



The Center for Nondestructive Evaluation is a Member of the Institute for Physical Research and Technology at Iowa State University.  
Volume 9, Issue 1 • March 1998

## Imagery was Focus of QNDE Review

The 24th Annual Review of Progress in Quantitative Nondestructive Evaluation (QNDE) was held at the University of San Diego July 27–August 1, 1997. It was an excellent review with some 350 technical papers presented and substantial international participation. The University provided an excellent setting for the Review with its many first-class facilities and amenities.

The opening plenary sessions this year focused on imagery and various technologies that use imagery as a main method of information transfer. Dr. H. Kumar Wickramasinghe of the IBM T. J. Watson Research Center, Yorktown Heights, New York, provided the keynote talk highlighting many exciting advances that have been made in Scanning Tunneling Microscopy and Atomic Force Microscopy. These techniques have been instrumental in the development of atomic scale images and have enormously enlarged the range of technologies available for the nondestructive characterization of material surfaces on the nanometer scale. Dr. Wickramasinghe is one of the early developers of these powerful technologies. He has contributed many times in the past to the QNDE sessions and to the advancement of NDE for electronic devices. It was indeed a pleasure to see his return as the keynote speaker.

Professor James Oliver of Iowa State University and William Green, Ph.D., of the Jet Propulsion Laboratory (JPL) at the California Institute of Technology, Pasadena, provided excellent summaries of other technologies that use imaging as a main communication vehicle. Professor Oliver described recent advances in the development of an integrated virtual reality (VR) and high performance computing and



## Thompson Named CNDE Director

R. Bruce Thompson was named the new CNDE director in July 1997.

A distinguished professor of engineering with appointments in two departments (materials science and engineering; aerospace engineering and engineering mechanics), Thompson has served as the deputy director of CNDE since 1985. He replaces interim director Les Schmerr, who served in the position after the phased retirement of D. O. Thompson began in March of 1997.

Bruce said he is excited to have the opportunity to “build on the strong foundation already established at CNDE, which includes an excellent staff, close interactions with many of the leading industrial practitioners of NDE, and important educational initiatives. Building on these research, education, and technology transfer programs, we wish to continue to advance the state-of-the-art in inspection technology and its integration throughout the life cycle of components, thereby driving the continued maturation of NDE as a cost-effective engineering discipline.”

### INSIDE

- 2** AACE, Shurtleff Join ISU
- 3** Collaboration Clearing NDE Road
- 5** Determining Accept/Reject Criteria for Castings
- 7** Bubbler; Imaging Technologies
- 8** NDE Reliability Validation Subject of Workshop
- 9** Modeling on Standards White Paper Available; Workshop Studies NDE Standards and Modeling
- 10** Short Course Offers State-of-the-Art Opportunity; Forum Provides Industry and Research Interaction
- 11** ETC Presents Research Results
- 12** 1998 QNDE Conference
- 14** In Memory of . . .
- 15** Student Wins Prize for Research  
*CNDE News is published twice each year by the Center for Nondestructive Evaluation. CNDE is a member of the Institute for Physical Research and Technology at Iowa State University.*

Designer: Janice Weedman  
Editors: Linda Poore  
Anita Rollins

communications environment at ISU. This environment creates a real-time interactive environment that enables visual interactions with computationally intense simulations to be pursued. This is an exciting utilization of imagery that provides many new paths for future developments.

Green provided an excellent overview of digital image processing that has been pursued at JPL for the past 30 years to support the scientific analysis of remotely sensed imagery. He highlighted his presentation with timely and spectacular visuals obtained from the concurrent probe landing on Mars.

On Wednesday evening, Tobey Cordell of the NDE Branch of the Air Force Materials Directorate, Wright-Patterson Air Force Base, Dayton, Ohio, provided a special discussion of the Air Force's NDE program with an emphasis upon the full spectrum concept. This concept involves the tailored utilization of NDE from product design and materials characterization to inservice maintenance and recertification inspections. He especially noted the need for advances in the education and training of NDE personnel. The presentation was followed by an extended and interesting discussion period.

Finally, the Review provided an opportunity to put together an integrated overview of technical advances that have taken place in QNDE over the past ten years. There were two standouts in this arena, with a third now making substantial progress. From papers given and discussion that developed, it is apparent that laser-based ultrasonics and thermal imaging have both evolved from a research base to maturing technologies. Both have been tracked in the Review over the past several years and both have developed a promising future. A third area, model-based simulation, showed many interesting advances in the simulation of real NDE problems using fundamental NDE models. These approaches are expected to provide cost-effective solutions in the design and engineering phase and in the quantitative estimation of system capability. It may be that this is the next area open to broad technical acceptance.

*—by D. O. Thompson*



*Poster session at the 1997 QNDE conference.*

## AACE and Shurtleff Join ISU



Retirement isn't what it used to be. At least not if you are William W. (Bill) Shurtleff. Shurtleff is the director of the newly formed Federal Aviation Administration's Airworthiness Assurance Center of Excellence (AACE).

After resigning in October from his position as manager of the FAA Aging Aircraft Nondestructive Inspection Validation Center (AANC) at Sandia National Laboratories, New Mexico, Shurtleff joined the staff of the Institute for Physical Research and Technology at Iowa State University to begin his duties at AACE.

The center will be managed by ISU and the Ohio State University, Columbus. The program will identify and solve critical technology challenges related to national aircraft safety, including research in the areas of aircraft inspection, maintenance, and repair; crashworthiness; propulsion and fuel system safety;

*AACE/continued on next page*

advanced materials; and landing gear systems.

Shurtleff sees the work by CNDE's Center for Aviation Systems Reliability (CASR) and his work at AANC as foundational to what will be accomplished during the possible ten-year, \$100 million project.

"The FAA has really liked the CASR and AANC programs," remarked Shurtleff. "Hopefully we can continue in that vein and expand into new areas as well."

CASR is an important element of the new program and received \$1 million in direct funding for the current year. "We expect it will eventually be expanded to include other schools that will do work in inspection, maintenance, and repair," said Shurtleff. The propulsion work of the Engine Titanium Consortium, which includes ISU, General Electric Aircraft Engines, Pratt & Whitney, and AlliedSignal Engines, will also be incorporated into AACE.

Shurtleff, whose work will shift from the technology transfer focus of AANC to research and development, has as his short-term goal to get the board of directors and bylaws in place. He will also be working to put together a portfolio of initial projects. In his short tenure, he has already attended an FAA kick-off meeting in Atlantic City, New Jersey.

