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(Homer Fisher 615-974-3240)

Tennessee Highlights

- ✓ The Science Alliance strengthens UT Knoxville's 40-year relationship with Oak Ridge National Laboratory. An important part of the Alliance is the Distinguished Scientist Program, which is bringing the world's outstanding researchers to UTK & Oak Ridge on joint appointments.
- ✓ Besides the Science Alliance, there are four other Centers of Excellence—in materials processing, MBA venture analysis and entrepreneurship, livestock diseases and human health, and waste management.
- ✓ Outstanding classroom teaching is at the heart of any state flagship university, and 12 Chairs of Excellence are part of UT Knoxville's 1,400-member faculty. The Chairs are filled with scholars whose academic interests range from 18th century literature to power electronics to genetic engineering in soybeans.
- ✓ Faculty win more than \$80 million annually in government and business research contracts, ranking UT Knoxville among the top 100 American research universities.
- ✓ UT Knoxville's 25,000 undergraduate and graduate students come from every county in Tennessee, every state in the Union, and about 100 foreign countries.
- ✓ UT Knoxville has developed in the last seven years cooperative international programs with universities in Australia, Brazil, Chile, China, Egypt, France, Germany, Great Britain, Japan and Jordan.
- ✓ UT Knoxville has gained national recognition for its innovative ties to business and industry. The Saturn Corporation and the University have a formal agreement to share information and perform research projects of mutual interest. UT Knoxville has laboratory facilities on the high-tech corridor between Knoxville and Oak Ridge.
- ✓ In addition to grading its students, UT Knoxville is giving itself a report card on the value of the educational experience it provides. The campus's academic assessment program is ranked as one of the best in the nation and is a model for such efforts at other universities.
- ✓ At the heart of the University and in the center of the campus is UT Knoxville's new \$29 million John C. Hodges Library. It is one of the most automated libraries in America.
- ✓ UT Knoxville has three presidential papers projects—the most of any university in the nation. Research projects on the documents of Tennesseans Andrew Jackson, James K. Polk and Andrew Johnson are located here.

ANFLOW System's Environmental, Cost Advantages Attract Notice

Waste Treatment 'Bioreactor' Uses Bacteria in Process

A process that uses bacteria to treat waste is attracting attention nationwide as an environmentally sound and economical method of waste treatment.

The ANFLOW (Anaerobic Upflow) system uses a "bioreactor," or a concrete container that provides an environment suitable for bacteria to ingest waste, that reduces sludge as much as 70 percent.

The treatment can then be completed in an artificial wetland area where other bacteria finish the process. The absence of machinery or the need for extensive manpower and maintenance has made the ANFLOW system very attractive to schools, state parks, and other developments where the demands on the system would fluctuate greatly during the year.

Scott Daley, president of ANFLOW, Inc., said a comparison of costs between his system and a traditional sewage system underscores the benefits.

"A traditional sewage system with 25,000 gallons per day capacity costs \$18,000 a year to maintain. A comparable ANFLOW system costs \$8,000 a year to maintain," Daley said. He added that the system is also less expensive and cheaper to install.

Daley added that the ANFLOW system was much cleaner than the conventional septic system. When conventional

systems break down the untreated waste is usually poured into streams, resulting in environmental damage. In the anaerobic upflow system, pretreated water is gradually returned to the ecosystem through a man made wetland, without mechanical parts that could break down and disrupt the process.

The wetland strips are more desirable than a drain field because they do not smell, aren't spongy, and can be used as landscaped areas near the residence, according to Daley.

The ANFLOW bioreactor, which was originally developed at Oak Ridge National Laboratory in the 1970s, is essentially a tank equipped with a mesh that provides an environment conducive to consistent bacterial growth. These bacteria are used as a pretreatment for the sewage. Because the bioreactor is an upflow device, different bacteria at different levels of mesh in the tank perform almost specialized tasks in reducing the sludge, according to Daley.

State parks have shown a particular interest in the system, according to Daley, primarily because of its low maintenance requirement (cleaning twice a year). In addition, a North Carolina school system is considering a system, and an ANFLOW system serving 140 homes is currently in use in Nashville.

In Progress...

Construction is underway on QualPro, Inc.'s new headquarters and training center. "We expect our growth to continue at a very rapid pace and this site allows room for our expansion," said Charles Holand, QualPro founder and chairman. Completion of the quality and productivity improvement consulting firm's facility is expected in January 1989.

A new subsidiary of CTI, Inc. is devoted to making its medical imaging system, Positron Emission Tomography, more affordable to hospitals. **CTI Services, Inc.** hopes to achieve this by helping hospitals in large cities work out arrangements to ease the expense of acquiring a cyclotron, which provides the radioactive isotopes necessary to the system.

Perceptics, a Knoxville-based computer technology firm, and 3M have joined to develop the market for the computerized license plate scanner. Perceptics' scanners caught 3M's eye when the U.S. Customs Service used them in the early 1980s. Under the latest agreement, Perceptics will further develop computer software and equipment for use in 3M's Retroreflective Image Analysis system.

Armed with a Small Business Innovation Research grant, **Quality Control Instruments (QCI)** is developing an instrument that sorts out mixed stainless steel alloys. The Thermoelectric Alloy Sorter has attracted the attention of NASA and the aerospace industry. "The contract is to examine different types of stainless steel as they are hardened by heat treatment," QCI President Roger Derby said. The alloys are formed at lower hardness and heat treated, or hardened, for service.

Development of a miniature oxygen sensing device is the aim of a new Oak Ridge firm. **Syn Cryst** (for synthetic crystals) has been established by Oak Ridge National Laboratory retiree Wayne Clark. Clark researched synthetic crystals during his years at ORNL, and has received a Small Business Innovation Research grant from the Department of Energy to develop the sensor. The device would be used in aircraft or other large engines to determine air/fuel mixture.

OXYRASE

CONTINUED FROM PAGE 1

Dr. Adler invested out of his own pocket to obtain the patent. The change in contractors at the DOE facilities in Oak Ridge from Union Carbide to Martin Marietta Energy Systems occurred during this time, and technology transfer was likewise a major goal of Martin Marietta. They were helpful in publicizing the development.

"Union Carbide and Martin Marietta constantly looked for ways to help," Dr. Adler said. "We had a facility at Martin Marietta where we made batches of Oxyrase to show to industries."

In fact, he was encouraged to apply for the Industrial Research 100 Award in 1984, and he won it. Oxyrase was recognized as one of the most significant new technical products.

Oxyrase started out as fallout from basic research, but could wind up being very useful and helpful to human health, such as in improving isolation of anaerobic bacteria in patients.

Dr. Adler had offers from different companies for rights to the technology, but ultimately decided to develop a company around the product with the help of Dr. Jim Copeland, a former student of Dr. Adler's who is now president of Oxyrase, Inc.

Oxyrase was first sold in December 1987 to universities, hospitals, clinical labs, and industries. The product is being evaluated as a way to prevent oxidation of wine and beer, which could result in tremendous growth of the product.

UT Program Strives for Business-Technical Balance

Controversial, yet ever more lucrative, biotechnology has bloomed from a research and development discipline into a full-fledged field of industry. Areas from agriculture to medicine to cosmetics point to the commercial promise of "tiddling with mother nature."

The challenge to prepare researchers who are sensitive to the ethical and environmental concerns brought on by the advances in this field, but who also are receptive to its growing promise, is being met by the University of Tennessee's masters degree program in biotechnology. In its third year, it is one of 15 such programs in the United States. Dr. Donald Dougall, professor of botany at UT-Knoxville, heads the master's program.

The program specifically prepares students to work in industry. The students study the philosophical and political aspects of biotechnology as well as the technical side.

The idea, according to Dr. Dougall, is

to prepare them with "background skills, obligations and professionalism" in order for them to put their expertise to use within a company or industry.

The program was developed out of a Centers of Excellence grant through the Science Alliance, which promotes joint research and education programs. Twenty-four faculty are associated with the program, and participating institutions include the Oak Ridge National Laboratory and UT's Institute for Agriculture, as well as numerous departments within UTK.

Students meet with social anthropologists and philosophers in a seminar conducted throughout the two year program to acquire an understanding of how to access bodies of knowledge outside of science and to become more familiar with business.

The students participate in ethical debates that cover subjects such as invitro fertilization, DNA manipulation, and other issues dealing with "the use



Students in the UT master's program in biotechnology study ethical and business, as well as technical, aspects of the field.

of cells and their parts for producing useful products," said Dr. Dougall.

The ultimate purpose is for them to be able to effectively and sensitively develop the ensuing technological advances for use in the marketplace.

In the United States, the initiative is in pharmaceuticals, diagnostics and therapeutics for human health care," said Dr. Dougall. "The next emphasis is in veterinary science."

But additional advances are being made in areas as diverse as food preservation, fermentation, cosmetics, and increasing plants' resistance to disease and drought.

Normally, one-third of the students go on to a PhD program in a classical discipline. The master's degree program is designed to encourage further training as students get a firm technical background.

In fact, there is no actual "biotechnology" course offered. The field is so large and diverse that offering such a course is not feasible on the graduate level.

"The students must take doctoral level or pre-existing courses, not watered down classes, to insure that they would be able to continue their training," said Dr. Dougall.

"We need to support high-technology economic development in Tennessee," Dr. Dougall said. One way, he said, is to produce professionals who understand the social, as well as the technical, aspects of their work and can make the general population feel comfortable with the science.

New Roane State Courses Reflect Industrial Demand

Two options have been added to Roane State Community College's Environmental Health Technology degree program — Waste Management and Industrial Hygiene.

The courses reflect a demand for professionals with expertise in two growing industrial concerns, hazardous



waste management and the workplace environment, according to program director Dan Hyder.

The Waste Management program familiarizes students with basic waste management concepts and the regulations involved in storing, transporting, and disposing of hazardous waste.

Hyder cited instances of hazardous waste mismanagement in the news both nationally and locally — Love Canal

in New York and the Pigeon River pollution issue in East Tennessee — as reasons for industries' growing interest in environmental management.

"Both industries and firms providing consulting services in environmental matters need individuals trained in environmental health," Hyder said.

The Industrial Hygiene option is aimed at contributing to the health and well being of workers, teaching students to anticipate, recognize and evaluate conditions and situations that adversely affect the workplace.

Those would include, according to Hyder, physical hazards such as noise, chemical hazards such as toxic gases, biological hazards such as molds and fungus, and hazards caused by improperly designed tools or work areas.

Hyder cites government regulation as well as expanding technology in the workplace as evidence of the need for persons trained in this area.

He added that paid internships with area industries are available to students in the degree program, and that demand for interns is considerable.

Computer Vision and Robotics Research at the University of Tennessee, Knoxville

Prepared by Mohan M. Trivedi

Researchers at the University of Tennessee's Electrical and Computer Engineering Department have been involved in robotics related work for the past fifteen years. Our research focus has been on the development of theories and techniques useful in sensing, control, and computational aspects of intelligent decision making systems. We are one of the four university research groups selected by the division of the advanced technology development of the U. S. Department of Energy to conduct research leading to the development of advanced robotic systems for nuclear power plants. Also, we have been selected by the chief scientists of the U.S. Army, R, D, & E Center to conduct basic research in the analysis of high resolution aerial scenes.

We have developed a well-equipped laboratory facility with several unique capabilities in support of our robotics and computer vision research, under the sponsorship of various state, federal, and industrial research support. The main resources in the laboratory include minicomputers and associated peripherals, image processing hardware, high resolution graphics displays, cameras, digitizers and an industrial robot. Recent additions to our facility include VLSI work stations, two TI Explorer LISP work stations, and a thermal imaging system. The T³ - 726 robot manufactured by Cincinnati Milacron Company has been extensively enhanced by adding sensory mechanisms. The sensors incorporated on the robot include vision, range, and proximity as non-contact devices, and touch and force/torque as contact devices. Each of these devices are interfaced directly to a VAX 11/750 computer. Recently, we have acquired a 16-node hypercube parallel computer.

Over the years we have performed research under the sponsorship of various federal and industrial research grants. Main sponsors of our work include the Departments of the Army, Navy and Air Force, the Defense Mapping Agency, NASA, the National Science Foundation, the Department of Energy, the National Oceanic and Atmospheric Administration, and the National Institutes of Health. The major industrial sponsors of our work are Martin Marietta Aerospace Company, and Martin Marietta Energy Systems Group.

