NISTIR 89-4060

National Engineering Laboratory's 1989 Report to the National Research Council's Board on Assessment of NIST Programs

U.S. DEPARTMENT OF COMMERCE
National Institute of Standards and Technology
(Formerly National Bureau of Standards)
National Engineering Laboratory
Gaithersburg, MD 20899

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National Bureau of Standards became the National Institute of Standards and Technology on August 23, 1988, when the Omnibus Trade and Competitiveness Act was signed. NIST retains all NBS functions. Its new programs will encourage improved use of technology by U.S. industry.

U.S. DEPARTMENT OF COMMERCE
Robert A. Mosbacher, Secretary

Ernest Ambler, Acting Under Secretary for Technology

NATIONAL INSTITUTE OF STANDARDS AND TECHNOLOGY
Raymond G. Kammer, Acting Director

Table of Contents

ABSTRACT

The 1989 report to the National Research Council's (NRC's) Board on Assessment of the National Institute of Standards and Technology (NIST) programs provides an overview of the National Engineering Laboratory (NEL). It describes the climate that influences NEL's work, program and budget trends, and the external interactions with industry, academia, and trade and professional organizations. Descriptions of NEL's program activities with accompanying lists of recent accomplishments, trends, and significant budget changes are also included. The programs described are Electronic and Electrical Measurements, Manufacturing Research and Standards, Building Research, Fire Research, Chemical Engineering Metrology, Mathematical Sciences, Computing Support, Energy Related Inventions and Law Enforcement Standards. The impact of the recently enacted Omnibus Trade and Competitiveness Act of 1988 is discussed.

Key Words: building research; chemical engineering; computing support; electrical measurements; electronic measurements; energy related inventions; fire research; law enforcement standards; manufacturing research; mathematical sciences; National Engineering Laboratory

Note: In a pending NIST reorganization request to the Department of Commerce, the Chemical Engineering Metrology program is proposed for transfer to the National Measurement Laboratory and the Office of Energy Related Inventions is proposed for transfer to a new Office of Technology Services.

NATIONAL ENGINEERING LABORATORY
NATIONAL INSTITUTE OF STANDARDS AND TECHNOLOGY (NIST)
1989 REPORT
TO THE
NATIONAL RESEARCH COUNCIL'S
BOARD ON ASSESSMENT OF NIST PROGRAMS

Introduction

The initial part of this report is an overview of the National Engineering Laboratory (NEL). It describes the climate that influences our work, program and budget trends, and our external interactions with industry, academia, and trade and professional organizations.

The remaining sections are descriptions of our program activities with accompanying lists of recent accomplishments, trends, and significant budget changes. These sections are:

- Electronic and Electrical Measurements
- Manufacturing Research and Standards
- Building Research
- Fire Research
- Chemical Engineering Metrology
- Mathematical Sciences
- Computing Support
- Energy Related Inventions and Law Enforcement Standards

NEL is composed of six Centers and two Offices with a staff of about 1250 people and has a total cash income of approximately $112 million.

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DIRECTOR'S OVERVIEW

Last August the Congress passed and the President signed the Omnibus Trade and Competitiveness Act of 1988. Within that Act is a section called the Technology Competitiveness Act, a measure that recharters the National Bureau of Standards as the National Institute of Standards and Technology (NIST). The new charter places emphasis first on supporting industry to improve competitiveness. The two pertinent functional statements are:

> "(1) to assist industry in the development of technology and procedures needed to improve quality, to modernize manufacturing processes, to ensure product reliability, manufacturability, functionality and cost-effectiveness...
> "(2) to develop, maintain, and retain custody of the national standards of measurement..."

Thus we are asked to focus on technologies of interest to industry and to do whatever technical things we can to improve the relative posture of American firms in the global economy.

While these are not entirely new ideas for us, the shift in emphasis and the explicit assignment to work in broad areas of technology per se are a departure from the immediate past. We have justified nearly all we have done in the 1970's and the 1980's under the rubric of standards and measurements and have narrowly averted having key programs killed because they appeared to go beyond these limits. We have felt this pressure particularly in the National Engineering Laboratory where many programs have strong technology flavors. Two examples are the factory automation program and the bioprocess engineering work. Now we find this kind of program is encouraged in the new paradigm.

The underlying assumptions are that whereas the United States is doing very well in science and the development of new concepts of products (prototypes) we are falling behind in commercializing the new technologies. Time and again we see our new concepts taken first to market by overseas competitors. We have problems with cost of goods produced, with quality, and with the speed with which we go to market. The new assignments in function (1) above in the Technology Competitiveness Act address these shortcomings explicitly. The Federal government believes that we in NIST can do something about these problems through new efforts both in the laboratory and in the field.

Before turning to the laboratory programs let's look at the field aspects. The Act sets up four new institutional mechanisms to improve relations among industry and governments at all levels. These are:

- Manufacturing Technology Centers (MTC's)
- Assistance to Technology Extension Services
- Clearinghouse on state and local initiatives on productivity, technology, and innovation
- Advanced Technology Program (ATP)

The MTC's are to transfer technology to small business. They are to be dispersed geographically and initially will deal with factory automation technology from NEL's Center for Manufacturing Engineering. After a vigorous competition we awarded the first three in December 1988. They are at Cleveland, Ohio; Rensselaer Polytechnic Institute in New York; and at a consortium at Columbia, South Carolina. We have set up a task force under the former director of the NIST National Measurement Laboratory to manage these new programs. Funding has only been received for the MTC's and that only for the first year and a half ($12M).

The Advanced Technology Program is an external funding mechanism that has the potential to deal with very substantial efforts such as SEMATECH, if the Congress and the Administration desire. At this time there is no funding for ATP.

Implications for NEL

The model for NEL programs has been, since the beginning, a blend of long-term fundamental work supporting the shorter term more applied problem solving. The fundamental programs assure the technical soundness and currency of the applied work and also serve as recruiting grounds for new graduates. This model will not be affected by the new assignments.

The work that NBS has done and now NIST that relates to industry may be fitted along an idealized time-line representing product commercialization (Fig. 1). Some of the work supports industry all along the time-line. This includes reference data, reference materials, and measurement services such as calibrations. These are nearly independent of where one is on the time-line. One needs the steam tables for new plant design and for operations. Many of our Standard Reference Materials are equally valuable in evaluating brand new prototypes or routine production samples. These activities are shown in Figure 1 below the line and are termed supporting technologies. The new legislation does not affect these services; we plan to continue to do this kind of work. Indeed we have a backlog of needed services that we would like to see funded as soon as possible. There are many segments of industry that we can best serve by continuing to do precisely these activities. Examples are the optical communications industry where we have defined a series of measurement services for each component of the system. It still appears that the most desirable help we could give this industry is to provide that supporting technology as quickly as possible.

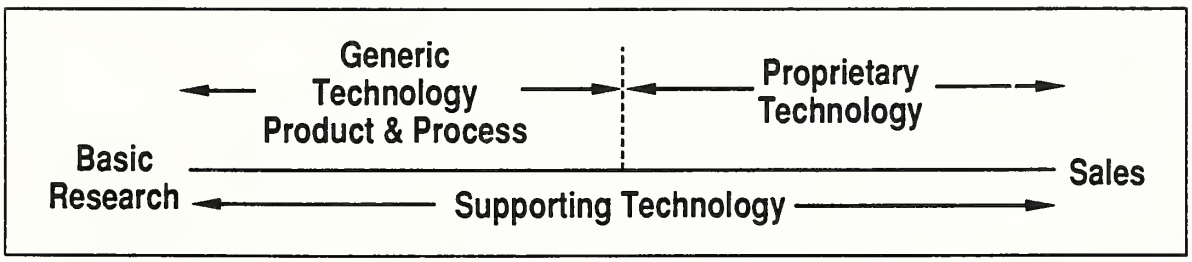


FIGURE 1. Time-line for Product Development.

The area above the line in Figure 1 represents product and process technology. For every product development there is a time during which the technology is generic, that is, applies equally to all potential competitors, and is public and shared. At some point the technology matures, competition increases, and the technology becomes protected and proprietary to each firm. Sometimes external conditions change and that which has been proprietary becomes shared again. Such has recently been the case with semiconductor process technology. This had been proprietary but because of overseas competitive pressure it is now being shared within the SEMATECH consortium. So the dividing line between open and closed moves back and forth in time from product to product and from situation to situation.