Shurtleff said the meeting was an opportunity for the FAA to impart "their vision—they discussed the processes and emphasized the opportunities for teaming based on core members' strengths."

And not surprisingly, he sees the team component—bringing together capabilities at 9 core institutions as well as 31 universities and 80 industrial and government organizations—as the most exciting opportunity and greatest task.

"It will be interesting working with such a different set of research institutions," he commented, but managing "the diversity of skills and different research sites will be a real challenge."

Once that challenge is overcome, Shurtleff expects to focus on new starts. "We will look more at what the customers want. We will put together a comprehensive program that looks like we are a center rather than diverse projects," he said.

Shurtleff, who has a three-quarter time position and will spend part of each month in Colorado, already has some experience working with diverse institutions. He was instrumental in preparing the joint proposal that resulted in AACE.

Shurtleff brings with him a total of 15 years of experience in nondestructive evaluation at Sandia. With a Ph.D. from the University of New Mexico in biomedical engineering, the work of Shurtleff and his colleagues at AANC recently resulted in an Aviation Week Laurels award for "contributions to aging-aircraft research."

Shurtleff said he is settling in well at ISU, and the support from Iowa State and CNDE has made the transition easier. "They've done a great job, and I appreciate their help," he said.

The AACE program office can be reached at 515-294-5276.  
—by Anita Rollins

## Collaboration Clearing NDE Road

Charting a course can be a daunting task. In areas without pre-existing roads, one relies on instincts and past experience to determine the best route.

In many ways, the North Central Collaboration for Education in Nondestructive Evaluation/Nondestructive Testing (NDE/NDT) has been charting a new course. With two grants awarded by the National Science Foundation, Iowa State University and CNDE have been working with area community colleges to enhance NDE education and make articulation to university technical degree programs easier. The destination is "improved technological education in NDE that results in an improved NDE/NDT workforce," said Brian Larson, program manager and CNDE principal investigator.

To reach that locale, ISU is working with Cowley County Community College (CCCC), Arkansas City, Kansas; Northeast Iowa Community College (NICC), Peosta; Ridgewater College, Hutchinson, Minnesota; and Southeast Community College (SCC), Milford, Nebraska, in a three-year



CNDE scientist Terry Jensen (left) explains the energy dispersive x-ray detector to a group of community college students.



Summer interns shared their experiences at NDE Engineering Information Day.

project. Industrial, professional society, and regional high school partners are providing input as well.

The program is using a number of strategies, all of which are making progress toward mapping the NDE high school-to-university road.

### ***Professional development and student internships***

Educators from each of the four participating community colleges attended a four-week professional development program at ISU during the summer of 1997. Instructors conducted research, monitored classes, and investigated new equipment and software.

Ervin Woodard, NDT instructor and program chair at SCC, said the professional development program exposed him to “research approaches and methods that I wouldn’t ordinarily have been exposed to.” He commented that the internship program in which two SCC students participated was also useful.

The internship allows potential transfer students to take a core engineering course and work up to twenty hours each week with a

research mentor. “There was some hesitation initially,” said Woodard of the students’ willingness to attend the ten-week summer program. But by summer’s end, one of the students decided to pursue a degree in engineering and the other had a better understanding of the opportunities.

The experiences with the collaboration have also helped Woodard give students better counsel. “Prior to the collaboration, when you talked with a student about continuing his or her education the sense was that you would leave NDT and do something else. Now we can tell students that they can be an engineer and do NDT,” said Woodard.

### ***Course and curriculum updates***

The collaboration is also working to enhance the education of students on community college campuses by updating courses and curriculum. Each of the collaborating institutions is working on some aspect of improving NDT education.

NICC is working on a teaching module for real-time radiography. The technique, which is gaining wider use in industry, requires special knowledge and training. The hands-on laboratory exercises being developed will help students use this advanced NDE technique. At the same time, CCC is developing a teaching module for XRSIM, the x-ray simulation model developed at CNDE. The program has been successfully ported to a personal computer environment, and work on instructional materials is proceeding.

Woodard is particularly excited about the possibilities presented as state-of-the-art technologies like XRSIM are used at community colleges. “If we had to do it ourselves—make this type of

technology available—it would be impossible. This is a tremendous benefit. But we also think we have something to give. We can provide feedback from a little different perspective since ultimately our students are going to use it,” said Woodard.

As Ridgewater converts to a semester schedule, it is obtaining industrial input to modify its NDE curriculum. Math and science requirements will also be reviewed. Meanwhile, SCC is working on an “Introduction to NDE” module for non-NDE disciplines and high school classes.

All of the projects will eventually be shared both locally and nationally. ISU is working on an Internet course offering as one communications vehicle. The beginnings of the course can be found at <http://www.cnde.iastate.edu/ncce/course.html>.

### ***Improving articulation***

Course improvements. Professional development. Student internships. Although they are important to completing the high school-to-university NDE roadmap, a central piece for improving articulation is the NDE Engineering Information Day.

With the College of Engineering, CNDE hosted a second, day-long event in October 1997. “This is an opportunity for community college students to hear from professors, industry representatives, and students like themselves about the possibilities in NDE,” said Larson. This year, the program had fifty participants from five community colleges.

“We think if we can get students here to see the advanced technologies and let them discover what it will be like

---

## Determining Accept/Reject Criteria for Castings

One of the factors limiting the use of castings in safety-critical situations is the wide range of values measured in strength tests. The occasional presence of a number of types of porosity and inclusions leads to a few samples that are much lower in strength than the majority of the population.

In compensation, the weight of the component is often increased, which in turn increases the likelihood that the very defects that led to the increased mass of the part occur. The result is that castings have not been frequently used in many of the applications that they would benefit most.

However, the significant cost savings that casting can afford is driving a reexamination of their use across a wide range of industries. For example, in the automotive industry a casting has been successfully used to replace the built-up structure of the cross member of a minivan. The function of this part is to hold the car's frame and provide part of the mounting for the engine, a decidedly safety-critical situation. Using the cast part in the minivan resulted in a better ride, a result of an overall stiffening of the frame. In the aerospace industry, castings are being considered for door frame assemblies in the fuselage. The result of a replacement of one such built-up structure is a replacement of over 100 components by one monolithic part. The resulting reduction of the inventory tracking and of the cost of assembly, and the elimination of manufacturing delays caused when one of the subassembly parts is not available, can run into millions of dollars.