Some of our major research accomplishments include, development of the "University of Tennessee Gripper." This refers to the robot arm having multiple sensor attachments for automatic manipulation studies. Under the sponsorship of NASA we have developed image enhancement hardware and software system for assisting astronauts in performing experiments in the Space Shuttle. Under the sponsorship of the Oak Ridge National Laboratory we have developed a pattern recognition system for detecting abnormal behavior in nuclear reactors. Also, under the sponsorship of the Defense Mapping Agency and the Army we have performed research dealing with the development of computer vision systems for analyzing high resolution complex aerial images. Under the sponsorship of the Army R, D, & E Center we are investigating techniques for object detection in high resolution infrared images.

Currently, we are pursuing several interesting research studies. These include development of a sensor driven autonomous robotic system for performing panel based inspection and manipulation tasks such as reading of analog and digital meters, manipulation of valves, switches and control knobs. This work is being performed under the sponsorship of the Department of Energy. In the image analysis area we are conducting studies for detecting defects utilizing textural prop-

erties of surfaces, for extracting 3-dimensional information with stereo and range information, for characterizing multispectral reflectance and thermal response of objects, and for measurement of motion parameters by analyzing several frames of images. Support for these image analysis studies is provided by Martin Marietta Corporation, Measurement and Control Center at the University of Tennessee and the Department of Energy. Also, under the sponsorship of the U. S. Navy and the Department of Energy we are conducting research on developing special purpose VLSI circuits and parallel programming methods.

Our research team includes four faculty members and over two dozen graduate students. Professor Ralph Gonzalez of our team has been active in the image processing, pattern recognition and robotics field for the past two decades. He has authored four text books in the field including the most recently published one on robotics. Professor Mohan Trivedi has been active in the multispectral image acquisition and analysis, computer vision and sensor driven intelligent robotics. He is also the current chairman of the Robotics Technical Committee of the Computer Society of the IEEE. Professor Dragana Brzakovic has been active in computer vision research specializing in the development of inspection systems using both 2 and 3-dimensional image analysis. Professor Mongi Abidi of our team has performed research in dynamic scene analysis and VLSI architectures. In our research graduate students play a very active and important role. In the past five years, 5 students have graduated with Ph.D. degrees and 20 have graduated with M.S. degrees while working in robotics and intelligent systems areas.

In summary, the faculty and graduate students at the University of Tennessee are pursuing several challenging and exciting research projects under the sponsorship of various research agencies. We believe that we have a very active research group dedicated to advancing our understanding of concepts related to the robotics and computer vision fields.

"Science Alliance"

The University

The University of Tennessee, Knoxville is the state's "campus of excellence" in undergraduate, graduate, and professional studies; research and creative activity; and public service.

The University offers more than 300 degree programs to its 25,000 students, who come from every county in Tennessee, every state in the nation, and more than 90 countries.

The faculty and staff of UT Knoxville are constantly working to enhance the quality of students' educational experiences, using information from student tests and surveys to improve teaching and student services. Recent improvements at the undergraduate level include an increased emphasis on advising and better training of graduate teaching assistants.

In 1988, the University moved from the quarter system to a semester system, giving teachers and students more time for special class projects. As part of the move, the faculty carefully examined each course to ensure its relevance to a changing world.

Developments in graduate education have been accompanied by expanded cooperation with Oak Ridge National Laboratory (ORNL) and the Tennessee Valley Authority and by growth of major research programs, including those in the fields of energy, biotechnology, and robotics.

The Science Alliance, is the largest in Tennessee's Centers of Excellence program for higher education. The Science Alliance's Distinguished Scientist Program, designed to strengthen cooperative instructional and research activities, attracts many eminent scientists to joint appointments at UT Knoxville and ORNL.

The University's libraries, with more than two million volumes and volume-equivalents, enhance an educational program dedicated to keeping pace with a changing society. A 350,000-square-foot library, in the center of the campus meets student and faculty research space needs and incorporates the latest advances in computer and automation technology.

Through public service activities, the University extends its resources throughout the state and nation. Continuing education programs, offered in more than 40 locations across Tennessee, respond to the needs of working adults who are seeking college degrees or preparing for career advancement.

HISTORICAL BACKGROUND

The University of Tennessee, one of the nation's oldest institutions of higher education, traces its origins back to 1794—when George Washington was President of the United States.

Two years before statehood was achieved, the Legislature of the Federal Territory which later became Tennessee granted a charter to Blount College, named in honor of William Blount, territorial governor.

Located near the center of Knoxville's present business district, Blount College was non-sectarian in character, which was unusual for an institution of higher education in that day. The University has remained non-denominational and is said to be the oldest such institution west of the Appalachian Divide.

From 1800 to 1804, Blount College admitted women as students, thus becoming the first coeducational college in the United States. The institution later restricted enrollment to men, but reestablished its coeducational status in 1892.

In 1807 the state legislature changed the name to East Tennessee College, and in 1828 the present site at Knoxville, the 40-acre tract known as "The Hill," was acquired. The college's name changed again in 1840—to East Tennessee University. The Civil War forced the institution to close, and its buildings were used as a hospital for Confederate troops and later occupied by Union troops.

East Tennessee University reopened after the war, and in 1869 the state legislature selected the University as the state's Federal Land-Grant institution, under terms of the Morrill Act passed by Congress in 1862. This

enabled the University to broaden its offerings by establishing an Agricultural and Mechanical College.

Ten years later, East Tennessee University was chosen by the state legislature as Tennessee's State University, and its name was changed to the University of Tennessee. The University pledged itself to the service and interest of the entire state, and the state pledged its name and reputation to the University, promising the institution a vital role in the progress of the state.

Today, the University is a statewide institution in terms of its physical locations as well as its services. The medical campus, founded in Nashville and acquired by the University in 1879, was moved to Memphis in 1911. The Martin campus, established in 1900 as a private institution, became part of the University of Tennessee in 1927. A fourth primary campus was established in Chattanooga in 1969 when the University of Chattanooga merged with the University of Tennessee. The University's Nashville Center, established in 1947, became the fifth primary campus in 1971, but eight years later merged with Tennessee State University.

The Agricultural Extension Service, with district offices in Chattanooga, Cookeville, Jackson, Knoxville, and Nashville, has agricultural extension leaders and agents in each of Tennessee's 95 counties. There are 15 Agriculture Experiment Stations located across the state.

In 1968, the University's Board of Trustees reorganized the five-campus institution into a University system, giving a central administrative staff responsibility for statewide functions of the University. Each primary campus came under the administrative direction of a chancellor.

State legislatures and governors, particularly those of the past half century, have shown an active interest in the development of the University of Tennessee. Their support has helped the University broaden and strengthen its efforts to meet the educational, research, and service needs of the people of Tennessee through programs which have earned national and international recognition.

*Environmental
Biotechnology*

I. INTRODUCTION

Over the past two decades, developments in recombinant DNA technology have promoted a virtual explosion of research and new knowledge in modern molecular biology. The rapid development of this field is the result of scientific breakthroughs allowing the controlled modification, introduction, and expression of foreign or native genes in a host organism. The recombinant DNA technology used to reach these achievements was the subject of serious scientific and public concern over the risks and ethics of such "genetic engineering". These concerns and their possible impediments to future research were expressed at numerous scientific forums, perhaps best exemplified by the Asilomar Conference,¹ and led to the eventual establishment of the recombinant DNA advisory committee (RAC) and the National Institutes of Health (NIH) guidelines for recombinant DNA research. The flexibility and evolution of the NIH guidelines, in response to an expanding knowledge base of the limitations and safety of recombinant DNA technology, have been largely responsible for the structured growth and transition from basic and applied research to the development and use of living organisms and their parts and processes to benefit mankind. Opportunities abound for the use of "tailor-made" microorganisms and their protein products in product-oriented areas such as health care, agriculture, commodity and specialty chemicals, and environmental protection.²

The direct use of microorganisms and their capabilities to solve environmental problems and for *in situ* agricultural and industrial applications can be defined operationally as environmental biotechnology. Applications include detoxification and/or destruction of pollutants and hazardous wastes, improvements in soil fertility and crop productivity, biological pest management, and restoration and renovation of perturbed ecosystems. Environmental biotechnology is differentiated from other areas of biotechnology in that successful process development must contend with the complexity of mixed (heterogeneous) populations and interactions occurring in ecosystems, as well as by the fact that the technology itself may be the subject of concern over environmental hazards. Consequently, there are major needs for both ecological and engineering research to enable utilization of modern applied molecular biology for successful process development and overall risk assessment.

The applications for molecular biology and recombinant DNA technology in the management of hazardous agricultural wastes and environmental decontamination fall into three general areas:

1. Isolation and microbial strain improvement for developing microorganisms with greater capacity for destruction of hazardous wastes and environmental contaminants
2. Field-site evaluation of microbial degradation processes contributing to overall contaminant fate predictions in a given system
3. Development, monitoring, and control of engineered processes for the biological destruction of hazardous waste and environmental contaminants

Each of these areas benefits directly from knowledge and research tools made available by molecular biology. However, it is the area of strain development or improvement which has received most of the popular, if not technical, attention. This attention has been directed toward research to develop genetically engineered microorganisms with new or improved biodegradative capabilities. While this is an important area of research with potentially significant contributions to developing biological treatment processes for difficult-to-degrade contaminants, molecular biology knowledge and recombinant DNA technology can also contribute to the development of nonengineered biodegradative microorganisms and processes. It can also be demonstrated that this same knowledge and technology will contribute, with even greater impact, to the successful understanding and utilization of microorganisms for hazardous waste control.

*management of
hazardous agricultural
wastes and
environmental
decontamination*

**The University of Tennessee
Center for Environmental Biotechnology**

The Center for Environmental Biotechnology (CEB) is an intercollegiate, interinstitutional research center focusing on fundamental training and research leading to the development and effective use of microorganisms for the destruction and control of hazardous wastes and environmental contaminants. These efforts are targeted at the interface of the molecular life sciences, engineering and ecology.

The need for this Center is exemplified by the \$1 trillion legacy of hazardous waste and environmental pollution problems of the United States. Superfund waste sites alone may require \$200-300 billion for remediation. These staggering costs impeded environmental cleanup and mandate the development of innovative and efficient new technology. Environmental biotechnology is on the forefront of these alternative technologies.

The current CEB is the result of five years of development and investment by the University. Its activities have been sanctioned by THEC and supported by the Waste Management Institute and Science Alliance, Centers of Excellence. CEB research activities have received international recognition in defining limitations on current waste treatment technology and demonstrating that new innovative biotechnology can be developed at the interface between modern molecular biology and engineering research. The leadership role is demonstrated by nearly \$5 million in Federal, Industrial, and University support.

A measure of the prominence of CEB research activity is its strong relationship with ORNL/DOE waste remediation and environmental research efforts. ORNL has joined in co-support of CEB in research efforts. Current support for fundamental research is from sources such as USGS, EPA, Air Force, GRI, EPRI, Procter and Gamble, NSF, TVA, ONR, and the State of Tennessee. A \$1,000,000 matching grant from the U.S. Department of Education has provided research training equipment and facilities. These activities are, in part, recognition of a leading research strength and industrial interest in hazardous waste management and environmental biotechnology in the east Tennessee region.

Major scientific resources and facilities include 15,000 sq. ft of state-of-the-science laboratory space, and \$2,000,000 in equipment ranging from ultracentrifuges and pulsed field electrophoresis systems to GC/HPLC/MSMS and FTIR.

These resources support a team of 50 scientists and students working on a basic four component research agenda in environmental biotechnology which includes:

- o Microbial strain development and improvement.
- o Bioanalytical methods development.
- o Environmental systems analysis.
- o Engineering systems analysis.

The University of Tennessee is pursuing new initiatives to ensure a leadership role for the CEB, to capitalize on previous investments, and to demonstrate technology development and transfer to the market place.

