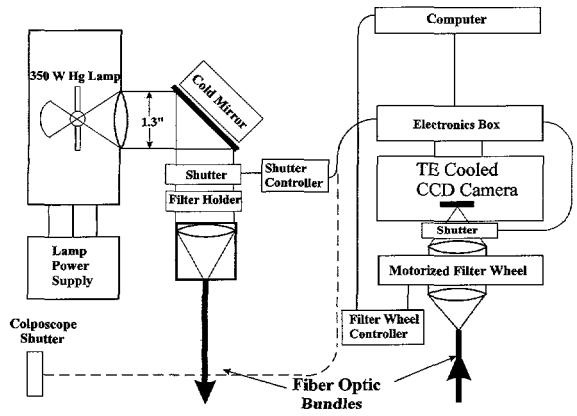


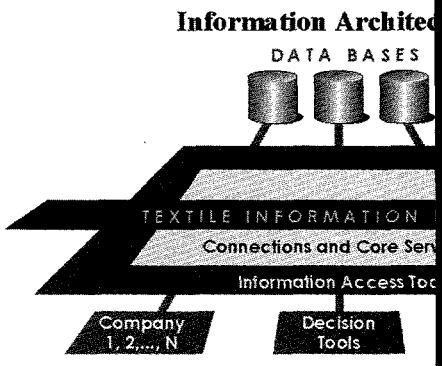
Block diagram shows the main components of the optical probe used to image precancerous cervical tissue.

DAMA project boosts competitiveness of U.S. textile industry

Sandia's goal: linking and moving the textile complex into an electronic marketplace

(Right) The DAMA project — through customer responsiveness, product development, and reductions in costs, inventory, and waste — hopes to reverse the trend of textile jobs moving offshore.

(Below) A conceptual view of DAMA's electronic marketplace of the future. Around the year 2000, shoppers could feasibly order customized clothes through their home computers, using the "smart card" — a sort of credit card that will store a customer's scanned 3-D body dimensions.



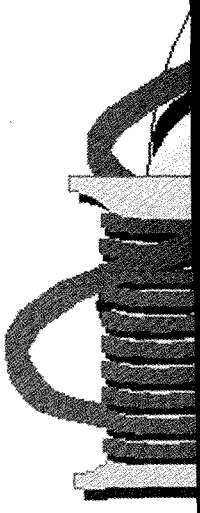
Imagine choosing a fabric and fashion on the screen of your home computer, including information from a preprogrammed smart card that contains your body measurements, and having a perfectly fitted suit delivered to your door a few days later.

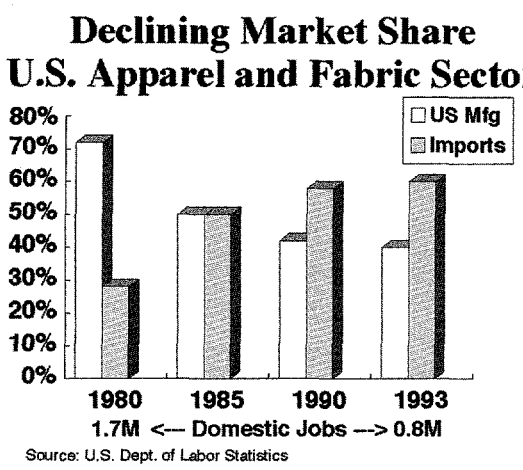
Such a thought is not at all farfetched to a group of Sandians who are taking part in a project that could revolutionize the textile/garment industry. Not only will potential changes please the consumer, they also are expected to save the U.S. Integrated Textile Complex (ITC) — made up of fiber producers, textile companies, sewn product manufacturers, and retailers — billions of dollars each year and prevent the potential loss of hundreds of thousands of jobs to overseas manufacturers.

The project, called Demand Activated Manufacturing Architecture (DAMA), was initiated in 1993 as part of the American Textile (AMTEX) Partnership. The AMTEX/DAMA project is a coordinated effort involving seven Department of Energy national laboratories (Idaho National Engineering Laboratory, Pacific Northwest, Lawrence Berkeley, Lawrence Livermore, Los Alamos, Oak Ridge, and Sandia), universities, and more than 30 companies to help the nation's textile industry improve its competitiveness in the global marketplace. Sandia is responsible for the overall laboratory project management and is working on a key technical component of the DAMA project called the Cooperative Business Management (CBM) task, which is part of an electronic marketplace that uses the information superhighway to provide communications links for the entire U.S. ITC, where all participants can buy and sell products and conduct business electronically. One goal is to link the entire integrated textile complex so that each company in the supply chain responds as quickly as possible to market demands.