When NEL works in product and process technology in the future it will do so largely in the open, generic technologies. Such has been the case with the automation program and with most other NEL activities that fall above the line. Working with proprietary technology is difficult for NEL and NIST. By reason of equity all firms should have an equal opportunity for our attention and services. Working with proprietary technology means this would not be the case; we would be working with one firm. Exceptions are closed consortia such as SEMATECH. We have not yet learned how to work with such groups and how to deal with their need for control of publication, lead time, and so on. On the one hand we do not wish to restrict our staff; on the other hand consortia will be more common in the future and will often be in areas of great national importance. We have to work this issue out soon.

We seek new opportunities to work in generic, open technologies. Our success with factory automation has emboldened us to look for similar openings in other areas. An obvious move is to try to take the information technology developed in the metal-cutting industry and apply it to as many other industries as possible. We have been at work on computer-integrated construction for several years in a modest way, and see several other possibilities (for example in material processing in the NIST Institute for Materials Science and Engineering). We believe the biotechnologists need a complete package of engineering technologies to scale up bench processes to plant operations. We have begun a major program in the old Center for Chemical Engineering (proposed to be part of the Center for Chemical Technology in NML). There are many others. Here is a short list of ideas that we have put forth:

- X-ray lithography beyond the synchrotron generation
- Bioprocess engineering
- Computer-integrated construction
- Computer-integrated materials processing especially for advanced materials
- Development of prototype devices and processes based on the new high Tc superconductors

And we are studying the advanced television arena to see what it holds for NEL.

With all this discussion of industry support we don't mean to overlook our other functions. We have about half our effort devoted to the interests of other Federal agencies. The military is the largest sponsor. While much of this military work is dual use in character there is some that is solely of interest at this time to the Pentagon. We do this because it is in the National interest and because we have unique capabilities and feel obliged to put them at the service of the defense effort. Support from the military for programs such as factory automation, microwaves, superconductivity and the like has been strong, reliable, and sometimes the difference between staying in a field and shutting down. We very much value the other-agercy support and do not intend to alter the level. (We do have some areas where the ratio of other agency funds to appropriated funds is too high to assure sufficient long-term fundamental work. We seek additional appropriations in these areas.)

We have traditionally worked on problems related to public health and safety. Often these are also industrial problems. Examples are the fire program, the structural safety work on building integrity for seismic resistance, special investigations of failures, indoor air quality, and new supporting information for developing replacement refrigerants (the ozone problem). This work usually has substantial economic impacts and tradeoffs as well as safety and health concerns.

All program planning comes together in the budget proposed to Congress. In recent years the restraints on the budget have been severe and NIST has had a hard time moving new proposals forward. The President's fiscal year 1990 proposals are now before the Congress and are the subject of hearings before authorizing and appropriations committees. Whereas most members are strong supporters of NIST and its programs, the pressures to reduce the overall Federal budget have produced each year a zero-sum exercise such that the overall number for NIST submitted by the President is met.

A case in point is the FY 1989 budget, the one we are now implementing. The President proposed $158 million, up from $144.8 million the previous year. This proposal included new funds for a series of internal lab-based initiatives such as lightwave technology, high-temperature superconductors, and bioprocess engineering. The President also proposed a reduction in fire and building research and deleted funds for the Regional Centers for the Transfer of Manufacturing Technology (Hollings Centers). The Congress restored the fire and building money, put in some funds for the Regional Centers and added some more, earmarked $7.5 million for an extramural grant for a new center on non-destructive evaluation, and radically reduced or deleted most of the program initiatives. Our proposed inflation adjustments were cut by three fourths and the final result was an actual shrinkage in available funds for laboratory work.

FY1989 STRS BUDGET CHANGES ($M)

	Request to DOC	Request to OMB	Request to Congress	Approp Bill
FY 1988 Base	138.6	138.6	144.8	144.8
Program Changes				
Adjustments to Base	4.3	3.9	-0.1	1.1
Computer Security	6.0		3.0	1.5
High Temp Superconductors	12.5	9.3	6.5	
Chemical Meas & Stds	11.1	4.3	2.5	0.4
Physical Meas & Stds	5.5	5.5		
Lightwave Meas Tech	8.0	8.0	3.0	0.4
High Performance Composites	5.8	3.1	1.0	
Bioprocess Engineering	4.0	3.0	2.3	0.2
Advanced Semiconductors	16.3	6.5		
Ultra-precision Metrology	3.8			
Advanced Automation	5.0			
Facility Modernization	5.0			
Advanced information Systems	4.7			
Computer Integrated Construction	6.0			
Scientific Computing Upgrade	6.0	1.0		
Edison Prize			4.0	
Fire and Building Research			-3.9	
Replacement Refrigerants				0.25
New Fire Res. on Ign. of Uphol. & Gen. Tox. Studies				0.25
Regional Centers for Transfer of Mfg. Technology			-5.0	2.5
Non-energy Related inventions				0.15
Non-destructive Evaluation Center				7.5
FY 1989 Total	242.6	183.2	158.0	159.0

The FY 1990 budget contains the same ingredients and the potential for the same result. The Administration has deleted all funding for the new responsibilities under the Trade Act, proposed the fire and building reductions, and offered a list of laboratory initiatives. Early comments from members of Congress suggest considerable unhappiness. Based upon these Congressional comments and past history, it is likely that Congress will again rewrite the NIST budget and it is equally likely that they will do so such that the overall total is unchanged. Probably some of the new responsibilities under the Trade Act will be funded in part out of our proposed initiatives. The effect is a slowing of momentum in our internal programs. The judgement as to the desirability of this in the broad context of the international competitiveness issue is properly being made by the President and the Congress.

FY 1990 STRS BUDGET REQUESTS ($M)

	Request to DOC	Request to OMB*	Request to Congress
FY 1989 Base	158.0	159.0	159.0
Program Changes			
Adjustments to Base			
Regional Centers for Transfer of Mg. Tech.	4.9	3.6	0.9
Center for Non-destructive Evaluation		-7.5	-7.5
Alternative Refrigerants		-7.5	-7.5
Non-Energy Related Inventions		-0.25	-0.25
Ignition of Upholstery		-0.15	-0.15
Fire and Building Research		-0.25	-0.25
Computer Security		-3.9	-3.9
Superconductivity	2.0	1.5	3.5
Chemical Measurement & Standards		2.2	0.7
Competence	5.7	4.9	2.1
Advanced Semiconductors	2.5		
Lightwave Measurement Technology	5.0	5.0	
High Performance Composites	5.6	8.2	2.6
Bioprocess Engineering	3.9	3.0	1.0
Ultimate Performance of Elec. & Opt. Sys.		2.3	2.3
Intelligent Process of Materials	5.5	2.5	
DB to Support Emerging Technologies	5.5		
Design for Quality	2.2		
US/Canada Free Trade	2.2		
Advanced Telecommunications	0.7		
Automation R&D	5.0		
Disaster Investigation	3.1		
Intelligent Machine Systems	1.0		
Scientific Computing Upgrade	5.0		
Telecom. System Replacement	6.0	6.0	3.1
Edison Award	1.5		
		2.0	
FY 1990 Request	225.3	180.7	155.7

*Adjusted to reflect FY1989 appropriation

EXTERNAL INTERACTIONS

NEL's major technology transfer efforts are achieved through extensive interactions with the private sector, trade and professional associations, and academia. These interactions enable us to disseminate our most recent technical advances and in turn to learn of the technical challenges facing engineers in industry.

In fiscal year 1988, 65 scientists and engineers from 22 companies participated in the NIST Research Associate Program and worked closely with NEL researchers on projects of mutual interest. The list of the industrial sponsors is contained in Appendix A. In addition, 219 scientists and engineers from universities, industrial laboratories, and other Federal agencies worked collaboratively with the NEL staff as part of the NIST Guest Scientist program. Over the past several years, we have received almost $9.4 million worth of donated equipment, materials, and software from the private sector in support of our programs.