Homer S. Fisher
Executive Vice President
University of Tennessee
7th Floor Andy Holt Tower
Knoxville, Tennessee 37996-0144
FAX 615-974-3213

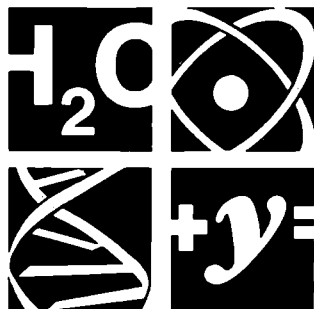
SUMMARY OF PROPOSED PRESENTATION FOR FEBRUARY 2ND, 1990 IN SHILO ROOM

Presentation Theme: Role of Microbial Influenced Corrosion in control of hazardous waste. Mixtures of different types of bacteria (consortia) stick to the surface of metals and by their metabolic chemistry create conditions that lead to the accelerated degradation of the metals. They are particularly effective in localizing attacks that lead to perforations and with the perforations comes serious contamination. This is important in pipelines transmitting high pressure gases and underground storage tanks. Leaking storage tanks are a primary cause of ground water contamination. Attack of concentrated toxic waste and/or radioactive mixed waste containers by bacteria is a serious problem in containing contamination until it can be remediated. The structural attack by bacterial consortia on the steel reinforcing rods in sewer pipes is a major problem in many American cities. These same bacteria attack structural metals in bridges.

Materials: Six to ten inch diameter pipes with large corrosion tubercules taken from the cooling system of a nuclear plant will be demonstrated. They will be compared with a pipe that has been properly treated. A poster will show the innovative methods of studying the formation and stability of the microbial biofilms responsible for corrosion with a non-destructive, on-line monitor that also is being proposed to monitor the water system in the Space Station. This system will be illustrated with a diagram showing how an entire plant or storage facility can be monitored for microbial corrosion so biocides and other countermeasures can be utilized for optimal protection of the integrity of the system. Microscopy of the microbial biofilm will be illustrated if the video microscope is available.

THE SCIENCE ALLIANCE

A Center of Excellence at The University of Tennessee, Knoxville



The Science Alliance

Administrative Staff:

Professor Lee Riedinger, Director
Bill Aiton, Director of Administrative Services
Tom Garritano, Technical Writer
Midge Marshall, Administrative Secretary
Wylene Vrba, Administrative Assistant

September 1989

The UTK/ORNL Connection

- 1943** Manhattan Project (100,000 people)
- 1945** First Ph.D. at UTK (in Chemistry)
Second Ph.D. at UTK (in Physics)
Third Ph.D. at UTK (in Chemical Engineering)
- 1964** Ford Foundation Program (60 part-time professors)
- 1968** NSF Center of Excellence (Physics and Chemical Engineering)
- Today** 322 UTK researchers at ORNL
16 ORNL researchers at UTK
\$4 million/year direct subcontracts
\$6 million/year indirect subcontracts



The Science Alliance

a Center of Excellence at the University of Tennessee, Knoxville

Background: Established in 1984, the oldest and largest of state-supported Centers of Excellence. Director is Dr. Lee Riedinger, UTK professor of physics

Organization: Four divisions (Biological, Chemical, Math/Computer Science, and Physics)

Mission: Expand and enhance research ties between the University of Tennessee and Oak Ridge National Laboratory

Support: \$4,000,000/year from State of Tennessee
\$2,500,000/year from outside "matching" sources
\$7,500,000/year from external grants to faculty

Programs: Distinguished Scientists
Joint Institutes (JIHIR, IRIS, proposed JICS)
Educational (Summer Research Fellows, Grad student stipends)
Equipment and facilities
Part-time ORNL faculty



State of Tennessee Centers of Excellence, 1988-89

<u>Institution</u>	<u>Center</u>	<u>Funding</u>
<i>UT Knoxville</i>	<i>Science Alliance</i>	<i>\$4,099,000</i>
Tennessee Tech	Manufacturing	1,713,000
Tennessee Tech	Water Resources	1,284,000
Memphis State	Earthquake Information	999,000
UT Space Institute	Laser Applications	900,000
Memphis State	Applied Psychology	893,000
UT Chattanooga	Computer Applications	890,000
Tennessee Tech	Electric Power	850,000
UT Knoxville	Materials Processing	795,000
UT Knoxville	Waste Management	695,000
UT Memphis	Molecular Resources	695,000
UT Memphis	Neuroscience	650,000
UT Agriculture Institute	Livestock Diseases	590,000
Austin Peay	Creative Arts	481,000
Memphis State	Teacher Education	450,000
Memphis State	Communicative Disorders	421,000
Tennessee State	Information Systems	400,000
Tennessee State	Basic Skills	350,000
East Tennessee	Appalachian Studies	300,000
Austin Peay	Field Biology	277,000
UT Memphis	Pediatric Phamacokinetics	231,000
UT Martin	Science/Math Teaching	225,000
Memphis State	Egyptology	175,000
Middle Tennessee	Historic Preservation	170,000
Middle Tennessee	Popular Music	159,000
UT Knoxville	Entrepreneurship	145,000
East Tennessee	Early Childhood	132,000
East Tennessee	Banking	100,000
Middle Tennessee	Recording Arts	100,000
Tennessee Tech	Teacher Education Evaluation	100,000
TOTAL		19,269,000



UTK/ORNL Distinguished Scientist Program

Positions are supported 50/50 by UTK and ORNL:

Twelve-month salary	\$112,000
Fringe benefits	17,000
Discretionary funds	93,000
TOTAL	\$222,000

Hold joint appointments in a UTK department (tenured professors) and an ORNL division. Disciplines considered include:

Physics
Chemistry
Biological Sciences
Engineering (Nuclear; Materials)
Computer Science
Mathematics

Candidates are screened by joint UTK/ORNL Distinguished Scientist Program Committee, co-chaired by Dr. Lee Riedinger (UTK Physics) and Dr. Loucas Christophorou (ORNL Health and Safety Research).



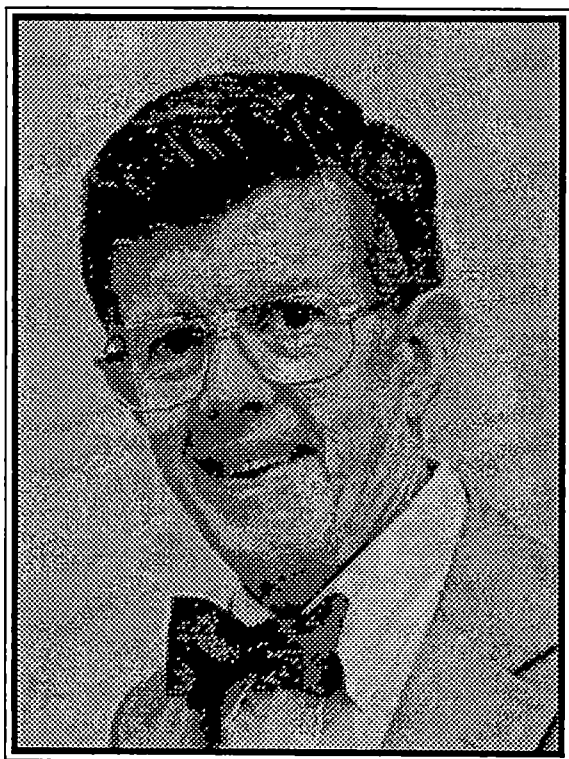
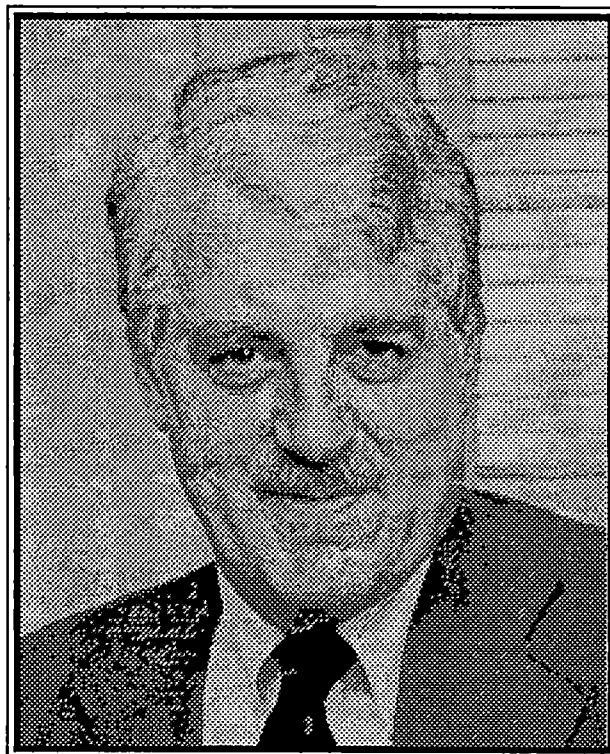
Distinguished Scientists

Gerald Mahan

Field: Solid State Physics

Previous Institution:
Indiana University

Start Date: August 1984



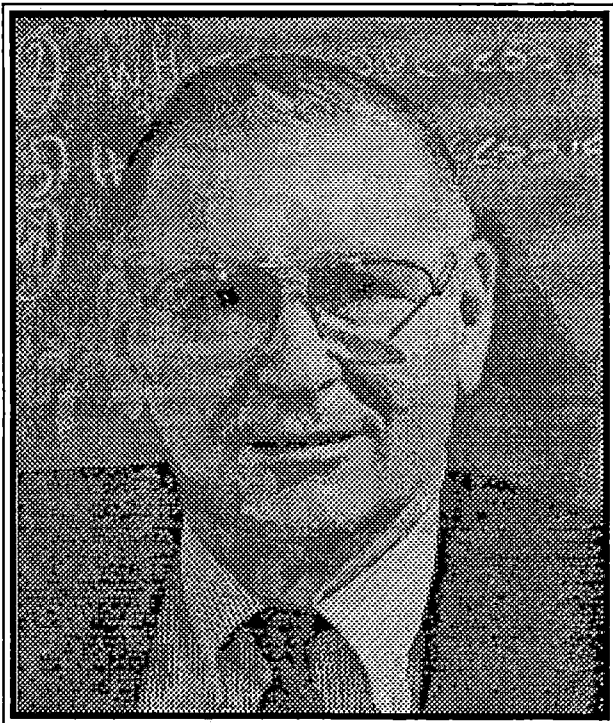
David White

Field: Microbial Biology

Previous Institution:
Florida State University

Start Date: January 1986

Distinguished Scientists



Robert Uhrig

Field: Nuclear Engineering

Previous Institution:
Florida Power and Light

Start Date: January 1986

Robert Hatcher

Field: Structural Geology

Previous Institution:
University of South Carolina

Start Date: June 1986



Distinguished Scientists

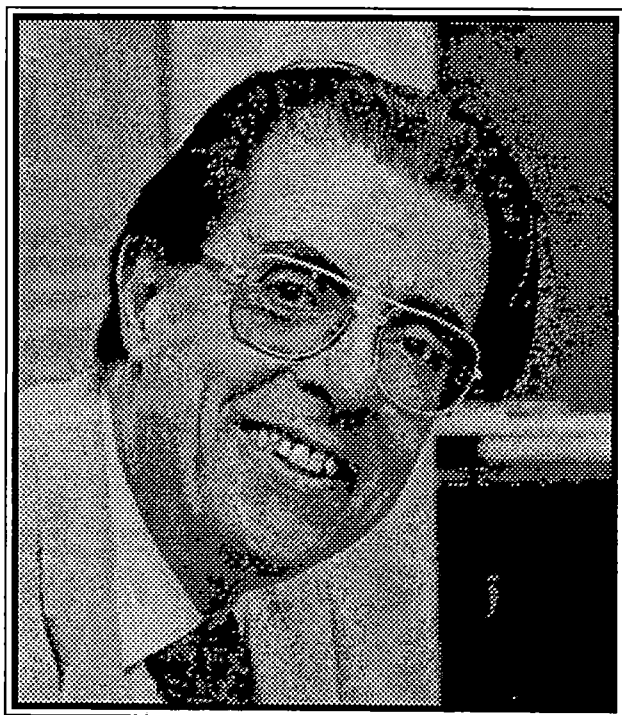
David Joy

Field: Electron Microscopy

Previous Institution:

AT&T Bell Laboratories

Start Date: April 1987



Georges Guiochon

Field: Analytical Chemistry

Previous Institution:

Georgetown University

Start Date: June 1987

Distinguished Scientists



Frank Close

Field: Elementary Particle Theory

Previous Institution:
Rutherford Appleton Laboratory

Start Date: January 1988

Bernhard Wunderlich

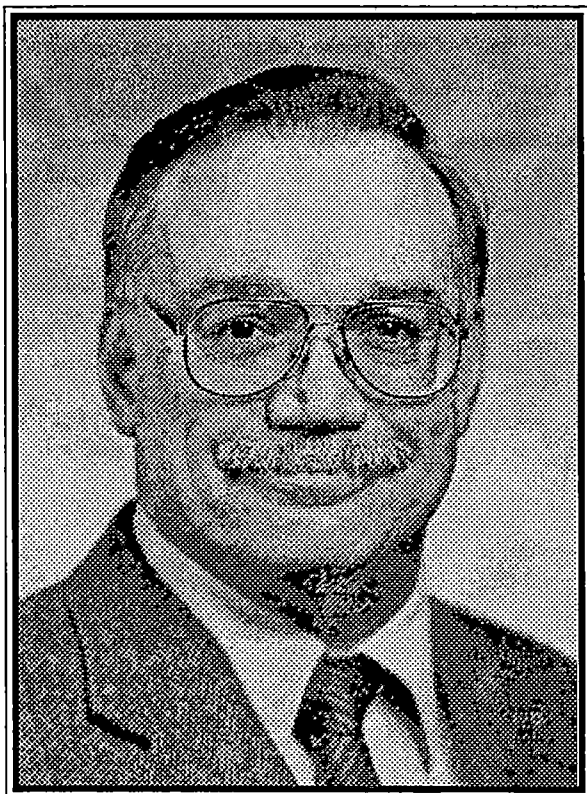
Field: Polymer Chemistry

Previous Institution:
Rensselaer Polytechnic Institute

Start Date: January 1988



Distinguished Scientists



Joseph Macek

Field: Atomic Collision Theory

Previous Institution:
University of Nebraska

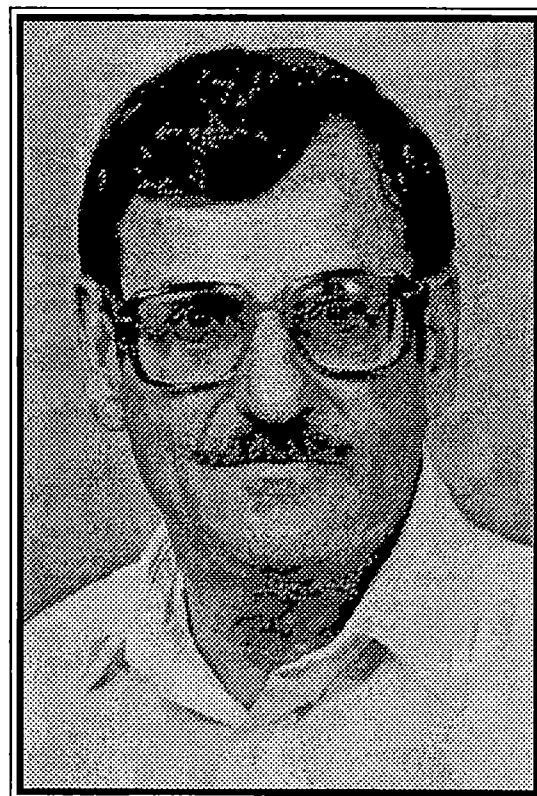
Start Date: July 1988

Jack Weitsman

Field: Composite Materials

Previous Institution:
Texas A & M

Start Date: September 1989



Distinguished Scientists



Jack Dongarra

Field: Parallel Computing

Previous Institution:
Argonne National Laboratory

Start Date: September 1989

Possible Future Appointments:

Relativistic Heavy-Ion Physics
Microbiology
Mathematics
Computer Science

Science Alliance Educational Programs

Graduate Stipends:

Supplements regular UTK stipends, making them more competitive. In 1988-89, 131 students received an average of \$2500/student.

Summer Research Fellows Program:

Undergraduates from across the U.S. conduct research with UTK and ORNL personnel.

1985:	42 students
1986:	61 students
1987:	80 students
1988:	91 students
1989:	80 students

Biotechnology Master's Degree Program:

Interdisciplinary effort of Science Alliance, UTK College of Engineering, UTK Institute of Agriculture, ORNL, and various biotechnology companies. Coursework includes biochemistry, microbiology, molecular biology, industrial-scale bioprocesses, and ethics of biotechnology.

Students in residence (as of 1989): 7

Students awarded degree (as of 1989): 9

Minority Recruitment

Existing:

Black students and faculty are targeted to participate in the Summer Research Fellows Program. One goal is to boost minority graduate enrollment in the sciences at UTK.

Committed:

Matching money for proposed UTK/NSF "Ron McNair Undergraduate Summer Program" for first-generation college students.

Future:

Recruiting weekend for black undergraduate science students from across the U.S. Patterned after successful Ohio State and Michigan State programs, the event would persuade black students to choose UTK for graduate study.

Joint Institute for Heavy Ion Research (JIHIR)

Location: Adjacent to Holifield Accelerator in Oak Ridge, TN

Facilities: Building #6007 owned by ORNL (4000 sq. ft, with dormitory accomodations for visiting scientists). Building #6008 owned by UTK (6000 sq. ft., with office space, conference rooms)

Sponsors: University of Tennessee, Knoxville
Vanderbilt University
Oak Ridge National Laboratory

Administrative Agent: University of Tennessee, Knoxville

Policy Council: Dr. Joseph Hamilton (Vanderbilt)
Dr. Lee Riedinger (UTK)
Dr. Russell Robinson (ORNL)

Budget:	UTK Science Alliance	\$175,000
	ORNL	30,000
	Dept. of Energy (via UTK)	40,000
	<u>Vanderbilt University</u>	<u>12,000</u>
	TOTAL	\$257,000

Spending:	Operating	\$37,000
	Equipment	5,000
	Workshops	10,000
	Visitors (approx. 40/year)	205,000



Selected Events Sponsored by the JHIR

<u>Event</u>	<u>Date</u>	<u>Attendees</u>
Workshop on Atomic Physics with Stored Cooled Heavy Ion Beams	Jan. 13-15, 1986	50
Recoil Mass Spectrometer Workshop	June 23-24, 1986	50
Workshop on Heavy Ion Physics and Instrumentation for a 15-Tm Booster and Storage Ring	Oct. 2-4, 1986	65
Holifield Theory Users Group	Sept. 25-26, 1987	53
UNISOR Exec. Committee Meeting	Nov. 18, 1987	29
Workshop on the Proposal for a National Gamma-Ray Detector Facility	Nov. 19-21, 1987	90
Computational Atomic & Nuclear Physics at One Gigaflop	April 14-16, 1988	52
UNISOR Workshop	June 21-21, 1988	45
Workshop on High Energy Nuclear Collision Monte Carlo Codes	Sept. 12-23, 1988	18
Workshop on Microscopic Models in Nuclear Structure Physics	Oct. 3-6, 1988	75
Town Meeting on High Energy Heavy Ion Physics	April 24-25, 1989	92
UNISOR Exec. Committee Meeting	June 19-23, 1989	50



Major Equipment Purchases

- 1. Spin Spectrometer detectors at ORNL (Nuclear Physics)**
Science Alliance: \$320K
Other: \$960K
- 2. Holographic Laser Scanner at UTK and the Stanford Linear Accelerator Center (High-Energy Physics)**
Science Alliance: \$107K
Other: \$1000K
- 3. Mass Spectrometer at UTK (Chemistry)**
Science Alliance: \$200K
Other: \$250K
- 4. Electron Microprobe at UTK (Geology)**
Science Alliance: \$70K
Other: \$220K
- 5. Scanning Electron Microscope at UTK (Zoology)**
Hitachi: \$600K
Science Alliance: \$30K
- 6. Vibroseis at UTK & ORNL (Geology/Environmental Science)**
ORNL: \$38K
UTK: \$22K
Science Alliance: support for technician/operator
- 7. Analytical Services Facility at UTK (Biology)**
Science Alliance: \$1 million
Other: usage fees from federal grants

New Initiatives

1. Gammasphere/Recoil Mass Spectrometer at ORNL (will create a world-wide center for Nuclear Structure Physics)

<u>Funding Source</u>	<u>Gammasphere</u>	<u>RMS</u>
Science Alliance	\$100K	155K
Vanderbilt University	100K	155K
State of Tennessee	800K	500K
DOE (FY 91 request)	16M	600K
ORNL/ORAU/others		800K

2. Nuclear Magnetic Resonance Spectrometer (Chemistry)
Science Alliance: \$250K (proposed)
Department Of Energy: \$380K (pending)
3. Collaborating Scientists
Hire scientists at various levels (joint UT/ORNL appointments).
Two under way (Physics and Informational Science).
Many divisions at ORNL and departments at UT are interested.
4. SSC Detector Development
Superconducting Super Collider going to Texas
Regional detector development center coming to Tennessee
ORNL: start research group in high-energy physics
UTK: take lead in university consortium to build detector
5. Joint Institute for Computational Science (see next page)



Joint Institute for Computational Science

Purpose: use parallel-processing computers to solve large-scale science equations.

Participants: UTK, ORNL, Vanderbilt. Computer scientists will develop parallel algorithms. Physicists will develop techniques to capitalize on parallel capability.

Education:

Computer science students exposed to exciting new field
ORNL physicists teach Computational Physics at UTK

Hardware:

Prototype Intel RX parallel supercomputers
UT/ORNL high-speed fiber-optic data link a top priority

Personnel:

Distinguished Scientist Jack Dongarra (leading expert in parallel computing)

Collaborating Scientist Ted Barnes, ORNL's Chris Bottcher and Mike Strayer (physicists)

Economic Potential:

Small support industries in parallel computing
State-wide access to powerful computer with capabilities similar to much more expensive supercomputers (\$1 million vs. \$20-30 million)



Benefits to State

1. Excellent new scientists attracted via Distinguished Scientist Program and the colleagues they bring.
2. Better graduate students, some of whom stay for careers.
3. Dramatically increased visibility of science programs.
4. More scientists coming to state for working visits.
5. External matching funds optimize state's contributions.
6. Spin-off technology
 - LipoGen (liposome technology)
 - Electron Microscope Facility (corporate users: Exxon, 3M)
 - Neural networking (Accurate Automation Corporation)
 - Gammisphere (detectors likely constructed by ORTEC)
 - Environmental biotechnology
 - Parallel computing
 - Gas-detector development (SSC project)
7. Prestige of a large university and a national laboratory working together to advance science and technology.

New Budget Request, FY 90-91

20% increase to \$4,923,600

- A.** Two new distinguished scientist slots in areas such as:
Mathematics, Physics, Computer Science, Microbiology
- B.** Joint Institute for Computational Science
- C.** Equipment:
 - Intel RX parallel supercomputer
 - DNA sequencer
 - Nuclear Magnetic Resonance spectrometer
 - ICP Probe
 - Picosecond laser fluorometer

Long-Range Needs

More Distinguished Scientists

Building blocks for new UT/ORNL collaborations.

Space

For new and existing experimental programs (Science & Engineering Building).

Equipment

Money to continue attracting large federal grants.

Reward and retain outstanding faculty

Chairs and/or salary supplements for excellent non-Distinguished Scientist researchers.

Funds for new initiatives as they arise

e.g., Joint Institute for Computational Science, SSC detector program, and others.

Minority Graduate Fellowships

To create opportunities for deserving young blacks and other minorities.

Showpiece Research Groups

Molecular Architecture: customizing drugs for PET and MRI scanning.

Dr. George Kabalka, Professor of Chemistry and Director of Basic Research for the UT Biomedical Imaging Center

Environmental Biotechnology: engineered microbes that "eat" toxic waste.

Dr. David White, Distinguished Scientist and Director of the Institute for Applied Microbiology; Dr. Gary Saylor, Professor of Microbiology and Director of the Center for Environmental Biotechnology

Nuclear Structure Research: unlocking secrets of the atomic nucleus.

Physics professors Carrol Bingham, Michael Guidry, Lee Riedinger, Soren Sorensen

Continental Crustal Studies: tectonic studies of how mountain chains formed.

Dr. Robert Hatcher, Distinguished Scientist; Geology professors Theodore Labotka, Harry McSween, Lawrence Taylor, and Richard Williams

Coal Fly Ash: demystifying an atmospheric contaminant.