The successful implementation of these components was not without major difficulties. The safety critical nature of these applications requires significant inspection of the parts and it requires that the casting process be understood and controlled. The weight sensitivity of these parts pushes the design to require that the material properties have sufficient safety margins but not excessive ones. In the automotive case, several factors push this to new levels. Global competition is driving reduced design cycles. The automotive industry is striving to reduce the 60-month design cycle typical of ten years ago to 30 months. Simultaneously, federal fleet mileage requirements are forcing new, lighter material into use. For example, cast iron parts are being replaced by aluminum parts. The result is a reduction in time to evaluate and build experience in how a new material will behave. The issue of weight versus performance has also traditionally been a key issue in the aerospace industry.

The traditional interplay of design of the part subject to the materials design allowables, the cost of manufacturing the part, and the inspection issues necessary to assure the safety of the final product is speeding up. At Iowa State University and Northwestern University, we have made significant progress in developing tools that provide a means to evaluate these competing, complex issues that are all driven by cost.

What are the issues that need to be handled in such a system? The first step is to determine what is a critical defect, i.e., what are the properties in terms of shape and location of, say, porosity, that causes a crack to grow before the design life of the component is reached. If you can

reliably detect these critical defects, you can be assured that the components are safe and can be used. We have developed modeling tools that allow the effects of defects to be calculated, the inspectability of the part to be determined and optimized, and the effect of casting parameters on the likelihood to produce porosity to be predicted. These tools allow the determination of how new materials will behave without the need for extensive and expensive testing of a large number of parts in testing stands.

This procedure is somewhat dependent on the sampling of prototype parts having the range of defects that will naturally occur in normal production. The modeling capabilities of the casting process allow the evaluation of the effects of casting parameters on the shape, location, and size of porosity. This gives input to the effects of defects model as to the type of defect that a particular process will produce. It also gives input to the inspection model, allowing a determination of the detectability of that particular shape, size, and location of defects. In the following we will go into detail on each of these components: the effects of defects calculation, the casting modeling, and the x-ray inspection of the parts.

### *Effects of Defects*

The goal of the effects of defects model is to calculate how long it will take a pore with a certain size and location to grow into a crack propagating through the part. This work has been led by Brian Moran at Northwestern. Several assumptions are made: the first is that a pore is already a crack; in other words, the initiation phase of the crack is zero. This is an appropriately conservative start for safety critical parts. The pore is approximated by an ellipse. The

parameters of the ellipse are taken as a best fit to the pore cross section perpendicular to the principal stress. A key parameter in these calculations is the distance the pore is from the nearest free surface.

The results of this model were compared with a series of tailored experiments, work led by Morris Fine at Northwestern. Cast A356 aluminum bars were first radiographed to locate porosity and to select a range of sizes and distances from the surfaces. Tension specimens were cut out of the larger bars. These samples were placed in a machine and fatigued. This set of measurements served two purposes: they were used to validate the effects of defects model and they established the effects of a number of casting parameters on the material strength. The results are displayed in

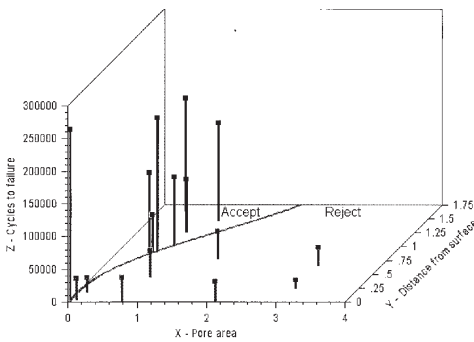


Figure 1

figures 1 and 2. In figure 1, a clear line can be drawn between those tension samples that failed early and those that took longer to fail. It also shows the importance of pore size and of its distance from the surface. This result has a serious implication regarding traditional accept/reject criteria based on the American Society for Testing Materials standard casting radiographs. A large pore deep inside the part may not be critical, while a

smaller pore near the surface is. An accept/reject criteria based on pore size, in this case the smaller size nearer the surface, will result in a number of acceptable parts with larger internal defects being rejected. Figure 2 shows the comparison of the model predictions to the experimental results. In all of the cases the agreement is within 20 percent, a remarkable result.

Code	a (mm)	b (mm)	l (mm)	L <sub>2</sub> W (mm <sup>2</sup> )	N <sub>exp</sub> (cycle)	N <sub>p</sub> (cycle)
D1M	0.653	0.493	1.94	10.92 x 4.96	149,718	90,500
B5G	0.401	0.497	1.75	10.90 x 4.93	80,828	88,000
A8G	0.315	0.535	1.39	10.96 x 5.11	59,436	79,000
D3	0.80	0.33	0.78	10.00 x 4.80	40,195	54,000
B6	0.453	0.543	0.55	10.90 x 4.75	36,575	53,000

A8G	0.315	0.535	1.39	10.96 x 5.11	59,436	79,000
D17	0.686	0.720	1.50	10.90 x 4.75	42,000	55,000
E14	0.491	1.380	1.40	10.90 x 4.75	30,684	38,000

B1	0.064	0.029	0.051	10.00 x 4.80	262,055	240,000
C3	1.400	0.702	0.95	10.90 x 4.75	11,952	21,000
A3	0.38	0.50	1.37	6.35 x 6.35	207,000	180,000
A8	0.60	0.28	1.10	6.35 x 6.35	128,106	145,000

Figure 2

**Casting Models**

For some time, several commercial casting solidification modeling codes have been available. These codes are best at predicting the regions of a casting in which porosity is most likely to occur. The principal mechanism is a region of the casting in which molten metal is cut off from the molten metal feed. Rough estimates of the amount of porosity can be made using various criteria, for example, Niyama and Huang-Conley. The present models are limited in predicting the shape of the porosity, a key input parameter in the effects of defects and the NDE models. Work led by James Conley at Northwestern is focused on developing refinements and extensions to the solidification models that predict location, size, and shape. Results of a solidification model on an engine mount casting are shown in figure 3a. The porosity is largest for the dark grey areas. Figure

3b shows a radiograph of the part. Note that the porosity in the part is in the area predicted by the solidification model. Although not shown in the discussion of the effects of defects, the

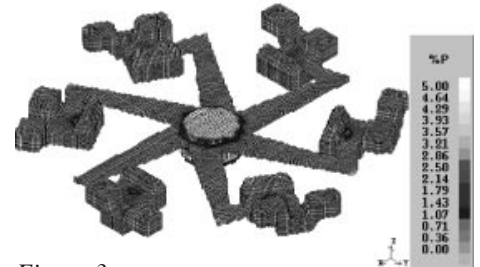


Figure 3a

stress throughout the engine motor mount part was calculated. This was the base stress field that the presence of the pore altered. The result of this calculation is that the region most likely to have porosity is also the high stress region.