We are very active in many voluntary standards organizations and other professional and trade associations, such as the American Society of Heating, Refrigerating and Air-Conditioning Engineers, the American Petroleum Institute, the National Society of Professional Engineers, the American Society of Mechanical Engineers (ASME), the American Society of Civil Engineers, the American Institute of Chemical Engineers, the Institute of Electrical and Electronics Engineers (IEEE), and the American Chemical Society. Our participation includes committee membership, committee chairmanship, conference planning, conference presentations, contributions to publications, and editorial responsibilities. Our role has been significant as reflected in the number of standards based on our research that have been adopted by these organizations. We have just completed two surveys of our extensive activities with ASME and IEEE. The results of these surveys have been published in NISTIR 89-4038 and NISTIR 89-4037.

In addition to the activities noted above, we are involved in several research consortia and other cooperative projects in which a number of private sector companies and NIST work together on a common technical problem. Examples of these type of collaborations along with the participants are contained in Appendix B.

ELECTRONIC AND ELECTRICAL MEASUREMENTS

In this our largest program, we provide support for the production of semiconductors, electric power generation and transmission, for the manufacture and use of components for communications, and for the commercialization of high-temperature superconductors. We offer a broad range of measurement services and develop new techniques in response to both industrial and governmental needs. The technology is fast-moving in both electronics and communications, requiring very close contact between our staff and the users of our services.

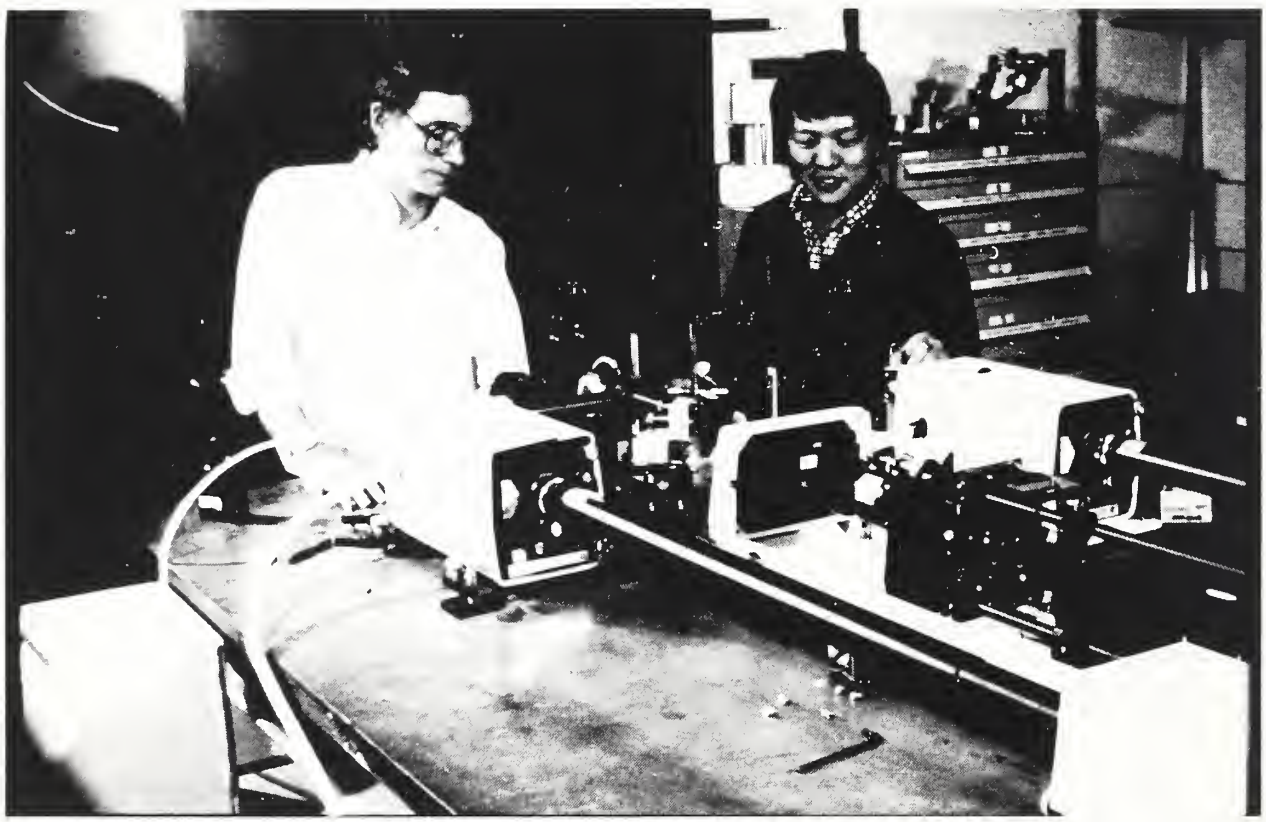
Recent Accomplishments:

- Joint Patent with Westinghouse: We are seeking three joint NIST-Westinghouse patents for a new technique of making very-low-resistance electrical connections to high-critical-temperature superconductors. This technique is a result of collaborative research between NIST and Westinghouse on high temperature superconductors. The ability to make low-resistance contacts to superconducting materials is essential for practical use of these materials as electrical conductors and for measurement of their electrical properties. The new technique for making contact resistance to yttrium-barium-copper oxide compounds represents a hundred-million-times improvement [eight orders of magnitude reduction] over contact resistances that were achieved before the NIST-Westinghouse work. Researchers at Cornell, AT&T, Bellcore, and IBM, among others, are using the new technique in their work on thin-film applications.

- Digital-Audio Tapes: At the request of Congress, NIST conducted a special analysis of the copy prevention system proposed for digital audio tape (DAT) recorders. The NIST report, which was released on March 1, 1988, concluded that the encoding system proposed by CBS Records to prevent prerecorded music from being copied by new DAT recorders did not consistently prevent recording, altered the sound of the recordings for some listeners, and could be easily bypassed. Our conclusions were based on a series of laboratory studies that we conducted to understand the copy prevention system and to exercise it in several ways to address the concern of Congress. Listening studies were conducted with a contractor using subjects drawn from the Audio Engineering Society, NIST staff, and a few local audiophiles and musicians.

- Expanded Coaxial Noise Calibration Services: We have expanded our calibration services for coaxial noise sources for the complete range of 2 to 12 GHz. For the first time, these electromagnetic noise temperature services cover any frequency within this range and for all noise power spectral densities. The calibration is achieved using an automated radiometer and a cryogenic coaxial noise standard. The service is valuable to users since noise is the ultimate limiting factor in electromagnetic system performance.

- NTT Recognition of Optical Sampler Work: Douglas L. Franzen and three of his collaborators from the Japanese Nippon Telegraph and Telephone Corporation (NTT) received the NTT Director's Award for their work carried out in NIST and NTT laboratories on high-speed optical samplers. The research team developed optical sampling systems that avoid problems associated with high-speed electronics needed for ultrahigh-bit rate optical communications. One U.S. firm has expressed interest in commercializing the NIST/NTT technique that uses a fiber coupler to sample target optical pulse waveforms. Their developments are described in joint research papers.



D. Franzen and T. Kanada (NTT) with their optical sampler set-up at the NIST Boulder laboratories.

- Improved Determination of the Unit of Electrical Resistance: We have made the best determination in the world (by a factor of two) of the unit of resistance, the ohm, in terms of a fundamental process in nature called the quantum Hall effect. We are constructing a new facility that will enable even further improvements in this determination. This capability coupled with NIST's other capabilities for accurate measurements of three additional fundamental quantities, including voltage based on the Josephson effect, absolute capacitance, and the gyromagnetic ratio of the proton, give NIST the best capability in the world for comparing experimental results and thus for detecting potential measurement errors or theoretical anomalies affecting fundamental electrical units.