Chemistry professors Gleb Mamantov and Earl Wehry

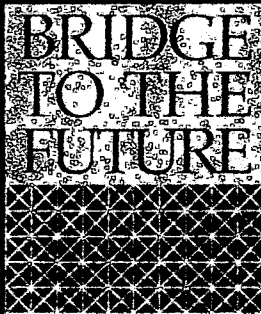
Behavioral Ecology: inherited social traits of spiders and other organisms.

Dr. Susan Riechert, Professor of Zoology

Elementary Particle Physics: understanding the elusive quark.

Dr. Frank Close, Distinguished Scientist; Physics professors William Bugg and George Condo

BRIDGE
TO THE
FUTURE

A square graphic with a grid pattern. The text "BRIDGE TO THE FUTURE" is written in a bold, sans-serif font across the top three rows of the grid. The bottom row of the grid is empty.

CIEM

3rd Flr

Perkins Hall

CAD

**THE
SUPERIOR ENGINEERING DESIGN
PROGRAM**

College of Engineering
The University of Tennessee, Knoxville
124 Perkins Hall
Knoxville, Tennessee 37996-2000
(615) 974-5321

November 1989

THE SUPERIOR ENGINEERING DESIGN PROGRAM

EXECUTIVE SUMMARY

The University of Tennessee, Knoxville College of Engineering has initiated a major program to enhance engineering education. This program is aimed at improving the engineering design skills of the next generation of engineers to enable the development of more competitive U.S. products and processes for the world markets. This interdisciplinary effort, called **The Superior Engineering Design Program**, focuses upon making a significant improvement in the educational experience of engineers by channeling information (from the best design, evaluation, and implementation techniques currently used in industry) into the educational curriculum. It has a component which addresses the "hardware deficiency" of today's student, who is knowledgeable in science and mathematics, but is ignorant of modern equipment and methods of implementation. There is the development of an interdisciplinary course for electrical and mechanical engineers that teaches the integration of microprocessors with complex electrical and mechanical subsystems. An Engineering Design Center is being developed which allows comprehensive design projects to be done using the most productive software programs and tools. This Center will provide software tools for design, evaluation, and manufacturing as well as prototyping of parts. A Flexible Manufacturing Facility that

contains computer-numerically-controlled (CNC) machines will be implemented to serve as a prototype facility for the senior design courses as well as a manufacturing laboratory. The Engineering Design Center computers and the Flexible Manufacturing Facility machines will be connected electronically and will communicate by computer-aided-manufacturing software. The sixth component is the Performance Evaluation Laboratory which will enable machine performance to be measured against its requirements.

The Superior Engineering Design Program includes the major engineering processes of design, implementation (manufacture), and evaluation of complex products and course work to allow the students to participate actively in these processes. The interrelationships of courses and facilities within the **Superior Engineering Design Program** are shown in the accompanying figure. In addition, the information sources are shown.

The Superior Engineering Design Program

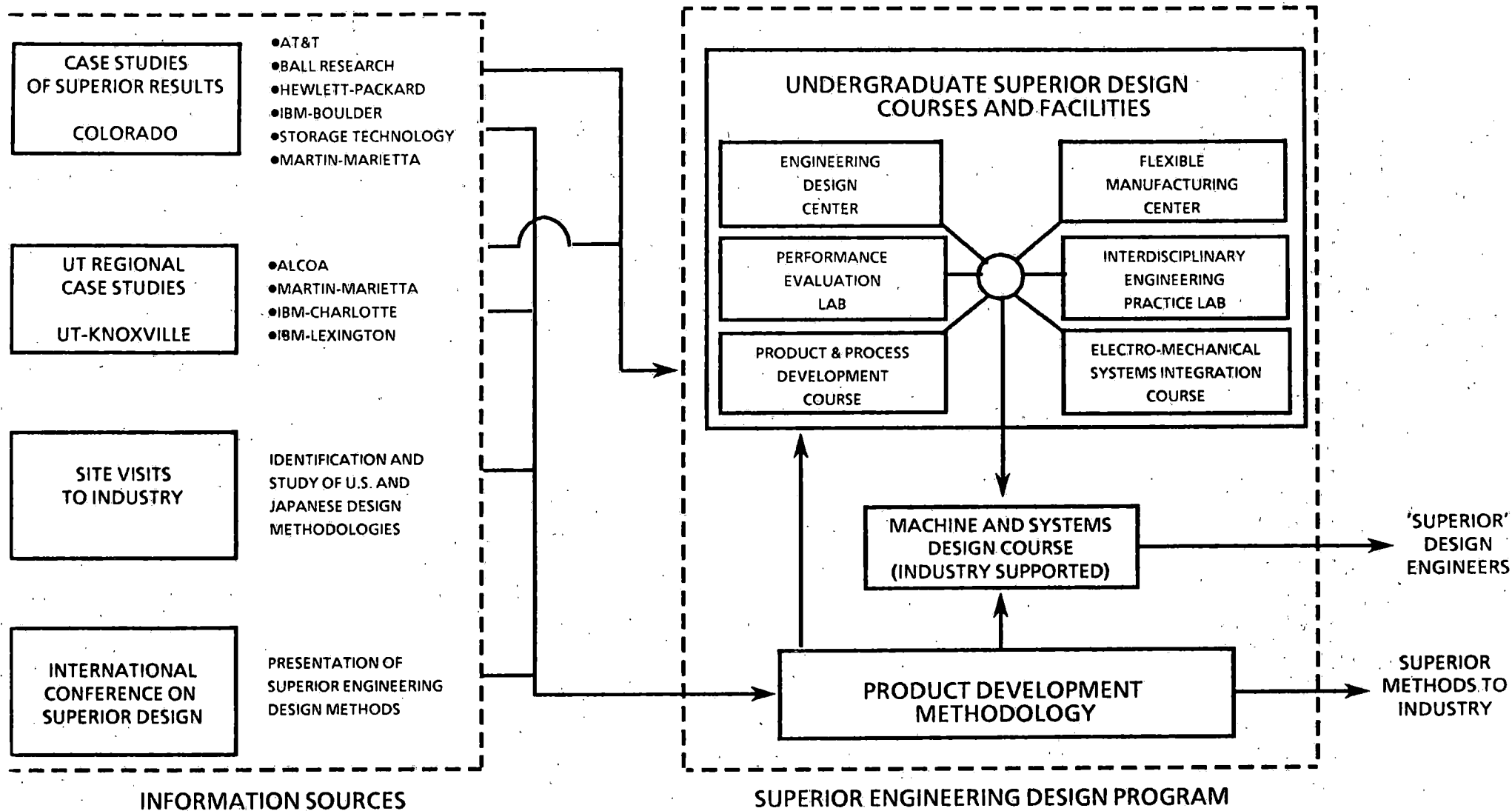


FIGURE 1

The **Superior Engineering Design Program** is being developed by an interdisciplinary team of professors who have significant industrial and academic experience. This interdisciplinary effort will provide a significant educational experience for students by channeling into the engineering curriculum case studies of successful product development in industry and product information which describes **Superior** design and implementation techniques currently used in industry.

INTRODUCTION

The College has evolved a respected tradition of successful research and educational programs over the last 154 years. Our graduates feel that their education has served them well in their careers in industry. More importantly, the corporate employers of our graduates feel that the experience they have had with hiring our graduates has been good. "We recruit at Tennessee as much as possible and as far as I'm concerned, you've got as good a school as any in the region," says a recruitment officer of a major national corporation.

Over the past three years, the College of Engineering has:

- (1) developed three new engineering centers involving the human and physical resources of the College, Oak Ridge National Laboratory, and member corporations, (Measurement and Control Engineering Center, Computer Integrated Engineering and Manufacturing Center, Materials Processing Center),
- (2) added four Chairs of Excellence with endowments of \$1 million each (areas include Power Electronics Applications, Computer Integrated Engineering and Manufacturing, Materials Processing and Waste Management), and
- (3) participates in two Centers of Excellence outside the College of Engineering (Science Alliance and Waste Management). Investments in these science and engineering programs exceed \$50 million.

In spite of our recent investments and accomplishments we face many challenges, present and future. Our faculty is mature with several retirements anticipated in the next five years; we need to fill positions with quality, new Ph.D.'s. Our equipment is obsolete; we need to upgrade our teaching and research labs with modern equipment. Competition for undergraduates and graduates is increasing; we need to develop additional sources of scholarships and fellowships. These challenges are not unique to our College, but we take no solace in this fact--we want to be better; we will be better.

There are a number of reasons why we feel that our College of Engineering represents an excellent investment in higher education:

A. Quality Engineering Education Stressing Engineering Principles with Current Engineering Practice.

At a time when advances in technology produce a number of specialty fields, we feel it is important to provide our engineering students a principle-oriented education. As technology continues to develop and production processes and applications change, only the engineer with a strong education in engineering principles balanced with an interdisciplinary technology orientation will be able to keep abreast in such a dynamic environment.

B. A Philosophy That Engineering is the Bridge Between the Academic and the Business Worlds and A Commitment That Our Programs will be Responsive to the Needs of Industry.

The establishment of partnerships between American universities and industry has been neglected until recently. It is now recognized that both universities and industry can benefit from increased collaboration. American industry recognizes our universities as a resource for research and innovation to improve productivity and its competitive position in the world economy. In addition, close collaboration between

industry and universities assists industry in recruiting well-educated personnel. Universities benefit through improved budgets, acquisition of scientific equipment, and increased relevance of their academic programs through closer collaboration with industry.

The College of Engineering is committed to university/industry partnerships which benefit each other and contribute to economic development. For example, our interdisciplinary engineering research centers serve as a source for research and innovation that can contribute to improving industry's productivity and competitive position in world markets. In addition, our educational programs are responsive to the training and education needs of engineering human capital required to meet the current and future needs of industry.

A. SUPERIOR ENGINEERING DESIGN PROGRAM

In the seventies, the Japanese entered several markets in the United States. Within a period of 10 years, it was apparent that names like Sony, Honda, Seiko, Canon, Minolta, Matsushita, Toyota, and Mazda, were becoming household words in the U.S. because these products were simply superior and were offered at prices which were competitive. (However, Sony always charged a premium price for their products and U.S. customers selected them because they were better). At first, Americans cheered because they had been displeased with inferior products, particularly their automobiles, and were pleased to have a selection of competitive, superior products.

At the same time, the high-tech companies sneered at the problem because the Japanese products appeared to be imitative versus the innovative products of the microprocessor industry. In just a few more years, the Japanese were leading the world in microprocessor memory chips. They have developed the majority of the components of the personal computer from their consumer recording business. They are now developing a super computer and a space station. They are leading the world in video recording and optical recording. The Sony Optical disk recording machine sells for under \$175, yet has very high recording densities. It is clear that the Japanese have demonstrated the ability to **develop and manufacture any device**

or product that they select, and can manufacture it at the **highest quality** available in the world.

In addition, they have **integrated** their engineering departments and manufacturing plants with their subsidiaries and vendors such that they can deliver a superior product significantly **faster** than a U.S. company (usually in half the time). They have **simplified** their manufacturing processes with the application of statistical quality control, total quality control, and just-in-time manufacturing techniques which allow the processes to be understood, controlled, and managed appropriately. The managers of the manufacturing facilities know the **product, process, and their employees**. The Japanese have also been the world leaders in **employee involvement** which has broadened the responsibility of the factory worker and dramatically reduced the need for the indirect professionals who are so apparent in U.S. organizations.

U.S. industries have finally responded to this competition. The ones who have responded first are the ones who compete directly with the Japanese and who have Japanese subsidiaries. They have studied the Japanese manufacturing methods and are adopting them as fast as they can assimilate them into their organizational culture. (U.S. organizational culture is a major problem since many of the financial measurements and practices are at the heart of the quality problems.) U.S. universities have responded to incentives

from industry to create the Master in Manufacturing Systems degrees. There is much activity as computer, robot, factory automation, CAD/CAM and communications companies push their particular products as the answer to making the U.S. competitive again.