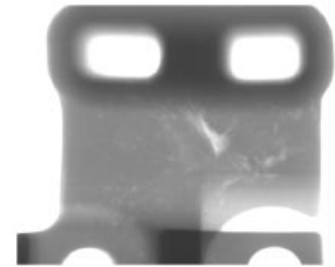


Figure 3b

**NDE Inspection Models**

The final component of the accept/reject criteria model is the inspection model. Several issues come to bear, the first being whether the inspection method can detect all of the critical defects. Second is the issue of inspection optimization; for example, a short exposure at a high kvP setting that lacks the sensitivity to detect a critical defect isn't acceptable, on the other

---

## Bubbler Selected by Tinker

The Dripless Bubbler, an ultrasonic aircraft inspection technology, was recently selected by the Air Force as the primary candidate for wing skin fastener corrosion inspection.

The Bubbler, developed by CNDE scientist David Hsu and engineers Thadd Patton and Dan Barnard, was chosen by Tinker Air Logistic Center, Oklahoma City, for inspection of C/KC-135, B-52, and E-3 aircraft in the depot.

The device allows automated, high resolution ultrasonic inspection of aircraft skins containing protruding rivets. The technology also permits testing over blended and painted surfaces and can focus down to 1/32 of an inch laterally. Around wing fasteners, the Dripless Bubbler can map out spreading exfoliation corruptions and reveal their depth. The device received an R&D 100 Award in 1996, recognizing it as one of the most significant technologies introduced to the world market in 1995.

The Air Force will purchase the Bubbler from Sierra Matrix, Inc., Fremont, California. The company licensed the technology from Iowa State University in 1996.

ARINC, Inc., Annapolis, Maryland, was instrumental in the selection process and has requested that ISU help develop inspection procedures and conduct training sessions.



## Imaging Technology Licensed

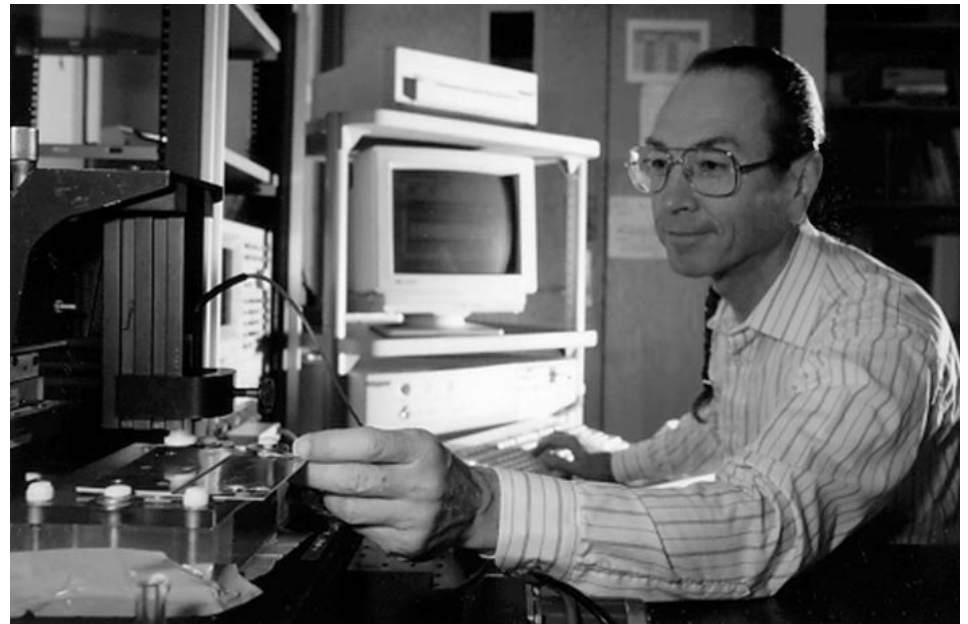
A CNDE signal and imaging process system that can improve the safety of nuclear power plants was licensed to Zetec, Inc. of Issaquah, Washington, in September 1997.

CNDE scientists John Basart and John Moulder with graduate student Sheng-Fa Chuang have developed a way to detect flaws in nuclear plant steam generator tubes. By providing impartial, accurate information, the system could serve as a second line of defense to ensure nuclear power plant safety.

Zetec licensed the technology to add to its existing line of eddy current inspection devices. It is the primary supplier for the nuclear industry.

Within a nuclear power plant, a damaged steam generator tube could transport radioactive fluid, putting workers at risk. The CNDE team has developed a computer program to automatically study data sets and identify changes in a tube's condition over time.

Now in its third year of development, the team's system has proven its ability in a number of tests. "We can automatically detect flaws in almost all of the cases where a human can detect flaws," said Basart. The team expects that as the system becomes faster and more accurate it will eventually minimize the human effort needed to conduct inspections.



*John Basart tests signal and imaging software that will be used in nuclear power plants.*



to be a student at a university, we will improve the chances of attracting them,” Larson added.

CNDE is also working with the College of Engineering’s Admissions Office to evaluate each community college’s curriculum so that credit transfer possibilities are clear.

With all of the components progressing and two years left to go in the NSF projects, Larson is optimistic.

“Our goals are to improve NDE education and develop an identifiable course so that the path from high school to community college to university is clear,” said Larson. “We think we are well on our way to accomplishing those goals.”

—by Anita Rollins



## NDE Reliability Validation Subject of Workshop

A European–American workshop titled “Determination of Reliability and Validation Methods of NDE” was jointly organized by the Bundesanstalt für Materialforschung und-Prüfung (BAM) in Germany and the National Institute of Standards and Technology (NIST) in the U.S., with the technical organization carried out by the Deutsche Gesellschaft für Zerstörungsfreie Prüfung (DGZfP).

The workshop was held in Berlin, Germany, June 18–20, 1997, and had approximately 95 participants. The conference included six technical sessions that contained twenty-eight invited papers, a poster session, and a series of consensus workshops.

At one of the workshops, Les Schmerr presented a paper on “The Role of Modeling in NDE Standards.” This paper summarized a number of the issues discussed at the Standards Workshop at Iowa State University (see article on page 9), using examples drawn primarily from ultrasonics. This gave the audience a chance to review some of the outputs of the Standards Workshop and to connect the ISU workshop topics to the reliability and validation issues discussed in Berlin.