- Industrial Use of Precision DC Josephson Source and Calculable AC Source: We have developed both a precision Josephson source for dc voltage and a digitally synthesized source (DSS) for ac voltage that have achieved new levels of performance. Through an Industrial Research Associate agreement with Hewlett-Packard Company (HP), we have used the developmental Josephson-junction-array to establish the performance of a new class of precision multimeters. The Josephson-junction array provides reference standards unavailable anywhere in the world for fundamental dc voltage measurements. By using this device, HP researchers were able to evaluate the essential dc linearity characteristics of their new instrument's data converter and verify the range to range accuracy of the internal calibration system. The NIST array generates any reference voltage in the range plus or minus 0.1 to 12 dc volts with an accuracy on the order of 10 parts per billion. HP has also verified the ac performance of the same HP instrument using our new digitally synthesized source (DSS) for ac voltage which has been circulated to industry for evaluation as a transportable standard. The performance of the DSS ac source can be traced directly to the Josephson dc source in a mathematically calculable manner. The DSS provides high accuracy (typically 10 parts per million) and accesses a broad frequency range (0-50 kHz) and low levels of ac voltage (below 250 mV) not directly supported by earlier standards.

Trends...

We are providing measurement support that the U.S. semiconductor industry needs to reestablish its international competitiveness. We are focusing increasingly on measurements to improve quality control during the manufacture of integrated circuits.

With funding from the FY 1988 Process Control and Quality Assurance budget initiative for low-frequency measurements, we are developing improved methods for transferring accurate electrical quantities to industry. We want to provide methods that are less costly and simpler to use, yet very high in accuracy, for better quality control in the marketplace.

With funding from the FY 1987, FY 1988 and FY 1989 budget increases for Lightwave Measurement Technology, we are expanding measurement support for components critical to optical fiber communications systems, such as light sources and detectors. These components set the performance levels for U.S. fiber optic products and will be required in very large quantities by emerging optical systems for local area networks. They are the subject of intense international competition.

We are developing measurements to support more sophisticated antennae for satellite communications systems, navigation, and radar. We are emphasizing high performance antennas that require complex mathematical analyses and complex test methods.

To the limit of our resources and with careful attention to the priorities of industry and government agencies, we are adding coverage of our measurement support for microwave systems.

With help from an FY 1988 budget increase, we have joined with the rest of NIST in embarking on a new program to provide measurement methods and materials data to support commercialization of the new high-temperature superconductors. As part of the President's July 28, 1987 Superconductivity Initiative, NIST was given the specific role to develop superconductor standards and to establish a center of excellence at NIST Boulder focusing on superconducting electronic devices.

Proposed Funding for FY 1990

The FY 1990 budget continues this program at $18,617,000 which includes an initiative for lightwave measurement technology at $2.6 million and an increase for high-temperature superconductors at $700,000. Reimbursable support for the program in FY 1990 is expected to be about $14.8 million, including fees charged for NIST calibrations.

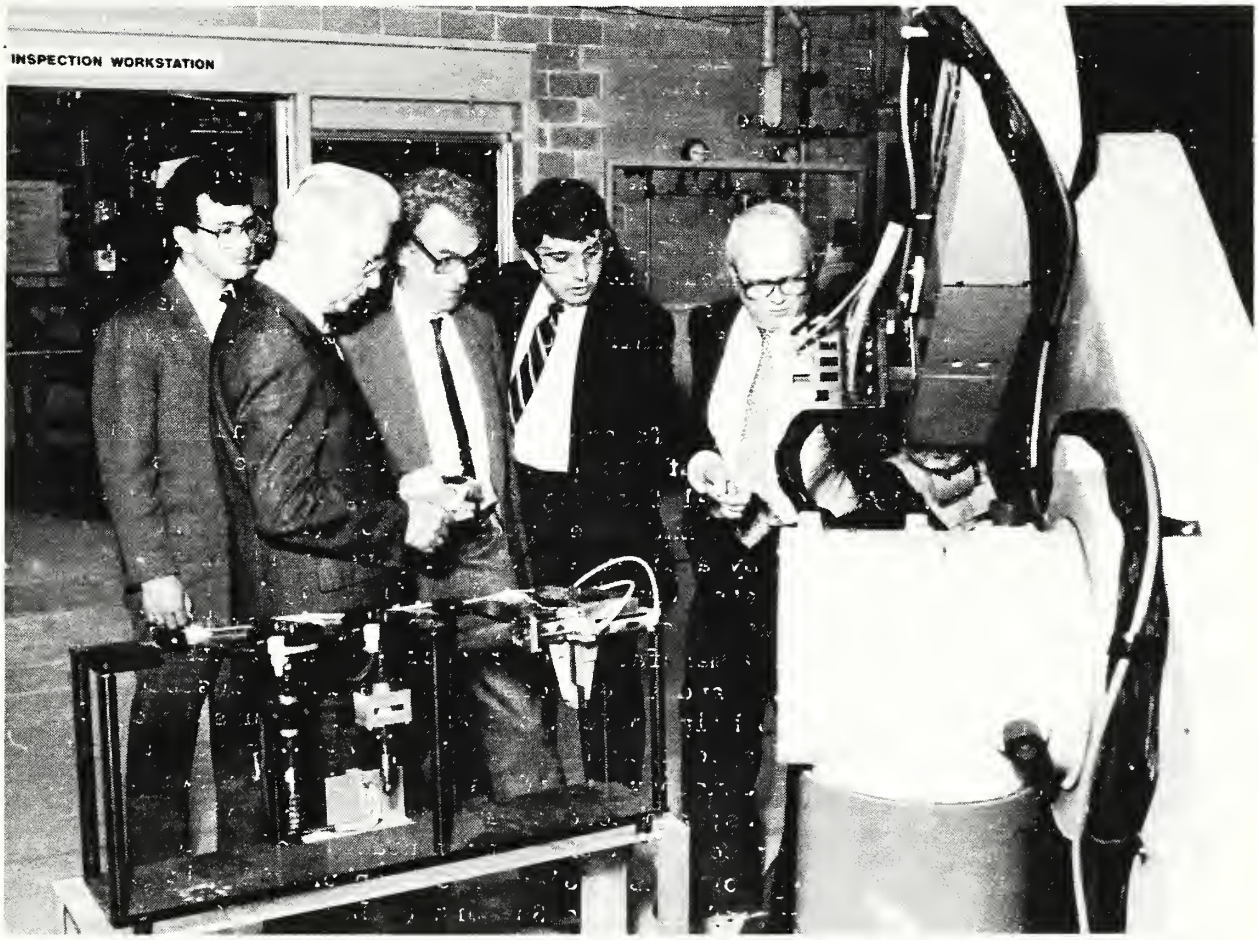
Increase for FY 1990 (Lightwave Measurement Technology)

An FY 1990 budget initiative of $2.6 million is proposed to provide increased measurement support for six components critical to optical fiber communication systems: light sources, detectors, waveguides, modulators, demodulators, and couplers. These components send, receive, manage, and process the signals carried by optical fibers for voice, video, and computer-data transfer.

Increase for FY 1990 (High-temperature Superconductors)

The FY 1990 proposed budget increase of $700,000 is a NIST-wide initiative and will increase NIST's ability to develop and provide U.S. industry with measurement methods, verified materials data, physical standards, and measurement services to support research, development, and manufacturing for new superconducting products. In addition, we will develop new measurement devices and apply our expertise in an array of scientific techniques including neutron, x-ray, electrical, magnetic, optical, thermal, chemical, and physical measurements, with supporting theoretical analyses.

This program provides services to the manufacturing sector of the economy for automated manufacturing, robotics, length measurements of all kinds, and special measurement technology for very high-precision machining.



Senate Majority Leader Robert C. Byrd viewing the cleaning and deburring robot station during his visit to the Automated Manufacturing Research Facility (AMRF).

Recent Accomplishments:

- Mare Island Flexible Manufacturing Workstation: We have designed and assembled a state-of-the-art manufacturing system for transfer to the Navy shipyard at Mare Island, San Francisco for round-the-clock, unattended production of any of 84 different parts used in nuclear submarines. The technology of the original NIST-AMRF Turning Center has been incorporated in the more advanced equipment of Westinghouse/Unimation and Warner and Swasey. The workstation consists

of an automated lathe, industrial robot, automated storage and retrieval system, and various control computers. It incorporates several advanced automation techniques such as chuck jaw changing and tool condition monitoring. A part that requires about 17 hours to manufacture using manual production methods can be produced by the workstation in under 30 minutes. The workstation is already producing parts for the Navy on a trial basis and will be transferred to Mare Island later this year.