At this time, new U.S. products are still being stopped in their development phase because the parts manufacturing cost is a few percentage points too high. Japanese companies are being asked to manufacture the product in order to meet the cost target. In other cases, Japanese products under development are acquired by the U.S. company to be marketed under a U.S. label. All of these actions signal a serious situation, which is getting worse. As manufacturing is going overseas, product development appears next-in-line. As U.S. industries continue to take this approach out of desperation to meet their quarterly profit goals, they gradually are losing their ability to engineer and manufacture products. As this process continues, the prices that will be paid by the U.S. consumer will continue to escalate as competition diminishes. Of course, the balance-of-payments situation will continue to deteriorate.

If one looks at the United States engineering colleges with a critical eye to see what has happened over the last thirty years, some interesting observations may be made.

1. The post World War II era of engineering education in the United States was characterized by an

emphasis on more mathematics, the basic sciences, and the engineering sciences. This emphasis on "the fundamentals" was embraced by the engineering education community as the only perceived way of dealing with rapidly changing technology within a four year curriculum. The inclusion of more fundamentals into a four year program, however, was accomplished at the expense of subject matter related to synthesis, design, and real systems. As Herbert Simon* stated, engineering faculty sought "academic respectability" by teaching subjects that are "intellectually tough, analytic, formalizable and teachable," i.e. the engineering sciences. Synthesis and design, which are the essence of engineering activity, were perceived by most faculty as "intellectually soft, intuitive, informal and cookbooky." The "formulation of design into a hard, formalized, and teachable body of knowledge remains an open challenge to engineering faculty."

2. The Electrical Engineering curriculum has been modified over the years to allow new technologies of microprocessor, digital electronics, and computers to be handled. With these new technologies, design

* Simon, H.A., The Science of the Artificial, M.I.T. Press, Cambridge, 1969.

methodologies were developed so that the technologies were able to be applied generally. An example is the design of a printed circuit board which now may be procured in weeks, but took over a year initially. Some electrical engineering departments have become Electrical and Computer Engineering departments to allow for the major specialty to be handled. The study of motors and electrical power have been reduced dramatically to make room for the new technologies.

3. The Mechanical Engineering Department has evolved into the Mechanical, Nuclear, Aerospace, Solid Mechanics, and Engineering Science and Mechanics Departments. Manufacturing processes studies still exist, but until recently were not considered a significant academic research area. The thermodynamics and fluids areas have been receiving funds from the Department of Energy and The National Science Foundation and appear to have become much more concentrated in scientific studies of phenomena and less in thermal system design. Mechanical engineering design is still being taught essentially the same way that it was 30 years ago, i.e. design of mechanical components followed by the design of a mechanical device. The aerospace design experience

appears more system oriented as the complete airplane is designed as the final design course. The airplane subsystems are characterized by their manufacturers which allows a systematic treatment of the total design.

4. The Industrial Engineering departments are still heavily concentrating on engineering economics, operations research, and plant design and layout.
5. The departments are operating just as independently as they were 30 years ago and very little interdisciplinary interaction occurs in the undergraduate design experience. Thus, the graduate must depend upon a host of other specialists as he or she goes into industry. **It is expected that today's graduate engineer will experience the same types of problems which are listed above, just as the previous generations have.**
6. There appear to be virtually no courses on technology selection, technology evaluation, product development, and product evaluation. Courses on statistical design of experiments usually are taught in the business school, but not in the engineering school. The students are still taught the fundamentals; however, they have virtually no experience with modern components and modern machinery. The machine shop experience has been

removed from the curriculum. The lab experience has been inadequately funded for years so that it has not been upgraded in many universities. Not only is it expensive to upgrade, this effort is not rewarded in the university system nearly as much as effort that results in funded research obtained by the faculty.

7. In many instances the professor's background is confined to academia with a narrow disciplinary research focus. Since World War II, there have been many additions to engineering faculty of persons with very little understanding of the problems illustrated in the beginning of this proposal. Thus, for professors who want to contribute to improving design engineering education in an interdisciplinary way, some additional experience is needed. They need exposure to the problems that are critical and need training in some techniques that are new to them. (This is not an insurmountable problem, but there must be time available for them to pursue the education, and the incentive for them to pursue this effort must be there.)

B. DEVELOPMENT OF THE SUPERIOR ENGINEERING DESIGN PROGRAM

The next phase in the evolution of the Center for Computer Integrated Engineering and Manufacturing is the development of a Superior Engineering Design Program that emphasizes design of not only the product, but also the manufacturing process. Dr. Clement C. Wilson, formerly with IBM, joined the faculty August 1, 1987, after a Technical Sabbatical at the University of Colorado, and heads the **SUPERIOR ENGINEERING DESIGN PROGRAM**. His resume is included in Appendix A. During his 26 years in industry, Dr. Wilson has experienced a range of assignments from technology development to manufacturing. His last assignment was Product Engineering Manager for Copiers before taking an early retirement to participate in IBM's Technical Academic Career Program at The University of Tennessee.

A fundamental element of the **Superior Engineering Design Program** is the belief that excessive specialization is one of the root causes of the U.S. manufacturers' competitiveness problem. Thus a **reintegration of engineering and manufacturing** is a necessary ingredient of the program. In addition, interdisciplinary work between the Mechanical and Electrical Engineers is essential in the new world of digital electronics which allows microprocessor control at the subsystem level. Just as these separations have taken place in industry, they exist in the university. Thus, educators need assistance from the industries who have reintegrated their engineering and manufacturing efforts and have established strong interdisciplinary

systems integration work. In order to have this assistance, the Superior Engineering Design Program plans to create a strong tie with a broad range of industries.

Based on the helpful critiques from outside industrial sources, the programs have evolved to the following items:

1. An industry-university cooperative course is being offered entitled, "Development of Superior Products and Processes", which develops case studies of superior results in design, evaluation, and manufacturing methods to be used in the academic program. This course establishes a continuous flow of information from industry to the university about what methods are currently the most successful. Both U.S. and Japanese firms are expected to participate in this effort so that the methods studied will be selected from the best in the world. The scope of this course will include topics from all phases of the new product development cycle, from technology to quality programs at parts vendors. This breadth is illustrated in Appendix B, Figures 1-B and 2-B, which illustrate the subjects covered in a pilot course previously offered by Dr. Wilson at the University of Colorado. The topic numbers from Figure 1-B are superimposed onto the new product development cycle in Figure 2-B to illustrate the scope of topics of the course. This course is now being implemented at the University of Tennessee. As senior and first-year

graduate students take this course, they are presented case studies of methods of design, evaluation, and implementation that currently are revolutionizing engineering and manufacturing practice in the U.S., presented by the industry professionals who are doing the work. They come face-to-face with these professionals, not only in the classroom, but as they go the worksite to interview the industrial people for the development of their own case study to present to the class. The experience at both universities showed that the students, who previously had no interest in product development and manufacturing, became quite interested. As they interviewed companies for their first jobs, they were prepared with knowledge about methods of product development and manufacturing from different companies they had studied in the course. This knowledge enhances their career selection as well as their professional growth by having a larger picture of the engineering and manufacturing challenges facing the U.S. A paper describing the course has been published* by the American Society of Engineering Education and an American Society of Mechanical Engineers Short Course was offered at Manufacturing International April 18-19, 1988, by Dr. Wilson.

* Wilson, Clement C., "Investigations of Design Methodology for Superior Products", ASEE Zone II Proceedings, p. 119.

2. An Interdisciplinary Engineering Practice Laboratory is being developed to enable the engineering students to cross disciplines and know what hardware is available to them as they initiate a design of a product or a process.

This laboratory is essential for today's modern student who has much less "hands-on" experience than those of 30 years ago and will develop a knowledge of both product and manufacturing methods that are currently in use.

Figure 1 shows the connection between this laboratory and eight courses in the Mechanical and Aerospace Engineering Program. Particularly, the knowledge of current engineering practice methods will enhance the major Mechanical and Thermal Systems Design courses allowing the students to be more innovative in their design project. It is anticipated that this laboratory will serve other disciplines as well.

3. An Electro-mechanical Systems Integration course is being developed which uses current complex systems as a basis for the course. This course will include the methods for integrating and evaluating complex electro-mechanical equipment containing microprocessors. Systems such as these are the basis of many of the innovative new products in the information processing area which is a major product growth area in world markets. Corporate support has been obtained for course development,

(ME 345, 3 credit hours) Instrumentation and Measurement
2nd semester, Junior year

(ME 363, 3 credit hours) Dynamics and Vibration of Machines
1st semester, Junior year

(ME 449, 3 credit hours) Mechanical Engineering Laboratory
1st semester, senior year

(ME 451, 3 credit hours) Systems and Controls
1st semester, senior year

**(ME 455, 2 credit hours) Introduction to Mechanical Design
or Introduction to Thermal Design**
2nd semester, senior year

(ME 465, 3 credit hours) Elements of Machine Design I
1st semester, senior year

(ME 466, 3 credit hours) Elements of Machine Design II
1st semester, senior year

**(ME 469, 4 credit hours) Machine Design or
Thermal Engineering Design**
2nd semester, senior year

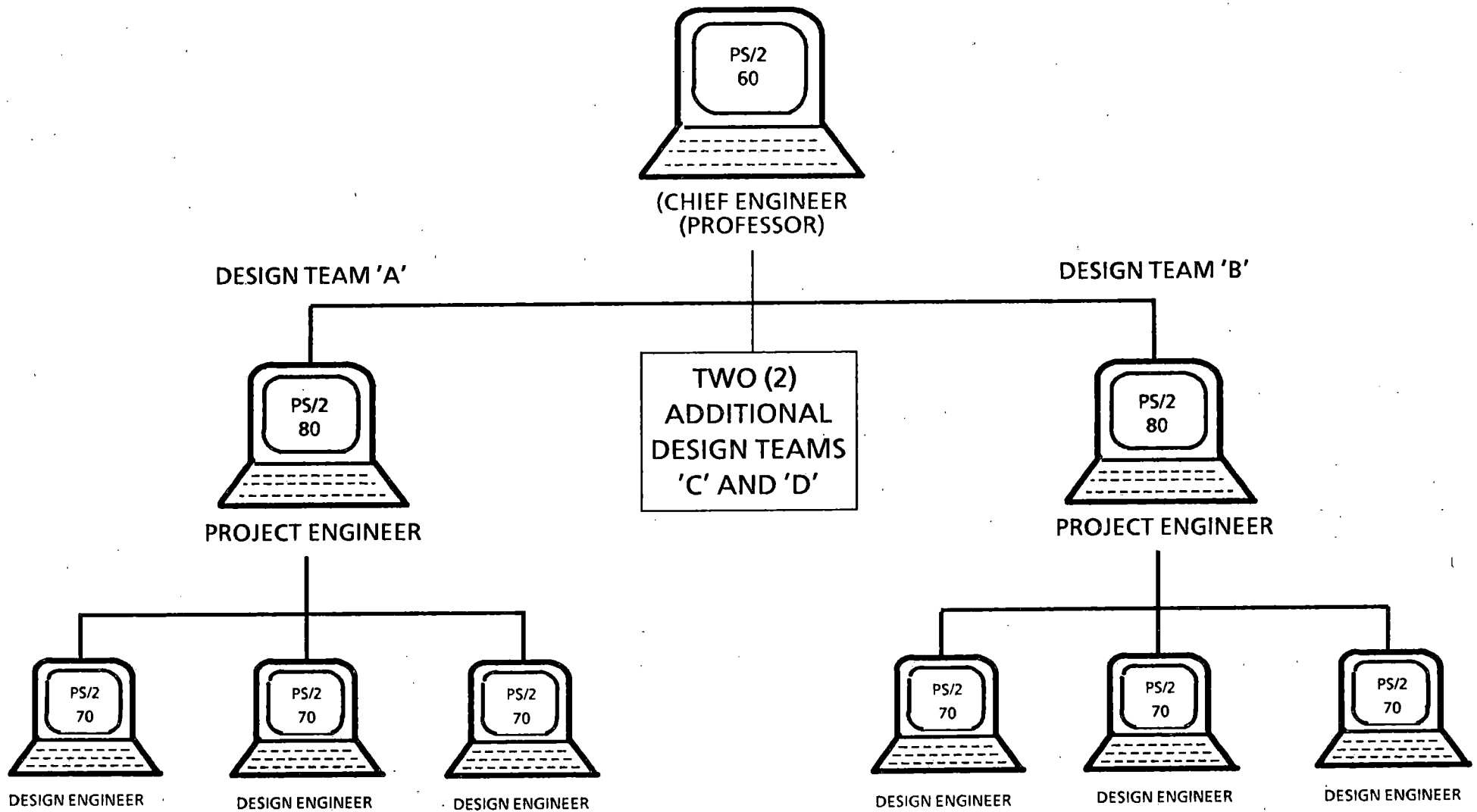
**INTERDISCIPLINARY
ENGINEERING PRACTICE
LABORATORY**

Figure 1. Relationship of the Interdisciplinary Engineering Practice Laboratory & Courses

including faculty release time, site visits to acquire industrial input, and graduate student support.