Model-based efforts, particularly probability of detection (POD) models, were also quite prominent in a number of invited talks, including R. Bruce Thompson’s on “A Methodology for POD Determination Incorporating Insights from Physical Models.”

—by Les Schmerr



---

## Modeling in Standards White Paper Available

A white paper by Les Schmerr and D. O. Thompson on “The Role of Modeling in Standards” is now available. Based on input obtained from both the Standards Workshop at Iowa State University and the BAM Workshop on NDE Reliability (see articles on pages 8 and 9, respectively), the paper summarizes four areas that were identified in these workshops as high priority items that future work in modeling (as applied to calibration/standards) should address. These were:

1. The use of models to design, validate (qualify or requalify), and extend the measurement process.
2. The use of models to calibrate and quantify the capabilities of NDE hardware.
3. The use of models to train and educate NDE personnel.
4. The validation of the models themselves.

The white paper also gives some recommendations on how each of these four areas might be addressed in the future. Copies of the paper can be obtained from Schmerr (fax at 515-294-6368, or e-mail at lschmerr@cnde.iastate.edu).

—by Les Schmerr

## Workshop Studies NDE Standards and Modeling

*Editors’ note: This article expands on a piece in the July 1997 CNDE News.*

A Workshop on Nondestructive Evaluation (NDE) Standards and Modeling was held at CNDE on April 23–25, 1997. The workshop was sponsored by the National Institute of Standards and Technology (NIST) Program for Integrated Design, NDE, and the Manufacturing Sciences. The workshop was attended by approximately 50 participants.

At the workshop, a number of speakers gave overviews on how the standards process is currently structured and where standards are going in the U.S. and internationally. These talks included: “Standards—An Industry Essential” by Gerald Posakony (J–Tech, Richland, Washington); “Current Standards Development Practice: A Look at ASTM Committee E-7 Activities” by Thomas Jones (Industrial Quality, Inc., Gaithersburg, Maryland); “Models and Standards—Past Barriers and Present Opportunities” by D. O. Thompson (CNDE); and “Bridges Between Standards—Setting Organizations” by George Alers (NIST).

To provide the audience with an up-to-date review of the capabilities of NDE models, particularly as developed at the CNDE in the NIST Program for Integrated Design, NDE, and the Manufacturing Sciences, there were talks on standards and ultrasonic modeling by Les Schmerr, x-ray modeling by Joe Gray, and eddy current modeling by John Moulder.

In addition, to give a closer view of the power of the models, a series of live demonstrations was held. CNDE’s Mike Garton and Tim Gray demonstrated the ultrasonic simulator UTSIM and discussed the industrial use of ultrasonic models for making surface curvature corrections and scan plan specifications. Similarly, Joe Gray, CNDE scientist, demonstrated the x-ray simulator XRSIM. Its use was demonstrated by describing some recent work with Northwestern University, Evanston, Illinois, on combining NDE models with casting solidification models to guarantee the reliability of safety-critical automotive castings.

Finally, Moulder, Garton, and CNDE’s Norio Nakagawa demonstrated the eddy current simulator, ECSIM, and discussed model validation efforts on the complex geometries of aircraft engine components and in steam generator tubing inspections.

In a session on current industrial uses of modeling, Robert Shannon from Westinghouse Electric Corporation, Pittsburgh, Pennsylvania, presented “Application of NDE Models in the Energy Industry.” The talk outlined a number of places where modeling already has played a significant role in solving industrial problems, including ultrasonic models for power turbine inspections and tubing applications, x-ray modeling for large castings, and eddy current modeling for nuclear steam generator tubing inspections. Dick Trantow from General Electric Aircraft Engines, Evendale, Ohio, also spoke in this

“To accomplish this, the development and transfer of new measurement techniques, hardware, and advanced software, as well as the education of the students who will provide an important mechanism for the transfer of these tools to industry, must continue to be central to the activities of CNDE,” said Bruce. He added that, “on top of this, we must continue to integrate these results with other engineering disciplines, often aided by models, so that the power of nondestructive measurements can have the fullest impact on product reliability at all stages in the life cycle. Working closely with other units of the university and with other institutions throughout the world will be important to helping the center accomplish that goal,” he added.

Bruce received a B.S. in physics from Rice University, Houston, Texas, and M.S. and Ph.D. degrees from Stanford University, California. He joined ISU in 1980 as a senior scientist with the U.S. Department of Energy’s Ames Laboratory and as an adjunct professor in the department of engineering science and mechanics. He also served as associate director of science and technology at the Ames Laboratory, a position from which he resigned to assume the CNDE Directorship.



## Short Course Offers State-of-the-Art Opportunity

Enhancing the education of engineers who use nondestructive evaluation (NDE) is the goal of CNDE/Iowa State University short courses.

The Quantitative Eddy Current NDE course offered October 29–31, 1997, provided an opportunity for industry practitioners to learn about quantitative eddy current technologies and gain hands-on computer modeling experience.

The course consisted of a series of lectures and computer laboratory sessions. The lectures introduced participants to automated measurement procedures, software modeling capabilities, and signal processing. The laboratory permitted hands-on experiences with ECSIM, an eddy current simulator used to help engineers better predict the effectiveness of eddy current inspection for a given situation. Instructors for the course included CNDE scientists John Moulder, John Basart, Mike Garton, and Norio Nakagawa.

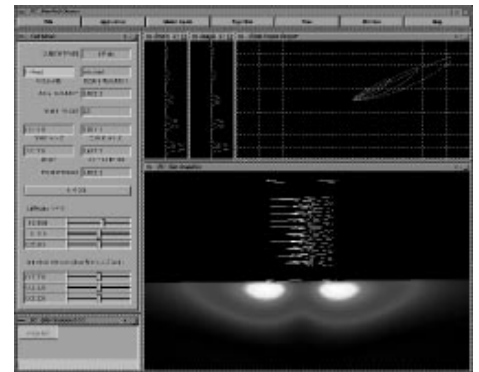
According to Moulder, the course information could be used to develop better test procedures, design probes, or train employees. Computer simulations of NDE procedures allow the user to explore a wide range of test variables without the cost in time and effort to perform trial and error development, Moulder said.

Such short courses provide sponsor industries, and interested ISU faculty and staff, with the opportunity to enhance their NDE education.

Continuing education credits are available to participants.

Robert Shannon, Westinghouse Electric Corporation, Pittsburgh, Pennsylvania, a senior research engineer, said the short courses are important offerings.