- Automated 3-D Laser Tracking System: Two NIST researchers received a patent for an automated laser tracking system that accurately measures the dimensions of large shapes, such as aircraft wings or fuel tanks. The five-axis system includes a laser interferometer, a servo-controlled tracking mirror, a similar target mirror, and a computer to control the system. The patent also covers a 3-axis system which is portable, fully automated, uses only one station, and can measure positions to an accuracy of about one part in 100,000. The tracking system can also be used to assess the static and dynamic performance of robot arms and the accuracy of machine tools and coordinate measuring machines.

- National PDES Testbed Facility: To speed the development and use of computer-integrated design, manufacturing, and logistic processes, we have begun to develop a national facility for testing implementations of the Product Data Definition Exchange Specification (PDES). PDES, which is under development by a diverse group of government agencies, academic institutions, private companies, and an industry-funded consortium, is a standardized format for representing and exchanging information about almost any manufactured product including its geometric design, materials, and tolerances. The "National Testbed Facility" project will also help to seek out and diagnose unsolved problems in the developing specification; provide a demonstration site for applications of PDES technology; coordinate a national network of other PDES testbed facilities; and conduct an information and technology transfer program to speed the implementation of PDES standards. Initial funding for this project has been provided by DoD's Computer-Aided Acquisition and Logistic Support (CALS) Office.

- Molecular Measuring Machine - "M-Cubed": We are making substantial progress on the development of the world's most advanced planar coordinate measuring machine, capable of positioning and measuring topographic features to atomic scale accuracies over an area of 25 square centimeters. Its first components have been delivered and consist of a custom-chambered vacuum system and a parallel-processor computer system for data acquisition, environmental monitoring and positional control. The design of this facility requires the combination of forefront technology in displacement measurement, mechanical positioning, probe resolution, servomechanism control and data acquisition rates and processing. This facility is a key step toward the long range goal of building machinery in the nanometer size range. We plan to complete the initial assembly of the overall system by December 1989 and make it fully operational by the summer of 1991.

- Manufacturing Technology Centers: With assistance from the Manufacturing Studies Board of the National Research Council, a panel of NIST staff selected three organizations that will establish regional manufacturing technology centers to aid small- and medium-sized businesses take advantage of advances in flexible automated manufacturing developed at the AMRF. These organizations are the Cleveland Advanced Manufacturing Program in Cleveland, Ohio, the Rensselaer Polytechnic Institute in Troy, N.Y., and the University of South Carolina in Columbia, S.C.

Trends...

The future for the manufacturing automation and robotics effort appears to be just as interesting as the recent past. We completed the building of the AMRF. The AMRF will now be used as a working research facility for technology transfer. As described above, it is also being used as a "testbed" to assist a joint industry-government project to develop PDES, the next generation of data interchange standards for automated manufacturing and for further development of Computer Aided Process Planning, Manufacturing Data Models, and Data Administration Systems. With the installation of a diamond tool turning center, we have begun to address such research questions as diamond tool properties and the accuracy enhancement of the machine by computer control at the sub-microinch (.025 micrometer) level.

We expect increasing collaboration with the private sector as our work becomes more directly applicable to the factory floor, and as industry becomes more automated. Based on the belief that this technology must diffuse rapidly if the Nation is to compete internationally, we plan to continue to give priority to our efforts to transfer this technology to industry; we will look for more research associates and visiting scientists, make more videotapes, give more talks, and write more articles. We continue to seek efficient ways to move the technology to small firms through intermediaries such as equipment vendors, trade associations, and professional societies.

In addition, we are turning to high-precision length measurements for applications such as measuring dimensions on integrated circuits and detecting very slight imperfections in highly polished mirrors. We expect demand for such services to be in the nanometer range almost immediately and into atomic dimensions within a decade. We have already directed some effort to getting ready for this and have rearranged some management responsibilities to sharpen our focus.

Proposed Funding for FY 1990

The FY 1990 budget continues this program at $5,834,000 in appropriated funds. We are benefiting from equipment loans from the private sector, research associates and visiting scientists, and substantial increased support by other Federal agencies, notably the U.S. Navy. Reimbursable support for the program in FY 1990 is expected to be about $15.9 million, including fees charged for NIST calibrations.

BUILDING RESEARCH

This program includes laboratory, field, and analytical research to develop technologies for the prediction and measurement of the performance of building materials, components, systems and practices. The work includes structural engineering, methods to assure the quality of building materials, characterizing the performance of the thermal, mechanical and electrical systems used in buildings and research on the use of advanced computation and automation in the building process. The program includes the NIST work on earthquake hazard mitigation and investigations of structural failures.

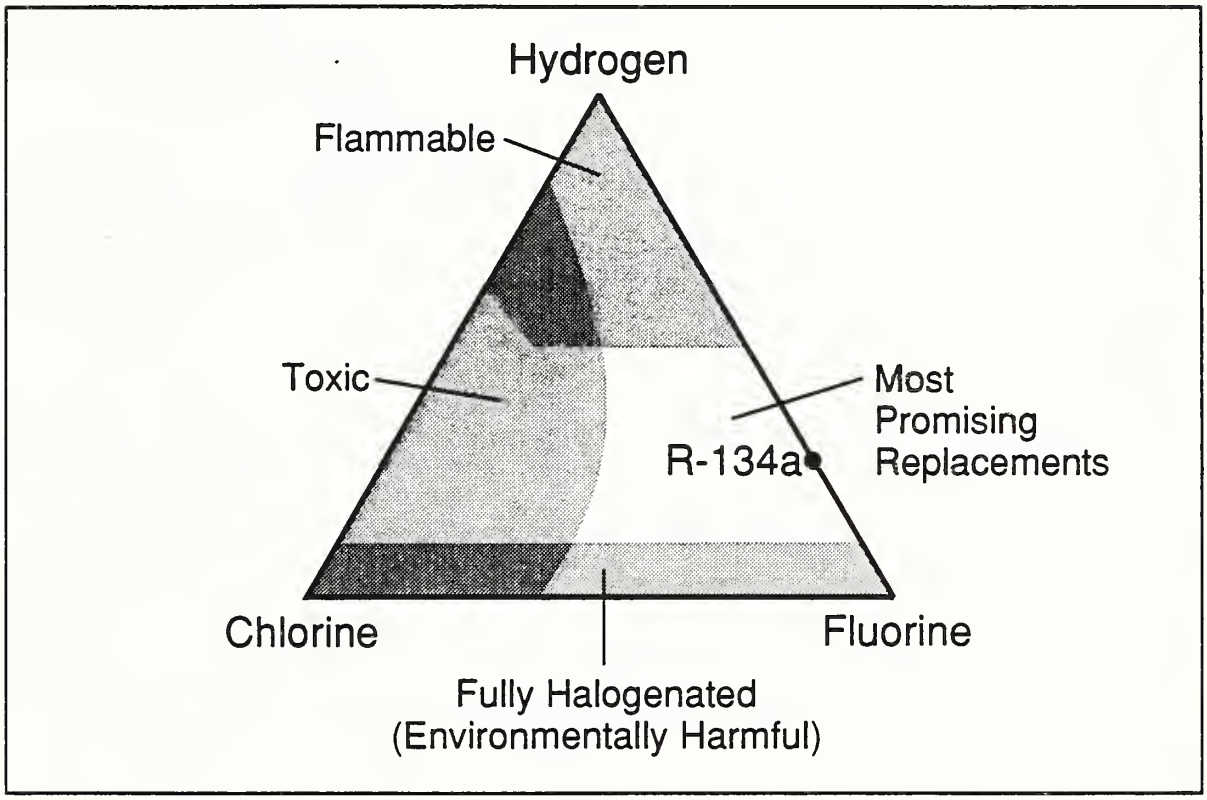
Recent Accomplishments:

- Armenian Earthquake Investigation: H.S. Lew, Chief of the Structures Division in the Center for Building Technology, was a member of the 18-person U.S. Scientific and Engineering Study Team that investigated the Armenian earthquake. The investigation was carried out under the auspices of the Soviet Academy of Sciences. The earthquake occurred on December 7, 1988 and had a magnitude of 6.8 on the Richter Scale with a 5.8 aftershock 4 minutes later. The quakes collapsed many structures and killed over 50,000 people. The team found that damage was most extensive for traditional multi-story stone masonry, precast concrete frame, and lift slab buildings. A reconnaissance report is being prepared by the team and will be issued by the Earthquake Engineering Research Institute in April, 1989. The National Academy of Sciences will issue a more comprehensive report at a later date.