4. An Engineering Design Center is under construction to bring efficient computer-aided design methodology and manufacturing prototyping evaluation techniques to the student. (Industry and State support of this component has provided funding for two facilities capable of accommodating thirty-two students with the appropriate software and hardware.) The **Engineering Design Center** serves to integrate the design and manufacturing processes with research in design methodology. Students in the Engineering Design Center will be organized into a "design team structure," so that four teams of four students will be able to work cooperatively on projects of significant complexity (Figures 2 and 3). The project engineer, who has system responsibility, has a computer that is connected to the **Flexible Manufacturing Center (AMF)**, as illustrated in Figure 2. Computer-Aided-Manufacturing (CAM) programs are used to produce parts on the numerically controlled machines in the Facility. Figure 4 illustrates the built-in design methodology questions and design tools which will assist the engineering student in using superior design methods.

ENGINEERING DESIGN CENTER CLASS STRUCTURE

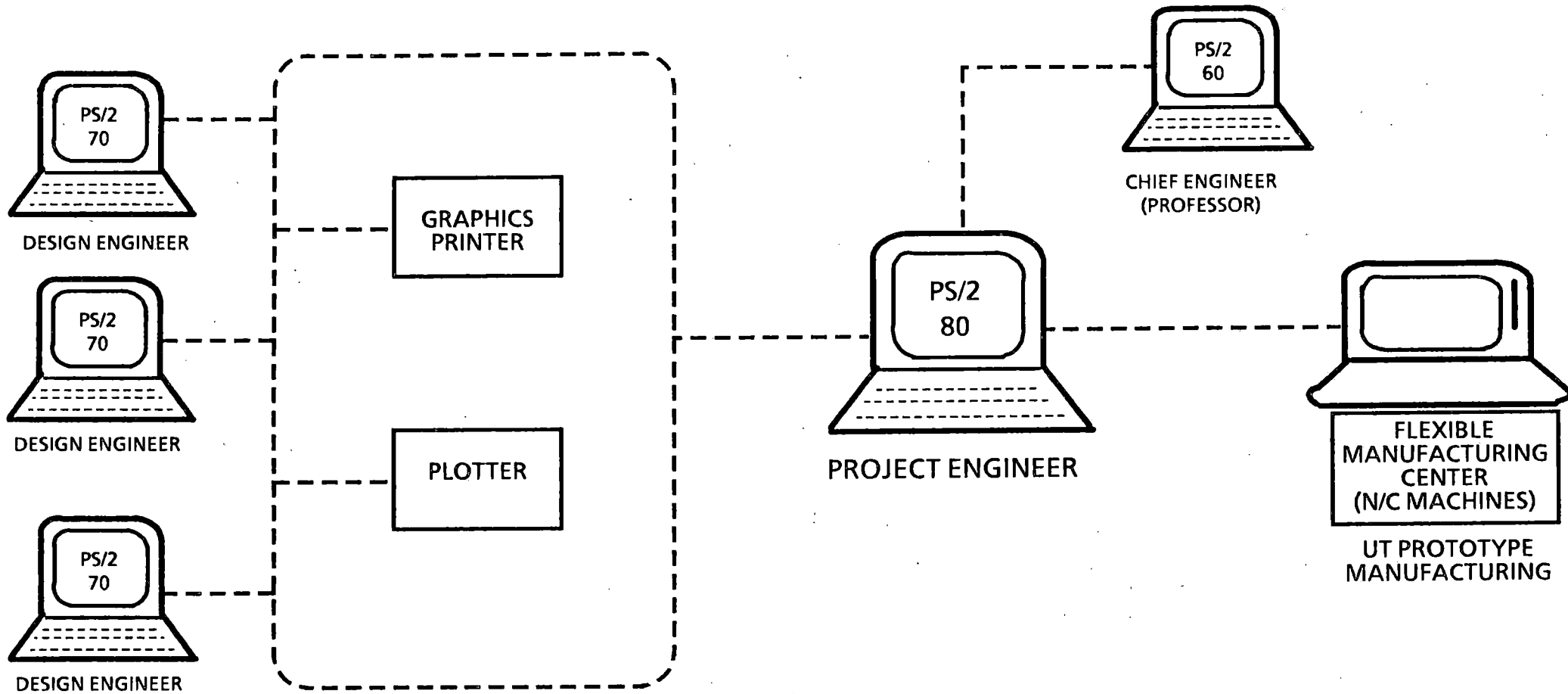


The Design Team Structure Within
The Machine and Systems Design Course

FIGURE 2

ENGINEERING DESIGN CENTER

DESIGN TEAM STRUCTURE



Relationship of the Flexible Manufacturing Center
To the Engineering Design Center

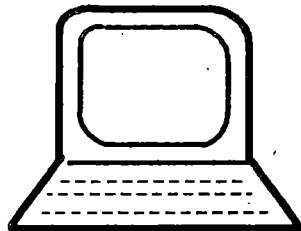
FIGURE 3

5. Product Design and Development Methodology is underway to extract superior industry design methods from the case study research.

The goal of this effort is to provide superior design and evaluation techniques to undergraduate students, graduate students, AND industry. Methodologies that are developed will affect many aspects of the Superior Engineering Design Program. The results will be used to develop design questions and to identify appropriate design tools in the Engineering Design System (Figure 4). Case studies from the research will be presented to students taking the Design Methodology and the Systems Design Classes. Superior electro-mechanical methodologies and tools will be incorporated into the Electro-Mechanical Systems Integration Course. Examples of superior product designs will be presented in the Interdisciplinary Engineering Practice Laboratory.

Additional corporate support is being sought for key elements of the Superior Engineering Design Program. Due to the extensive nature of this program, assistance from several sources is required.

ENGINEERING DESIGN SYSTEM EXAMPLE

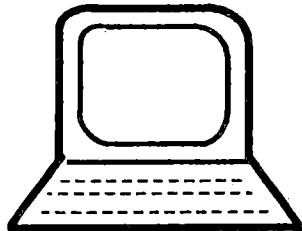


PROJECT
ENGINEER

DESIGN QUESTION

* RELIABILITY

* SYSTEM ASSEMBLY



DESIGN
ENGINEER

* MANUFACTURING PROCESS SELECTION

* MANUFACTURING PROCESS CAPABILITY

DESIGN TOOLS

- FMEA
- PREDICTOR
- STRESS TESTS
- EXTREMES

- DESIGN FOR ASSEMBLY

- PARTS DESIGN
- TOOLING

- STATISTICAL
PROCESS CONTROL

Use of Design Methodology Research In the
Engineering Design Center

FIGURE 4

THREE YEAR PLAN

Other activities of the overall **Superior Engineering Design Program** over a three-year period are planned if full support of the program is underwritten. These plans are outlined below.

SUPERIOR ENGINEERING DESIGN PROGRAM

1988-89 Results

1. Offer a pilot course, Development of Superior Products and Processes. (Spring 1988)
2. Plan the Interdisciplinary Engineering Practice Laboratory experience (emphasis on the integration of this information with the other engineering design courses in ME, EE and IE). Obtain and organize equipment for a pilot version for initial evaluation.
3. Initiate the planning of the Electro-mechanical Systems Integration course as explained above.
4. Solicit industrial financial support (in process) to develop the Engineering Design Center. Purchase representative hardware and software to initiate the Engineering Design Center. Install initial Center (16 stations) for use in 1989-90 school year.
5. Purchase Computer Aided Manufacturing software to link the design teams to the Flexible Manufacturing Center.

6. Solicit industrial financial support to develop the Flexible Manufacturing Center.
7. Identify and present some of the essential elements for superior product development (Product Development Methodology Development).

1989-90 Activities and Results

1. Evaluate the Development of Superior Products and Processes course to be a permanent interdisciplinary course in the engineering curriculum. Investigate the possibility of an international conference on Superior Methods.
2. Implement the Interdisciplinary Engineering Practice Laboratory on a pilot basis.
3. Develop the syllabus of the Electro-mechanical Systems Integration course as explained above.
4. Establish, test, and begin use of the Engineering Design Center.
5. Install and use the CNC Mill and the Injection Molding Machine as Phase One of the Flexible Manufacturing Center.
6. Demonstrate use of some design methodology results in the Engineering Design System (Design Questions and Tools).

1990-91 Activities and Results

1. Prepare documentation of the Development of Superior Products and Processes Course, for dissemination to other universities

through a conference. Schedule the conference with the appropriate planning to support it.

2. Initiate the Electro-Mechanical Systems Integration Course as mentioned above.
3. Prepare documentation of the Interdisciplinary Engineering Practice Laboratory for transfer to other universities.
4. Assess and acquire additional software to support the Engineering Design Center. Define software development needs that are required to support the Engineering Design Center.
5. Install and use the Wire Electric Discharge Machine as Phase Two of the Flexible Manufacturing Center.
6. Use the Engineering Design System (design questions and tools) in the Machine and Systems Design Course.

The Superior Engineering Design Program

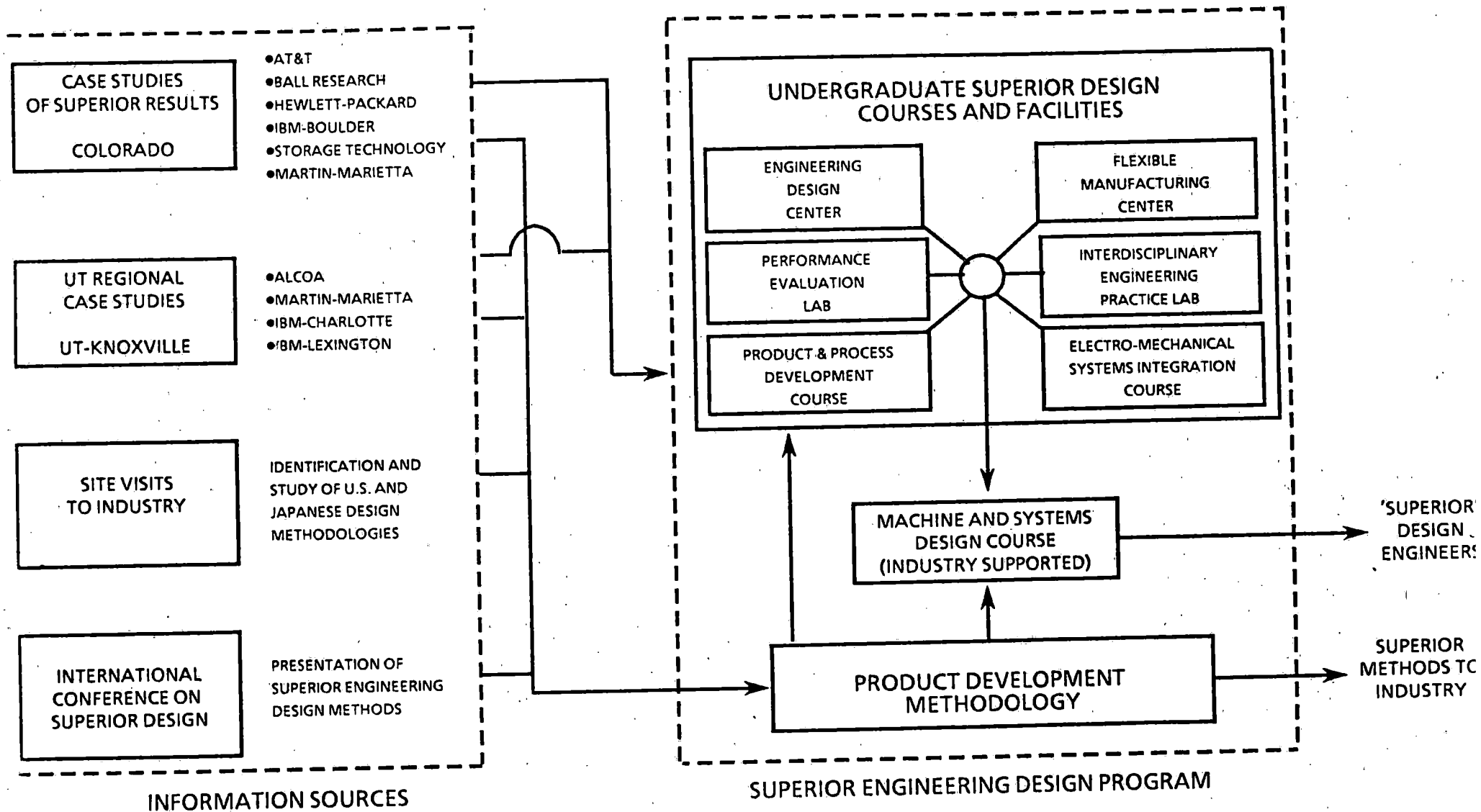


FIGURE 1

Participating Companies

Other companies who are being asked to participate in this research effort are: Hewlett Packard, Honda Motor Company, Sony, Minolta, Polaroid Corporation, Storage Technology Corporation, AT&T, Eastman Kodak Corporation, and Boeing.