"The coordination and rapid transfer of information throughout the supply chain is a key element in producing the right product at the right time at the right cost," says Leon Chapman of Manufacturing Systems Reliability, who serves as the DAMA seven-laboratory project manager. "Warehousing costs, inventory size, and waste can be reduced, while customer responsiveness and product development can be greatly improved through an effective electronic marketplace."

DAMA's electronic marketplace will allow information to be dispersed



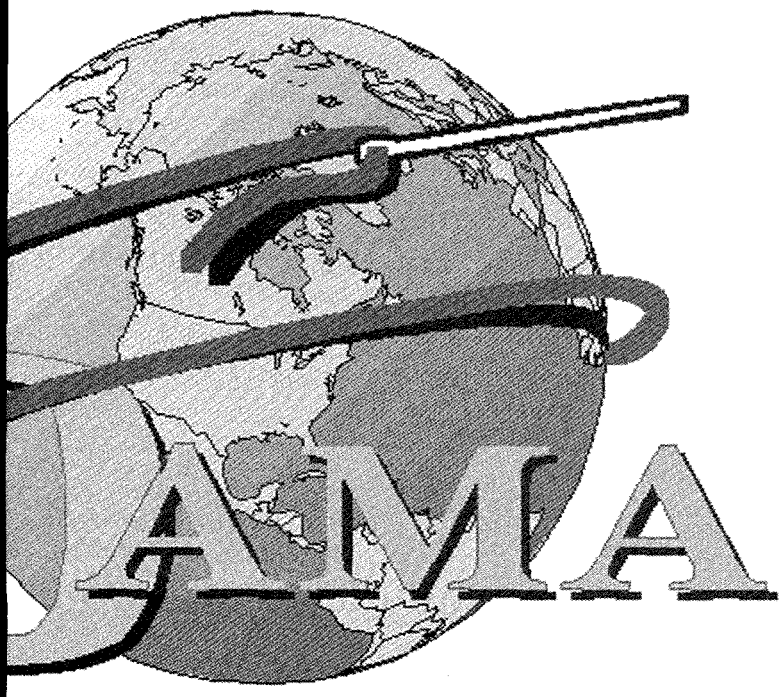


instantly throughout the ITC. When an item is sold and an order is placed, every company involved in the manufacturing process of a particular product would be notified through the information superhighway. Through prearranged electronic trading partnerships, all activities for meeting an order could be cooperatively managed to minimize inventories, reduce lead time, and more effectively respond to consumer demands.

DAMA's potential impact on the nation's economy is substantial. In 1992, the textile industry contributed $58.9 billion to the nation's gross domestic product. The ITC provides about 1.6 million jobs and is the largest employer within the U.S. manufacturing sector, about 12% of the workforce. Thousands of apparel manufacturers supply the nation's 100,000 retail stores. Two billion retail stock-keeping units are annually tracked by point-of-sale information, typically bar codes. Clothing manufacturers engage in as many as 2 million fabric-yard transactions with a single supplier in one week.

As the lead lab for the Cooperative Business Management task, Sandia is developing ITC business tools, which operate by sharing information throughout the supply chain. Sandia must ensure that the tools will be viable in the future electronic marketplace and available to existing companies and to the more than 26,000 small and medium businesses involved in cut-and-sew operations. An important step toward this goal has already been achieved with the development of the Textile Exchange Network (TEXNET) prototype for securely sharing inventory data, point-of-sale information, and other business data over the Internet for all sectors of the industry.

The three Defense Programs labs — Los Alamos, Lawrence Livermore, and Sandia — are exploring various dual-benefit opportunities.



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SEAMIST cuts contamination cleanup costs

Instrumented borehole liner reduces soil analysis time from several weeks to a few days