“Most of the NDE educational opportunities available are at the technician level, not at the engineer level,” he said. Shannon, who has attended every CNDE short course offered over the past three years, said the modeling work is particularly beneficial to Westinghouse as a method to train their own engineers.



## Forum Provides Industry and Research Interaction

The 1997 Air Transport Association Nondestructive Testing (ATA NDT) Forum was held in Indianapolis on September 8–11, 1997. United Airlines (UAL) and Allison/Rolls Royce, Filton, Bristol, England, served as corporate sponsors for this year’s event.

A highlight of the Forum was the tour of the recently-opened maintenance

FORUM/continued on next page

facility for UAL. This facility was designed with effective maintenance practices in mind and represents the state-of-the-art in aviation maintenance and inspection.

An important contribution to the event for aviation programs was made by Iowa State University and included interaction with industry as part of the demonstrations of FAA-funded projects. Lisa Brasche, CNDE associate director, said, "The ATA NDT Forum offers the best opportunity for FAA-funded researchers to discuss their efforts with a broad segment of commercial investigators in the aviation community. A critical part of what we must do for successful technology transfer involves acquiring and listening to the input of the industry." Projects from the FAA Center for Aviation Systems Reliability (CASR) program at ISU, the Airworthiness Assurance Nondestructive Inspection Validation Center (AANC) at Sandia National Laboratories, New Mexico, and the Engine Titanium Consortium (ETC) were highlighted in demonstrations at the meeting. CASR and AANC are cornerstones in the FAA's National Aging Aircraft Research Program. ETC, which is a partnership that includes AlliedSignal, Phoenix, Arizona; General Electric, Evendale, Ohio, ISU; and Pratt & Whitney, West Palm Beach, Florida; has inspection development efforts under way in production and inservice areas for aircraft engine materials and components.

ETC technologies showcased included the portable scanner and data acquisition system (Pratt & Whitney) and the flexible substrate eddy current

probe (General Electric). CASR demonstrations of a thermal wave imaging system (Wayne State University, Detroit, Michigan), pulsed eddy current system (ISU), dripless bubbler (ISU), XRSIM (ISU), self-compensating ultrasonic (UT) technique for multilayer inspection (Northwestern University, Evanston, Illinois), and laser-based UT detection technology (Northwestern) were featured as well. The response from industry was very positive, according to Brasche, and arrangements were made for several field tests in the near future. For more information on any of these technologies, contact Brasche at 515-294-5227.

The 1998 ATA NDT Forum will take place in Albuquerque, New Mexico September 8–October 1. Call Art Columb at 202-626-4134 with any Forum questions.



## ETC Presents Research Results

The third Engine Titanium Consortium (ETC) Open Forum was held November 18–20, 1997, in Houston, Texas. The meeting was organized by ETC on behalf of the Federal Aviation Administration (FAA) Technical Center and the FAA New England Engine Propeller Directorate.

The Forum's attendance of 80 represented all segments of the titanium industry. The agenda included technical presentations on fundamental studies, production inspection, probability of detection, contaminated billets, and inservice inspection.

To open the government/industry/university consortium forum, Bob Guyotte and Al Broz of the FAA presented the agency's perspective. Presenters included the FAA; Iowa State University; General Electric, Evendale, Ohio; Pratt & Whitney, West Palm Beach, Florida; AlliedSignal, Phoenix, Arizona; Wyman-Gordon, Houston, Texas; Allison/Rolls Royce, Filton, Bristol, England; American Airlines, Tulsa, Oklahoma; and SNECMA, Evry, Cedex, France.

Wyman-Gordon sponsored a tour of their forging manufacturing facility where the majority of the world's engine disks are made. U.S. Inspection also held an open house of their new forging inspection facility, which includes two state-of-the-art ultrasonic testing immersion systems for zoned inspection. Included in the event was a roundtable discussion of nickel and titanium billet inspection.

The meeting accomplished its objectives of presenting the results of FAA-funded research and promoting the discussion of those results. The fourth Open Forum is tentatively scheduled in Boston, Massachusetts, home of the ETC technical sponsors, the FAA New England Engine Propeller Directorate.

—by Lisa Brasche

---

# 1998 QNDE Conference

1st Call for Papers  
December 1997

Papers are sought for the 25th Annual Review of Progress in Quantitative Nondestructive Evaluation to be held July 19-24, 1998, at the Snowbird Ski & Summer Resort in Snowbird, Utah.

The Review of Progress is organized by CNDE in cooperation with the American Society of Nondestructive Testing, the U.S. Department of Energy, the Federal Aviation Administration, the National Aeronautics and Space Administration, the National Institute of Standards and Technology, and the National Science Foundation Industry/University Cooperative Research Centers. Cooperation with other technical societies interested in NDE is encouraged.

Verbal and poster sessions will emphasize both the basic science and early engineering developments in quantitative NDE and closely related technologies such as materials characterization and process control, that utilize quantitative NDE techniques.

Categories of the Review will include advances in:

- fundamentals of all QNDE methods (field-flaw interactions and field-property relations, scattering, probability of detection, inverse methods and their application to flaw

sizing and property measurement, process models, reliability of measurement, and component inspectability)

- flaw imaging and reconstruction, image analysis—all techniques
- signal processing methods, including application of advanced techniques to QNDE
- sensors, transducers, and probes for flaw detection, material property measurement, and process control
- new and emerging QNDE techniques (e.g., NMR)
- new QNDE instruments and systems
- QNDE reliability and inspectability
- materials characterization (properties, stress, processes, weldments, corrosion, others)
- QNDE for advanced materials (composites, electronic materials and devices, ceramics)
- QNDE of civil structures and materials
- QNDE in manufacturing design and process control

Prospective authors are requested to prepare a 200 word (or less) abstract. The abstract should be typed and include the title, author(s) and affiliation before the body of the abstract. Abstracts may be submitted by mail or fax, or be submitted electronically. Each abstract must

have a separate submittal form attached.

Submission information:

- Fax: 515-294-2367
- Electronic: To submit abstracts by e-mail, contact [abstracts@cnde.iastate.edu](mailto:abstracts@cnde.iastate.edu)
- Mail: Send to QNDE Programs  
Attn.: ABSTRACT ENCLOSED  
Center for NDE  
ASC II  
Iowa State University  
1915 Scholl Road  
Ames, IA 50011-3042

The deadline for submissions is **April 30, 1998**. Questions concerning abstracts should be directed to Connie Nessa or Sarah Kallsen at 515-294-9749, or fax at 515-294-2367.