- Collapse of the Ashland Oil Storage Tank: At the request of Congressman Doug Walgren, the Governor of Pennsylvania and the Fire Marshall of Allegheny County, we conducted an investigation of the January 1988 failure of a forty-year-old 96,000 barrel oil storage tank located at the Ashland Floreffe terminal. The tank failure was caused by a brittle fracture that began at a 3/4-inch flaw in the tank shell. The tank shell ruptured because the steel lacked sufficient toughness to arrest a propagating fracture at the temperature and stress level existing in the tank shell. Our studies indicated that the steel did not meet current, nationally recognized standards for fracture toughness. In the NIST report released in June, 1988, we recommended that standards be reviewed to identify those with provisions for sufficient fracture toughness to prevent this type of catastrophic failure. We also recommended that standard protocols be developed to test and assess the fracture safety of steel in tanks which lack adequate documentation.

- Alternative Refrigerants: Collaborations between staff in the building research program and the chemical engineering metrology program have resulted in substantial progress in the study of new alternative refrigerants. As estimated by the Chemical Manufacturers Association, about 70 percent of present chlorofluorocarbon (CFC) emissions are due to R11 and R12. We have completed chemical and physical property measurements for R134a, a candidate replacement for R12 used in residential refrigerators and freezers and automobile air conditioners.

We have also measured the thermodynamic property data for R123, a potential replacement for R11 used in cooling equipment for commercial buildings. In addition, we developed a series of 13 large-scale charts that indicate the thermodynamic properties of refrigerants and refrigerant mixtures. In a separate study, we demonstrated that optimum mixtures of R22 and R114 can achieve a 30 percent increase in the efficiency of heat pumps with little or no additional cost in design and manufacturing of the equipment. This mixture using R114 is not environmentally benign, but the work shows the potential of mixtures for improving equipment performance.



Trade-offs among alternative CFC refrigerants.

- Offshore Structures: We completed a four-year cooperative research project with several oil companies and the Minerals Management Service of the Department of the Interior that involved the study of punching shear behavior of thick lightweight concrete walls used in offshore structures. The oil companies are using the data generated from this research to design safe and economical perimeter walls for Arctic offshore structures that can resist concentrated forces, such as those resulting from ice impact.

Trends...

Research in this program has three principal focuses: (1) Quality Assurance and Condition Assessment; (2) Computer-Integrated Construction; and (3) Earthquake Hazards Reduction.

Advances in computers, making them smaller, faster and cheaper, allow much improved measurements of the properties of building materials, components and systems in the laboratory, factory or in the field. These are needed vitally for quality and international competitiveness in the U.S. construction industry. This research produces service life prediction, measurement and test methods for materials, components and systems of new construction (quality assurance), and means to assess the characteristics, capabilities and remaining service life of existing facilities (condition assessment). It comprises the majority of this program's research.

Computer-integrated construction technologies include: (1) Automation of Building Operating Systems; (2) Robotics in Construction; (3) Information Interfaces for Integrated Computer-Aided Design, Construction, and Operation; and (4) Technologies for Standards and Expert Systems. These are areas vital to the technical leadership and international posture of the U.S. construction industry. Research at present deals with information interface technologies and automation of building operating systems.

NIST has lead responsibilities in the National Earthquake Hazards Reduction Program for research and technical support for the development of improved seismic design and construction practices. Research activities have included important post-earthquake investigations, significant improvements in soil tests for liquefaction potential, and knowledge of the performance of full-scale bridge columns and the resistance of masonry. Technical support activities have included leadership of the Interagency Committee on Seismic Safety in Construction and led to issuance of recommendations for design provisions for new Federal buildings. NIST also leads the U.S. Japan Panel on Wind and Seismic Effects which has conducted significant cooperative research activities. Half of the funding for NIST earthquake research is provided by the Federal Emergency Management Agency.

Decrease for FY 1990

The President's budget submitted to the Congress proposes to decrease this program from the FY 1989 level of $3,720,000 to $2,250,000 in FY 1990. This reduction eliminates $250,000 in additional research funds received in FY 1989 to accelerate work on alternative refrigerants. Reimbursable support for the building research program is expected to be about $6.5 million in FY 1990.

FIRE RESEARCH

This program provides technical support for efforts by government and the private sector to reduce fire losses and the cost of fire prevention efforts. This work includes research on the physics and chemistry of fire, the reaction of materials to fire, the effects of fire on its victims, and the development of improved engineering practices to render the man-made environment more resistant to fire.

Recent Accomplishments:

- Hazard I: We have completed the development of HAZARD I, a user friendly software package for the prediction of fire hazard in buildings. The program produces a fully time-dependent prediction of the fire environment and impact of this environment on building occupants. This software is the first thorough integration of fire science into a practical tool for use by fire safety practitioners. A revised edition of the code taking into consideration comments made by "beta test" users has been prepared and documented for unlimited distribution. We are in the process of selecting a vendor to market and sell the software package for the rapid transfer of this technology to the fire safety community.

  We are working on an improved version of the Fire Hazard Analysis Method, HAZARD II, that should be available two years after HAZARD I is issued. HAZARD II will contain improved models of smoke detector response, sprinkler activation and egress of people. A new model for sprinkler fire suppression will be added.

  We have also developed a prototype computer game based on the fire modeling in HAZARD I. With the addition of enhanced graphics the game will be an effective means of educating children on the hazards of fire.

- Fire Retarded Product Hazards Studies: We have completed the study of the fire hazard of five commonly-used plastic products with and without fire retardants as requested by the Fire Retardant Chemicals Association. The five products were a television cabinet, a business machine housing, an upholstered chair, an electrical cable, and an electric circuit board. In the study material fire properties were evaluated in laboratory tests, the products were burned in room size enclosures, and predictions of behavior were made using computer fire models. The NIST study showed that fire retardants can improve the fire safety of plastic products without increasing the hazard of combustion toxicity. However not all fire-retarded products can be expected automatically to perform the same, so new combinations of plastic and fire retardants should be tested.

- Cone Calorimeter: We have developed an apparatus which provides the data critical to predicting the fire hazard of a product from a small sample of material. The instrument, known as the NIST Cone Calorimeter, measures the heat released and the rate at which it is released, the time it takes for a material to ignite, the amount of smoke produced, and the amount of several known toxic gases. Equipment previously available could not measure as many fire properties as the Cone Calorimeter. Both the ASTM and the International Organization for Standardization are proposing voluntary fire hazard test methods based on the NIST Cone Calorimeter. The instrument was recognized by Research and Development Magazine as a significant technical product with a 1988 R&D 100 Award. Commercial units are now being sold by two U.S. manufacturers and a rapidly growing number are in use worldwide.

- Sharon, PA Fire Investigation: We performed an on-site investigation of a fire that killed three young adults in a two-story duplex house in Sharon, PA. The fire occurred in the first floor kitchen. The deaths, all of which were on the second floor, were caused by the toxicity of normal combustion products from a kitchen fire and not exotic toxic compounds. The results of this fire investigation are relevant to all residential fires.

  Using our unique "two-story townhouse" fire test facility, the major features of the Sharon fire were simulated in a carefully instrumented fire reconstruction. This test showed how a rapidly growing wood fire in a simulated first floor kitchen was capable of producing lethal conditions of oxygen, temperature, and carbon monoxide in second floor bedrooms within two-minutes after ignition. Our computer simulations of the flow of fire gases through the house were able to duplicate the results of the test. The calculations showed that different combinations of open and closed doors and windows on the second floor would alter the time to reach lethal conditions but could not prevent them. Our fire modeling effort can be used to provide a clear and complete picture of the hazards of residential fires and their mitigation.