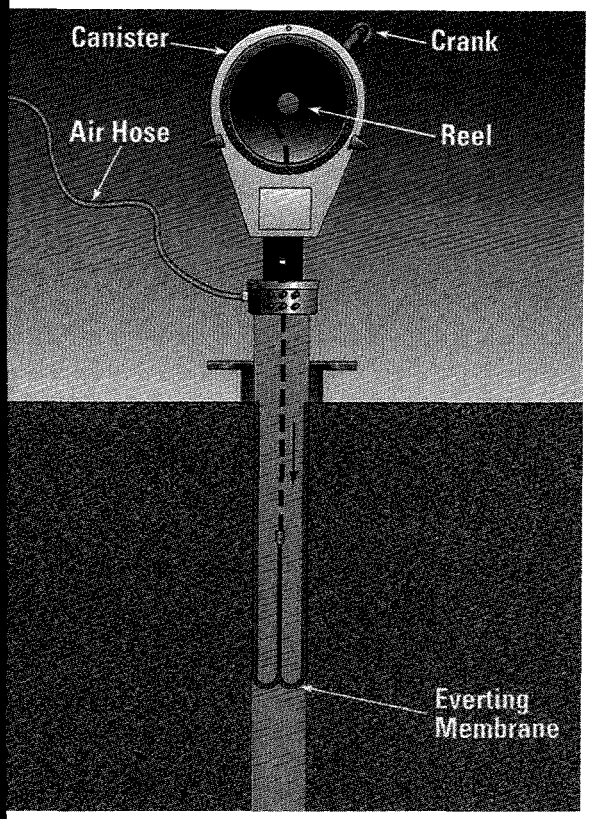
"The world needs better methods to clean and monitor subsurface contamination," says Jennifer Nelson, manager of the Environmental Restoration Technologies Department at Sandia National Laboratories. "Our job is to help develop those methods." One cost-cutting, time-saving monitoring system developed with the help of Sandia environmental scientists is the SEAMIST™ Instrumentation/Sampling System.

The basis of SEAMIST (Science & Engineering Associates Membrane Instrumentation and Sampling Technique) is its impermeable membrane liner, which installs directly into a borehole. Fluid sampling devices and monitoring sensors, attached to the outside of the liner, are positioned in the borehole as the liner is installed. SEAMIST dramatically improves access to the subsurface for effective characterization of contaminated sites.

Air or water pressure pushes the SEAMIST liner into a borehole in a unique manner: The coated fabric liner is initially inverted and contained on a reel within a canister. After the liner membrane is sealed to the top of the borehole, gentle air or water pressure is applied to extend the liner into the borehole — much like one blows a rubber glove finger from a pulled-in, inverted position to right-side-out. This everting liner easily moves horizontally, vertically, around corners, and over obstacles in the borehole, and can be installed to a depth of 1,000 feet or more. It has also been installed in horizontal boreholes up to 450 feet long at Sandia. The liner is retrieved by an attached tether; the tether "peels back" the liner, which inverts and follows the tether back into the canister.

SEAMIST was invented at Science & Engineering Associates Inc. Its functionality was further developed and demonstrated through collaborations with Sandia environmental scientists, funded by DOE's Office of Science and Technology. Science & Engineering Associates then sold the patent rights to Eastman Cherrington Environmental for commercialization. *R&D* magazine recognized SEAMIST as one of the 100 most technologically significant new products of 1994 by presenting Sandia, Science & Engineering Associates, and Eastman Cherrington an R&D 100 award. "SEAMIST is an excellent example of how we work with the private sector in the design, assessment, and demonstration of state-of-the-art technologies for monitoring and remediating landfills," Nelson explains.

SEAMIST's liner provides stability to the borehole and protects workers from exposure to contaminants. A few things the liner can deliver into the borehole include gas sample lines, fiber optics, thermocouples, and psychrometers; the liner can be further instrumented with chemical, hydrologic, and radiologic sensors.



SEAMIST's impermeable membrane is fed from a reel into a borehole, driven by air as it turns inside out. Fluid sampling devices and monitoring sensors are attached to the outside of the liner; other equipment can be transported on the membrane's inside surface or on the center tether.

In addition, the retrievable tether can transport larger instrumentation such as cameras and logging instruments down a borehole. SEAMIST's design prevents instruments from being dragged along the borehole wall, where they are likely to become contaminated. SEAMIST minimizes contamination and cross-contamination because the surfaces of the liner that touch the walls of the borehole invert as the membrane is removed, sealing any contamination on the inside of the removed liner. Another advantage is the rate at which the instrument-carrying liner is installed — a small unit can be emplaced in a 100-foot borehole in less than five minutes.

The useful life of a SEAMIST liner varies: It can be used once and removed. Or it can be semipermanently installed by filling the membrane with sand, which is removed by vacuuming to allow the liner to be retrieved and the borehole reused. The liner can also be permanently installed by filling it with grout, effectively sealing the borehole.