Abstracts will be reviewed by a program committee, and author(s) will be informed by May 22, 1998, of acceptance and whether the presentation will be in a verbal or a poster session for the Review.

The proceedings will be published as a hardbound volume. Details of manuscript preparation will be sent at the time of notification of acceptance of the abstract. Manuscripts are due on September 1, 1998.

Conference information and forms are available on the center's Internet site: <http://www.cnde.iastate.edu/qnde/qnde.html>.



hand an exposure at a low kvP assuring the required sensitivity may take longer than needed. Adequacy of coverage is often an issue. Due to a casting's near net shape, one projection often will not cover the entire part. The issue then is to determine a particular technique's ability to detect a pore and to assure that the part volume is thoroughly inspected. The cost of an inspection can be dramatically effected by the number of orientations needed to assure proper coverage. The x-ray radiographic simulation code, XRSIM, can predict the detectability limits and coverage issues. Figure 4a shows the CAD model of the engine motor mount. For a particular orientation, the projection through the parts is shown in figure 4b. As is typical of a casting, there is a large range of projection thickness. Parameters for the inspection can be selected that favor

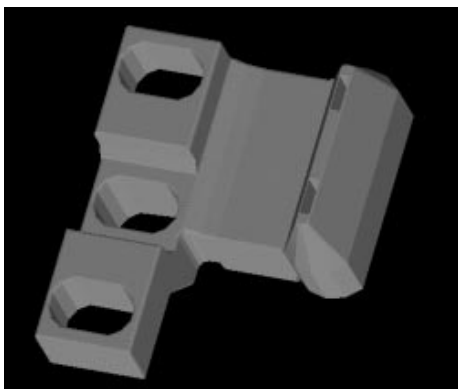


Figure 4a

the thin areas or the thicker areas; in this case we have selected the region for optimization that was predicated as having the largest porosity and the largest stress. Figures 5a-c show the results of a calculation of the detectability of a 24, 20 and 15 mil pore. The part was divided into ~60,000 voxels; the pores of the noted sizes were placed at each location and

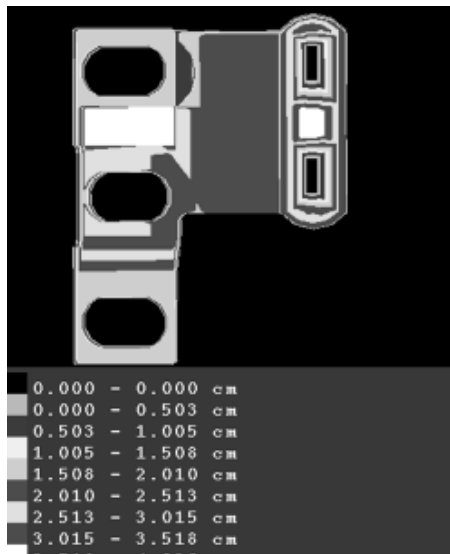


Figure 4b

a contrast was calculated. Voxels shown in the patterned shades of grey identify regions in the part where the detectability was poor. As can be seen, the thickest areas and the thinnest areas have poor detectability (figure 5a), while the transparent regions, having intermediate thickness, have good detectability. As the pore size is reduced, figure 5b and c, the poor detectability regions increase, demonstrating the limits of the particular selection of x-ray generator, tube voltage, and film choice. Exposure conditions or orientation changes will provide different maps, the combination of which demonstrates a method's adequate coverage of the part.

### Conclusions

There are several new capabilities that are demonstrated in this approach to determining accept/reject criteria. The first is from the NDE modeling area, the ability to determine the limits of detectability for a given type of defect is often the starting point for the design of a part. Present design allowables are a function of the

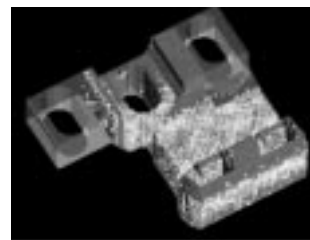
Figures 5a-c



6 mm defect



5 mm defect



4 mm defect

POD	
0.8 - 1.0	transparent
0.6 - 0.8	
0.0 - 0.6	

material properties and the inspection limits. The inspection limits can be highly dependent on the geometry of the part. Without this new capability, there can be an overly conservative estimation of the detectability limits.

The second point is one that inspection struggles with, namely, what is the critical defect that must be found. The effects of defects models, discussed earlier, give for the first time a means to determine and supply this information to NDE. As noted, the effects of defects is highly influenced by the casting

## In Memory of...



**Otto Buck**, on November 20, 1997, passed away after an extended illness. Born in Stuttgart, Germany, on May 14, 1933, Buck was educated at the University of

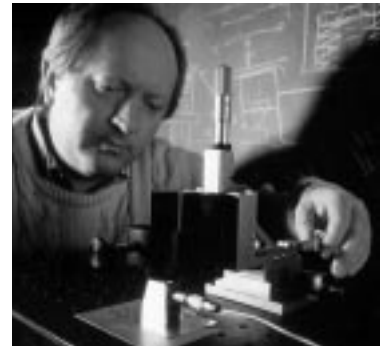
Stuttgart and Max-Planck-Institut for Metallforschung, receiving his Ph.D. in metal-physics from the latter in 1961.

Buck came to the U.S. in 1964 to join the ranks of the newly-formed Rockwell International Science Center, Thousand Oaks, California, where he worked until 1980, first as a member of the technical staff and then as the leader of the Physics of Failure Group. During this period, he made many important technical contributions that laid the foundation for his interests in nondestructive evaluation (NDE) and materials reliability. Included were fundamental studies of radiation damage based on internal friction measurements, important contributions to the Apollo project, and pioneering studies in crack propagation, including the effects of closure stresses on crack propagation.

In 1980, Buck moved to Iowa State University, assuming duties as staff member of the Center for Nondestructive Evaluation, director of the Metallurgy and Ceramics Division of the Ames Laboratory, and professor of Materials Science and Engineering. His many important contributions in NDE are well known, including studies of the influence of crack closure on ultrasonic response,

development of techniques to measure mechanical properties and residual stresses, and important contributions to the development of ultrasonic harmonic generations as an NDE tool. Perhaps not so well known to the NDE community are Buck's important educational contributions in developing the current mechanical metallurgy course sequence at Iowa State and in guiding the development of the Metallurgy and Ceramics Program of the Ames Laboratory within the DOE community, with special capabilities in materials processing.