- First Interstate Bank, Los Angeles Fire Investigation: We assisted the Los Angeles Fire Department and the Federal Bureau of Alcohol, Tobacco and Firearms in the investigation of the First Interstate Bank high rise building fire. This fire gutted floors 12 through 15 of the 62-story building. This fire revealed the vulnerability of continuous glass wall construction used in many modern buildings and the potential value of sprinkler protection. Analysis of the fire using computer modeling techniques showed that if the fire had burned longer on each floor or had spread faster between the floors, the entire building above the 12th floor could have been destroyed. Our analysis of the fire with fire models demonstrated the potential usefulness of calculations to fire investigators in reconstructing the events involved in a fire.

First Interstate Bank fire, Los Angeles, CA, May 4, 1988.

Trends...

The strategy for this program's future consists of three elements: providing strong leadership in fire research, providing timely and effective response to current/critical fire problems, and developing scientifically-based fire protection practices and technology.

Areas of basic fire research that will continue to be addressed include ignition mechanisms, mass burning rate, fire gas evolution, soot formation and fire spread.

We expect to continue our work on fire safety issues that remain critical, such as combustion toxicity and residential furniture flammability, and start exploratory work on emerging issues, such as the vulnerability of computers and other high value facilities to smoke contamination and the development of replacements for halogenated fire fighting agents.

Most of our resources have been focused on demonstrating the feasibility of predicting the outcome of an accidental fire as the basis for rational procedures for fire safety. In FY 1987 the prototype fire hazard analysis procedure, HAZARD I, was introduced. We plan to make it more user friendly, expand its data base, refine it to handle a few more realistic cases, and run more seminars and tutorials on its use. We have announced a conference on user applications to identify needed improvements in future releases of HAZARDS. This procedure and others developed in this program will be used as tools in the scientific investigation, analysis, re-creation and/or simulation of significant accidental fires to complement ongoing local and national fire investigations of such disasters. We will also expand analytical capabilities to include applications involving whole building fire development, and detection and suppression system performance.

Fire research has little impact unless it is used. We are streamlining our input to fire and building codes and domestic and international fire safety standards, and supporting a greater variety of mechanisms for the transfer of research results such as demonstration programs and train-the-trainer programs. We foresee a continued increase in the use of our computerized bulletin board and bibliographic data base Firedoc, both of which are publicly accessible seven days a week.

Longer term trends include the introduction of expert systems-based fire codes.

Decrease for FY 1990

The President's budget submitted to the Congress proposes to decrease this program from the FY 1989 level of $5,652,000 to $2,750,000 in FY 1990. This reduction includes $250,000 in new funds received in FY 1989 to carry out research on fire problems with upholstered furniture. Reimbursable support for the fire research program is expected to be about $3.3 million in FY 1990.

CHEMICAL ENGINEERING METROLOGY

This program provides industry with the engineering foundation for reliable measurements and reference data that help the engineer to design, develop, and control chemical processes. Our research facilitates design of more efficient processes and helps assure fair and equitable exchange of chemical feedstocks, fuels (oils and gas), and other commodities throughout the American economy. We emphasize support for three major segments: the chemical industry, the petrochemical industry and the segment making very high value-added products - products from biotechnology and chemicals for the electronic industry, for instance. With the recent support of Congress, we have strengthened our efforts to provide measurement methods and process design data for biomanufacturing (manufacturing of biomolecules). We provide a wide range of measurement services, instrument calibrations, and new procedures for accurately measuring and predicting the engineering properties of fluids and solids of importance in industrial chemical systems.

Recent Accomplishments:

- New Measurements on Ozone-Safe Refrigerants: Our recent work on the properties of refrigerant fluids illustrates NIST's ability to respond to important national problems. We have completed property measurements on the first of a series of new refrigerants designed to replace chlorofluorocarbon (CFC) fluids that are thought to be depleting the Earth's ozone layer. The recently completed measurements include PVT (pressure-volume-temperature), phase equilibrium, heat capacity, speed of sound, and surface tension for Refrigerants 134a and 123 (both of which are halogenated ethane compounds). Accurate data and models for the thermophysical properties of these and other promising alternatives are essential to the replacement of refrigerants in current use.

- Optical Sensing in Bioreactors: We are developing generic on-line measurement techniques for the control and optimization of bioprocesses, and in particular, for nonintrusive, rapid, and selective measurements of key process variables such as cell mass, activity, and concentration, and the concentrations of substrates and products. Experiments have been carried out on the fluorescence characteristics of aromatic amino acids, dipeptides, polypeptides, commercial biomolecules (antibiotics, artificial sweeteners), and the components of a typical yeast fermentation. We have demonstrated that there is significant fluorescence sensitivity, making fluorescence a viable candidate for on-line monitoring. Work is underway to develop deconvolution techniques for determining the concentration of single components in complex multicomponent mixtures, and several other approaches are being explored to improve the selectivity of fluorescence measurements.

Trends...

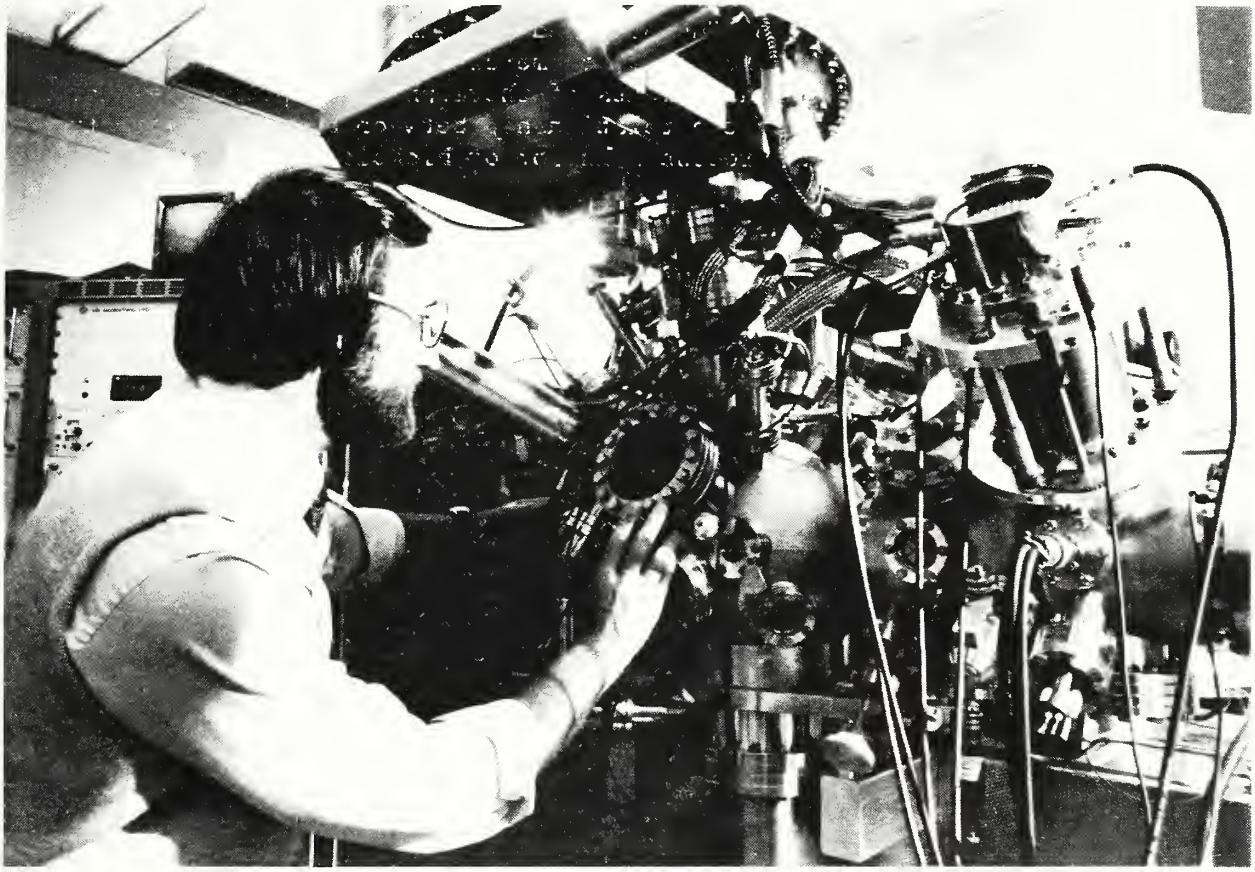
In the rapidly emerging biochemical field, the ability to quickly move from the laboratory to the marketplace with high quality cost-competitive products is very important. This capability requires process design and manufacturing know-how in a growing new field called bioprocess engineering. NEL has initiated a new effort to provide vital measurement capabilities and data for the design and control of commercial-scale bioprocessing equipment. This effort is supported in part by NIST competence funding, the FY 1986 NIST Biotechnology initiative, and the FY 1988 NIST Bioprocess Engineering initiative. We plan to provide new measurement techniques to aid in control of the bioreactor, to provide new engineering concepts and data for efficient product recovery processes, and to provide data on the thermophysical properties of biochemical substances data to be used in the design and operation of the entire manufacturing plant. All of these areas are considered crucial to industrial production of biochemicals within the time, cost, and quality-competitive constraints of developing world markets.