SEAMIST's versatility speeds up site monitoring. "The conventional approach is to drill a dozen or so holes around the site to locate the boundaries of the contaminant plume and send soil samples from the boreholes to an off-site lab for analysis, which can take several weeks," says Cecelia Williams, Sandia's principal investigator for SEAMIST. "But by using SEAMIST in conjunction with other technologies, we can drill just one-third the number of boreholes and in a few days get more information than we could over several months using the conventional approach." These other technologies, also developed for the DOE Office of Science and Technology program, include a computerized site planner, directional drilling techniques, and specialized sampling technology.

SEAMIST is one of several environmental technologies the Environmental Restoration Technologies Department has helped commercialize by collaborating with industry. Among 15 commercialized technologies, noteworthy items include a nonintrusive geophysical technique for locating and mapping buried wastes containing ferrous metals, a technology for drilling shallow horizontal boreholes for landfill characterization, and a method for mapping subsurface contaminants by measuring radio signals propagated between boreholes.

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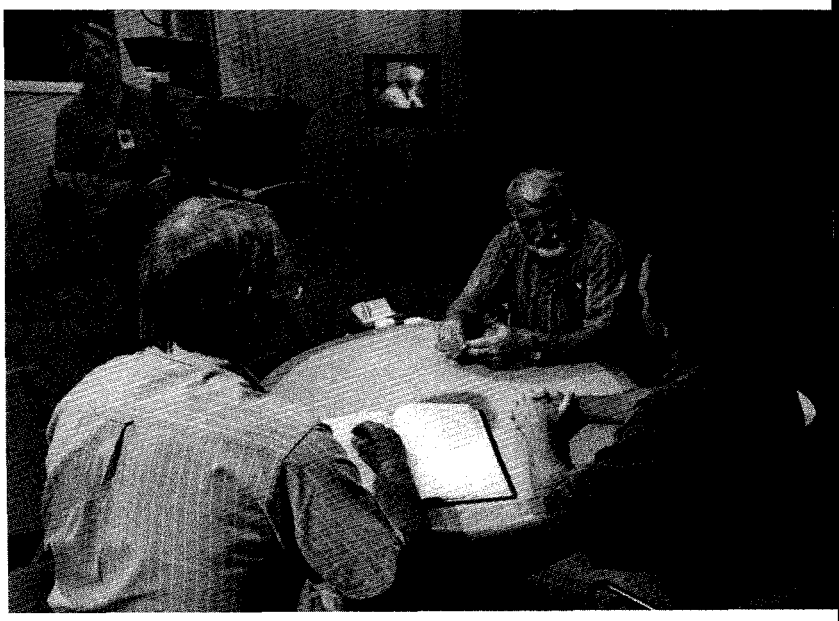
RePAVing the roads to the past

Sandia technology preserves nuclear weapon engineering knowledge

The first generation of nuclear weaponeers has passed from the scene. The second generation, responsible for most of the modern stockpile, is beginning to depart. RePAV, or the Relevant Point of Access Video, was proposed by Sandians Keith Johnstone and John Taylor as a way to access the information being collected by Sandia's Knowledge Preservation Project.

Taped interviews with key design engineers, begun in May 1994, attempt to capture all aspects of undocumented, perishable nuclear weapon design, testing, and manufacturing information. Areas of discussion include technologies, components, systems, and the managerial, economic, and political interactions that impacted the weapons program. "During the course of an interview, we attempt to define the state of technology and technical challenges at a point in time," said Carmen Ward, Knowledge Preservation Project leader. "We probe into how problems were solved, how many solutions were proposed, what they were, and why one was selected over the others. We explore the reasons that various solutions failed and elicit suggestions for the future." Ward thinks that the legacy interviews will be completed by 1998, and from that point, a handful of interviews per year will be conducted to keep current.

RePAV technology was developed by Sandian Jim Borders to manage and instantly access information contained within the eventual thousands of hours of video tapes. The RePAV process works like this: After an interview has been taped, the video tape is digitized, compressed, and stored on a network server. The audio track is transcribed to a text document and full-text indexed by an information management system. The audio text is linked to the digital video files in one-minute time-code intervals. Access to the video information is provided by the information management system. While the audio track is currently transcribed manually, electronic transcription may be possible within the next 3 to 5 years.



After the video tapes have been processed, information is easily accessed by users. "The user simply queries the system on any topic of interest. Videos that meet the search criteria are identified to the user, who then can select and access the video with a mouse click. The VHS-quality video is displayed immediately, in real time, on the user's PC, and [the user will hear] the search key words spoken within one minute of the time the tape begins playing," says Ward. A mouse-controlled media player enables the user to reverse or fast forward the video instantaneously.