Buck's great technical knowledge and experience, patience, humor, personal warmth, and wisdom will be sorely missed by colleagues, students, and friends. For those wishing to contribute to his memory, a fellowship has been established in his name. Contributions can be sent to: Iowa State University Foundation, 2229 Lincoln Way, Ames, Iowa 50014. Please indicate that your gift is sent in memory of Dr. Otto Buck for the "Otto and Martha Buck MSE Scholarship Fund."



**John Moulder**, senior scientist at the Center for NDE, passed away on January 19, 1998, of complications from surgery. John was born in Berea, Cuyahoga County, Ohio, in August 1944. On a full Norggrer Scholarship, Moulder pursued a double major in Physics and Philosophy at the Massachusetts Institute of Technology from 1962 to 1964. After an absence from school, which included pursuits of his interests in poetry and science, he received the B.S. in Physics and English from the Metropolitan State College in Denver, Colorado, in 1984.

Moulder joined the National Bureau of Standards (now NIST) in Colorado in 1964 prior to enlisting in the Air Force in 1968. His military obligations included performing research on lasers at Kirkland Air Force Base near Albuquerque, as well as serving two tours of duty in Southeast Asia, working in avionics repair in Thailand. He was honorably discharged in 1972 at the rank of staff sergeant with an Air Force commendation for outstanding service.

Moulder joined the Center for NDE as a scientist in 1987 and founded the eddy current research group within the Center. He was a highly innovative scientist who invented a novel method for the inspection of multilayered

*MOULDER/continued on next page*

metallic structures, contributing significantly to aircraft safety in the process. He devised a photothermal/resistive scheme to measure quantitatively, and with high spatial resolution, the field of an eddy-current coil. For these and other innovations, Moulder was awarded three patents, with a fourth pending. His publications include well over 100 contributions to the technical literature. He was the advisor for 12 graduate students at ISU and served on international committees that oversaw aspects of eddy currents inspections and the setting of worldwide standards.

Moulder served as technical editor for the *Journal of Nondestructive Evaluation* and refereed for many journals publishing work in electromagnetic inspection methods. In 1992, he received the Technical Achievement Award of the TTCP, an international panel of defense specialists from five Allied, English-speaking countries and the 1992 Achievement Award of the American Society of Nondestructive Evaluation.

The John Moulder Memorial has been established to provide assistance to students studying for a career in nondestructive evaluation. Gifts may be made out to the ISU Foundation and mailed to: John Moulder Memorial, Center for Nondestructive Evaluation, 111 Applied Sciences Complex II, Iowa State University, Ames, IA 50011-3042.

CASTINGS/continued from page 13

conditions in that pore size, shape and location can have significant impact, indeed the final solution may be to alter the casting process and eliminate the formation of porosity. Figure 6 shows a schematic of the method that we have begun to demonstrate. An example illustrates the need for this type of integrated environment. The first example is at an intermediate stage in the development of a cross member casting mold. In the

prototypes a laminar flow of the metal through a narrow passage resulted in a partial solidification of the molten metal. The narrowed passage led to incomplete filling of the mold cavity opposite the constriction. The solution was to add a cross hatch pattern to the mold walls; the irregular surface generated enough turbulence that the solidification didn't occur. The effect on the inspection was to produce a mismatched grid pattern on the radiograph. The slight mismatch in the overlap of the top grid with the bottom makes a contrast that looks exactly like porosity. The solution to one problem generated another one in the inspection. The result was yet another modification to the mold, this time by adding the cross hatch pattern with less depth.

-by Joe Gray

## Student Wins Prize for Research

Brandon Verbrugge has won the 1997 Philip H. Trickey award for research on characterization and improvement of magnetic laminations. He beat competition from the University of Illinois, Urbana-Champaign, and the Massachusetts Institute of Technology.

The prize included a check for \$2,500 awarded by the Electric Motor Education and Research Foundation and the Small Motor Manufacturers Association. His work with David Jiles, CNDE senior scientist, involved the treatment of magnetic laminations to improve core losses.

Verbrugge is a senior in electrical and computer engineering at Iowa State University. He will be continuing his research this year under a special National Science Foundation grant.

WORKSHOP/continued from page 9

session on "Application of DICOM to NDE Images," which addressed the possible use of an existing medical image communication and storage standard, DICOM, by the NDE community.

The workshop wrapped up with a panel discussion and a group breakout/feedback session on the needs in standards and how models might fit into those needs. The panel consisted of Alers, Jack Spanner Jr. (Electric Power Research Institute, Charlotte, North Carolina), and Tom Jones (ASTM). The breakout leaders were Joe Gray, Tim Gray, Moulder, and Schmerr.

-by Les Schmerr

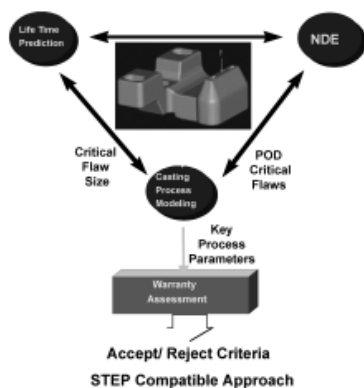


Figure 6

*For more information about the Center for Nondestructive Evaluation, please contact:*

*R. Bruce Thompson, Director  
Center for NDE  
Iowa State University  
515-294-8152 phone  
515-294-7771 fax  
cnde@cnde.iastate.edu*



*The Center for Nondestructive Evaluation is located in the Applied Sciences Complex, one mile northwest of Iowa State University's central campus.*

*Center for NDE  
Applied Sciences Complex II  
1915 Scholl Road  
Ames, IA 50011-3042*

We wish to acknowledge with thanks the following agencies and industrial sponsors who have helped to develop the Center through their financial support and technical interests. We hope this newsletter contributes to achieving a common goal—the continued development of both technology and people for NDE as an engineering discipline.

AlliedSignal Propulsion Engines  
Aluminum Company of America  
The Boeing Company  
Caterpillar, Inc.  
Eaton Corporation  
Electric Power Research Institute  
Electricité de France  
Federal Aviation Administration  
Framatome  
General Electric Company  
Herzog Services, Inc.  
Howmet Corporation  
Knolls Atomic Power Laboratory  
Lockheed Martin  
National Aeronautics & Space Administration  
National Institute of Standards and Technology  
National Science Foundation  
Northrop Grumman Aerospace Corporation  
Ontario Hydro  
Pratt & Whitney  
Samsung Advanced Institute of Technology  
U.S. Department of Energy  
Westinghouse Electric Corporation