Current sponsors:

IBM

Martin Marietta Corporation

Northern Telecom

Saturn Corporation

University of Tennessee, Knoxville

Westinghouse Foundation

Pending Sponsorships:

Ford Motor Company

The National Science Foundation recommended that a proposal be submitted in 1989 for the NSF Program for Improvement of Undergraduate Engineering Education.

Participating Faculty

The interdisciplinary team from the Mechanical and Aerospace Engineering and Electrical and Computer Engineering Departments are: Professor Clement C. Wilson, Principal Investigator, Professor Robert Bodenheimer, Professor Andrew J. Edmondson, Professor James Euler, Professor Frank Speckhart, Assistant Professor Rajiv Dubey.

For additional information, please contact Professor Clement C. Wilson, 607 Dougherty Hall, The University of Tennessee, Knoxville, Tennessee 37996-2210.

APPENDIX A

VITA

PERSONAL

Name: Clement Card Wilson
Address: 11915 W. Fox Chase Circle
Knoxville, Tennessee 37922

Telephone: (615) 974-6144
Marital Status: Married
Place of Birth: High Point, North Carolina

EDUCATION

University of Tennessee BS Mechanical Engineering, 1956
MS Mechanical Engineering, 1959

Purdue University Ph.D. (Mechanical Engineering Major, 1964)

University of Kentucky Simulation of Dynamic Systems, 1968
(Continuing Education) Design of Experiments

Colgate Darden Graduate Financial Decision Analysis Course
School of Business at the University of Virginia & IBM June 20, July 1, 1983

Carnegie-Mellon University Information Technology Engineering Seminar
(Post-College Professional Education) (6.3 CEU's), June 13, 1986

WORK EXPERIENCE

Company/University

The University of Tennessee
Knoxville, Tennessee

Work Description

Development of the Superior Engineering Design Program.
Teaching senior design courses
Teaching Development of Superior Products and Processes (Graduate Course)
Directing two master theses and one doctoral dissertation.
1987 - present

The University of Colorado
Boulder, Colorado

IBM Development Lab
Boulder, Colorado

IBM Development Lab
Lexington, Kentucky

University of Kentucky

Visiting Adjoint Professor, IBM Technical
Sabbatical 1986-87
Developed and offered course: Investigation
of Design Methodology for Superior Products

Area Manager, Product Engineering, Announced
Copiers, 1983-1987. Developed Models 50,
70, and electrophotographic and reliability
improvements for Model 85.

Copier Quality Improvement Center, 1982-1983.

Area Manager, New Product Development,
1978-1981.

Area Manager, Copier Process Technology,
1974-1978.

Senior Engineer - Project Manager, Fuser
Technology Group, Magnetic Brush Project,
1971-1974.

Senior Engineer, Manager of Mechanical
Analysis Department, 1967-1971.

Development Engineer, Manager of Mechanical
Analysis Department, 1966-1967.

Staff Engineer in Mechanical Analysis
Department, 1964-1966.

Associate Engineer, Summers 1960-1961.

Lecturer in Mechanical Engineering.
Introduced and taught ME 649, Analysis of
Mechanical Systems & Components, 1966-1974.

Introduced ME 780, Simulation of Dynamic
Systems.

Served on Master's Examining Committees.

Supervised papers for MS Degrees.

Purdue University

Teaching (Machine Design & Analysis), Lab Instructor, 1963.

Research Assistant, Vehicle Dynamics Group, 1961-1964.

University of Tennessee

Research project for Oak Ridge National Lab, experimental stress analysis, 1956-1961.

Teaching (Kinematics, Dynamics of Machines, Mechanical Vibrations, Production Processes, Thermodynamics), 1956-1961.

Tennessee Eastman Company

Cooperative Student, 1952-1955.

HONORARY & PROFESSIONAL SOCIETIES

A member of Sigma Xi, Tau Beta Pi, Pi Tau Sigma, American Society of Mechanical Engineers, ASME National Nominating Committee 1982, Editorial Board of IBM Journal of Research & Development, Engineers Council for Professional Development Ad-Hoc Accreditation Visitor 1979.

A member of The University Board of Engineering Visitors, 7 years.

HONORS

IBM Outstanding Innovation Award: Copier II Magnetic Brush Implementation, 1973.

IBM Division President's Award: S-III Task Force Contribution, 1978.

IBM Invention Achievement Award 1st Level, 1978.

IBM Quarter Century Club, 1986.

Outstanding Engineering Alumnus of University of Tennessee, 1976.

PUBLICATIONS

Wilson, C.C., "A New Fuser Technology for Electrophotographic Machines," Journal of Applied Photographic Engineering, Vol. 5, No. 3. 1979.

Bishop, R.E. and Wilson, C.C., "Dynamic Control of Spring-driven Mechanisms," IBM Journal of Research and Development, Vol. 16, No. 3, May 1972.

- Meyer, D.R. and Wilson, C.C., "Measurement of Elastohydrodynamic Oil Film Thickness and Wear in a Ball Bearing by the Strain Gage Method." Transactions of the ASME, Journal of Lubrication Technology, April 1971.
- Meyer, D.R. and Wilson, C.C., "The Design of a Ball Bearing Speed Reduction Drive System." IBM Office Products Technical Report, T.R. 08-053, October 6, 1969.
- Miles, B.W. and Wilson, C.C., "The Proportional Escapement System of the IBM Selectric Composer." IBM Journal of Research and Development, Vol. 12, Number 1, January 1968.
- Quinn, B.E. and Wilson, Clement Card, "Can Dynamic Tire Forces Be Used As A Criterion Of Pavement Condition?" Highway Research Record, Number 46, Publication 1168, pp. 88-100 (1963).
- Smith, J.E., Wilson, Clement C., and Swinson, W.F., "Photoelastic Analysis of EGCR Pressure Vessel." Oak Ridge National Laboratory, ORNL-3690, UC-80 Reactor Technology, 37th Ed. (February 1965).
- Wilson, Clement Card, "A Dynamic Tire Force Measuring System" (Doctoral Dissertation), Purdue University (June 1964).
- Wilson, Clement Card and Maxwell, R.L., "An Experimental Investigation of the Stresses and Deflections of a Perforated Place in Bending." The University of Tennessee, Knoxville, Tennessee, Department of Mechanical Engineering, ME-61-1 (June 1961).
- Wilson, C.C. and Kennedy, M.E., "Some Essential Elements for Superior Product Development." ASME Winter Annual Meeting, San Francisco, CA, December 1989.
- Wilson, C.C., "Quantification of Critical Product Characteristics for Superior Product Development." to be presented at ASME Winter Annual Meeting, San Francisco, CA, December 1989.
- Wilson, C.C., "Some Essential Elements for Superior Product Manufacturing" Abstract accepted for Manufacturing International 90 ('90), Atlanta, GA, March 1990.
- Wilson, C.C., The U.S. Product Development Dilemma, Survey of Business, Center for Business and Economic Research, College of Business Administration, University of Tennessee, Knoxville, Summer 1989.

PRESENTATIONS

- Queener, Carl A. and Wilson, C.C., "Development of IBM Series III - A Study in Change." Presented by Wilson to the 16th Annual Fall Symposium-Business Graphics, November 9-13, 1976.

Wilson, Clement C., The Enemies of Copier Reliability. Presented to Dataquest 1985 Copying and Duplicating Industry Conference, June 19-21, 1985.

Wilson, Clement C., The U.S. Product Dilemma, Plenary Speaker, WATtec '89, February 14-17, 1989

Wilson, Clement C., Some Essential Elements For Superior Product Development, 3-Day Short Course, Transferencia De Tecnologia Enlace Al Futuro, University of Santiago, Santiago, Chile, Nov. 6-8, 1989.

PATENTS AND PATENT PUBLICATIONS

Bishop, R.E., Wilson, C.C., Dynamic Controlling Device for Spring-Driven Mechanisms - Published 1971.

Cail, N., Rogers, J.C., Wilson, C.C., Tapered Arbor Overriding Spring Clutch - Patent filed 1970. LE8690053.

Wilson, C.C., Wedge Decelerator - Published 1966. LE8111204.

Brandon, F.Y., Wilson, C.C., Hot Roll Cleaning & Release Assist Scheme. Patent filed 1/31/76. BO8750110.

Wilson, C.C., Copy Darkness Sensor for 2-Cycle Process. Continuation filed 4/21/80. BO0760060.

Brown, L.C., Peterson, C.E., Wilson, C.C., Edwards, E.G., Robinson, P.G., Hot Roll Fuser Having Manually Operable Jam Clearance Mechanism. Patent issued 8/29/78, No. 04,110,068.

Wilson, C.C., Velocity Limiter & Decelerator for Spring-Driven Device. LE8700113. Published 2/18/72.

Caudill, A.H., Hoekzema, R.J., Wilson, C.C., Toner Dust Control & Recovery System. LE8730145. Patent filed 12/20/73.

Wilson, C.C., Wilzbach, B., Get Bent Cassette. BO8790431. Published 2/19/80.

Bajgert, T.A., Cochran, J.L., Duane, W.J., Mojica, A., Stone, J.D., Underhill, T.T., Williams, D.M., Wilson, C.C., Continuous Form Feeder For a Reproducing Machine and Process. Patent filed 11/27/85. BO985004.

APPENDIX B

MECHANICAL ENGINEERING 597
INVESTIGATIONS OF DESIGN METHODOLOGY FOR SUPERIOR PRODUCTS

LECT.	SUBJECT	LECTURER
1	Introduction of course	C. Wilson
2	The U.S. Product Development Dilemma	C. Wilson
3	What is a Superior Product?	M. Miller, Mgr. of IBM Competitive Lab
4	From technology selection to production, a fuser case study	M. Headrick, IBM Product Dev. Manager
5	Product Initiation, Reaching Far Enough	C. Queener, IBM Fellow
6	Prediction of the Reliability & Life of a Machine in Development	J. Rhodes, IBM Advisory Engineer
7	Evaluation of the Reliability of a Production Machine	G. Bishop, IBM Technology Manager
8	A Diskette Drive Design for Automatic Assembly	D. Janssen, IBM Senior Engineer
9	Design Methodology for Assembly	L. Carlson, C.U.
10	A Satellite Subsystem Design	Frank Manders, Ball Aerospace
11	Controlling a Mfg. Process, S. P. C.	Bob Godlewski, IBM Supplies
12	Manufacturability as a Prime Objective, Equip. Design Methodology	Len Buist, A.T. & T. Staff
13	Improving the Development Process	T. Abbott, Storage Technology Corporation Development Mgr.
14	Case Study in Space Station Req.	Bob McMordie, Martin Marietta
15	Design Methodology used in the design of H.P. C. A. D. Equipment	Terry Pilsner, Hewlett Packard
16	Stress Testing in the Mfg. Process	Dennis Estabrooks Advisory Engineer, Gil Norris, Staff Engineer, IBM
17	Product Development at Xerox, Meeting the Competitive Challenge (Project Reports, Due)	C. Wilson

Figure B-1 Course Agenda

Figure B-2 **Lecture Topics Illustrated in New Product Development Cycle**