Clearly, a careful study of historic development data accessible through RePAV can be an enormous advantage to the individuals charged with maintaining the enduring stockpile and maintaining readiness to repair or replace systems. In addition, non- and counterproliferation communities will be able to use the historic database as an input to their analysis of the proliferation posture of various potential proliferant nations or subnational groups. Once the database is established and accessible to properly cleared individuals, other users may also express an interest in the information. The RePAV technology is currently going through patent review, and CNN has expressed interest in the technology for its huge video archive. RePAV was also the subject of a segment that will be aired on ABC's World News Tonight at a future date.

Ward expects full potential of this system to emerge when it is integrated into a central knowledge base with hyperlinks to reports, memos, engineering drawings, other videos, data, and computer codes; development of time- and image-dependent hyperlinking tools is underway. According to Keith Johnstone, the RePAV project will become part of a Nuclear Weapon Engineering Knowledge Base. This will include, in addition to video tape information, a full-text retrieval database of all relevant nuclear weapon engineering design, manufacturing, maintenance, and dismantlement information, drawings, images, data, etc. Combine this archive with state-of-the-art data management systems, and Sandia will have a truly revolutionary stewardship capability.

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Carmen Ward, *Recorded Information Management, (505) 845-9824.*

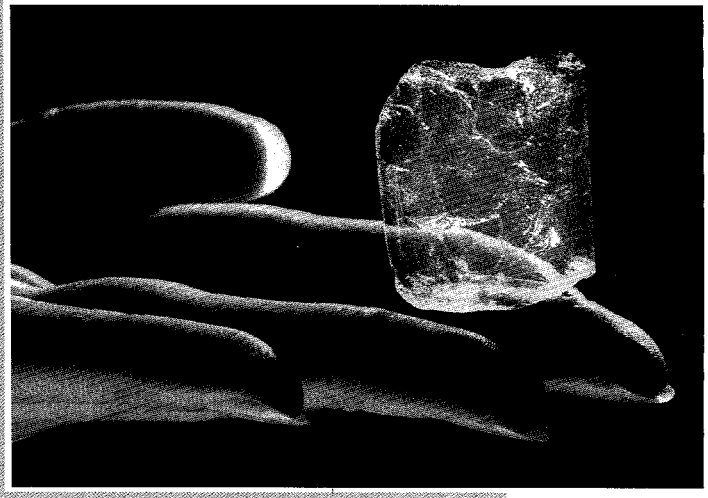
Sandians Keith Johnstone (left) and David Weigand (right) conduct a taped interview with retired Sandian Henry Street to capture perishable nuclear weapon information.

Sandia receives DOE Basic Energy Sciences award for sol-gel achievements

Recognizing Sandia's continued achievements over the last ten years in sol-gel thin film deposition work, the Department of Energy's Office of Basic Energy Sciences/Division of Material Sciences presented Sandia with one of its 1995 Basic Energy Sciences (BES) awards in the Sustained Outstanding Research category. Sandia, competing with the other DOE labs, received one of three DOE BES awards presented annually for sustained achievement.

"Sandia's main contribution," says Al Hurd, Manager of the Ceramic Processing Science Department, "is developing a fundamental understanding of the processing of [sol-gel] films."

A recent achievement in sol-gel research is the ability to measure the stress in films caused when ambient gas condenses into a "liquid" in the pores of the film. Another major advance is the development (with the University of New Mexico) of a technique to produce aerogels — the world's lightest solids — at room temperature and pressure. The conventional high-pressure technique was prohibitively expensive and hazardous.



One inch of aerogel offers about the same thermal insulation as ten inches of fiberglass. A low-cost granular form would serve as a superinsulator for the next generation of energy-efficient refrigerators.

Sol-gel thin films have already been commercialized for some uses; proposed uses cover a wide range of applications in optics, acoustics, electronics, and sensors. A thin aerogel layer on integrated circuits might reduce unwanted capacitance between semiconductor layers and ultimately contribute to faster and more compact computers and smaller batteries. Also, researchers hope to use aerogels for lightweight spacecraft components, for super-insulators in refrigerators, for thermal isolation in multilayer thin-film architectures, in ultra-sensitive molecular recognition sensors to detect deadly warfare agents, and even as "gentle mitts" aboard satellites that could catch tiny "micrometeoroids" without destroying them.

Three Sandia centers (and two UCLA professors) were involved with the sol-gel research award: the Materials and Process Sciences, Microelectronics & Photonics Core Competency, and Engineering Sciences centers.

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