We are currently studying aqueous two-phase extraction for the separation of biomolecules and bioparticles on a commercial scale. These efforts include the development of measurements and models of the phase behavior of polymers and proteins in benchmark systems; the investigation of novel polymers and additives; and the exploration of new process configurations, including the use of electric fields to greatly increase the rate of phase demixing. The goal is to evaluate novel, scaleable systems and to develop predictive models for all aspects of the separation process, including phase contacting and demixing.

We have been very quick to apply our expertise in thermophysical properties to problems affecting the Earth's global environment, including ozone depletion and global warming by chlorofluorinated hydrocarbons. With industry and industrial trade associations, we have initiated a modest effort to identify and characterize the most promising, environmentally-acceptable alternatives for these widely used and important materials. The FY 1989 Budget provided $200,000 of additional support for this program. An important future goal is to expand the program to include mixtures of refrigerant fluids. Mixtures offer versatility and potential efficiency (of heating and cooling equipment) so high as to compel their use, provided databases and models are available that accurately predict their thermophysical properties.

Another emerging technology in chemical engineering overlaps electronics engineering and materials processing, and deals with thin-film coatings-optical coatings, semiconductors, thin-film sensors, etc. Chemical vapor deposition processes (CVD) are ideally suited for growing useful ultrathin (10-100 nanometers) layers of metallic and semiconductor films on insulating substrates. These processes are currently widely used but poorly understood and controlled. Mastery of this deposition process will permit tailoring of thin-film products to satisfy specific applications and to produce such films with uniformly high quality and low product reject ratios. Diagnostic

measurements of gas phase reactants and products, surface species, and the epitaxial layer are needed to understand these processes. We have initiated a competence-building project in this area.



Dr. Semancik and his colleagues utilize the unique capabilities of the NIST Surface Analytical Facility to study the processes by which solid state sensing materials can detect and quantify chemical species in gases as well as in solutions.

Proposed Funding for FY 1990

The FY 1990 budget continues this program at $7,990,000 and includes an initiative for bioprocess engineering at $2,300,000. Reimbursable support for the program in FY 1990 is expected to be about $7.4 million.

Increase for FY 1990 (Bioprocess Engineering)

An FY 1990 budget increase of $2,300,000 is proposed to expand our program in bioprocess engineering. Specifically, we will provide measurement methods, data, and models for commercial scale-up needed by U.S. industry to optimize biochemical processes. The proposed program includes research on measurements and control of bioreactors, commercial separation and purification of bioproducts, measurements of thermophysical properties for design, and characterization of the relationship between molecular structure and conformation and chemical process behavior of biomolecules.

MATHEMATICAL SCIENCES

This program provides support in mathematical modeling, statistics, data analysis, systems analysis, and computing to the engineering and scientific programs of NIST. We develop mathematical and computational methods in a host of mathematical subdisciplines working through extensive research collaborations with NIST scientists and engineers. The Center for Computing and Applied Mathematics (CCAM) also operates the Institute's central computer system, as well as communications systems that link computers, word processors, and terminals throughout NIST. The computing support function is described in the next section.

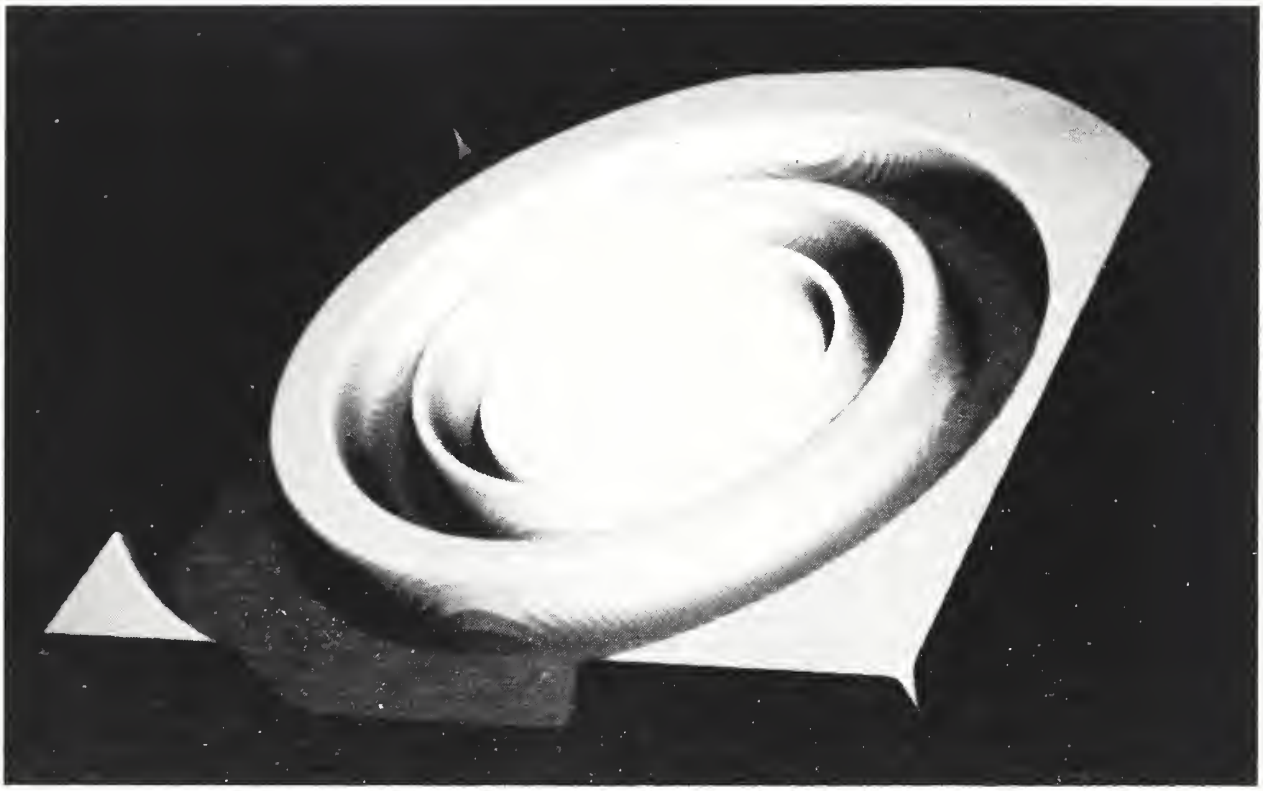
Recent Accomplishments:

- Design for Quality: In cooperation with George Washington University, we organized and hosted a conference on "Uncertainty in Engineering Design". The purpose of the conference was to bring engineers and statisticians from industry, academia, and government together to explore and encourage collaborations for achieving national quality and productivity goals. About 175 top experts from the United States, United Kingdom, Israel, Australia, Canada, and Japan attended the conference including representatives from General Motors, Westinghouse, IBM, and AT&T. A special speaker at the conference was Professor Genichi Taguchi who has broken new ground in the application of statistically planned experiments to improve engineering designs.

  In collaboration with an Industrial Research Associate program in the Institute for Materials Science and Engineering, we also began a new study of quality assurance technology focusing on materials processing. Since material processing involves a very large number of variables and inter-relationships among these variables are usually not well understood, the techniques of statistically planned experiments are appropriate for use in this environment. Since statistically planned experiments enable scientists to predict results beyond the tests actually conducted, such experiments can be used as elements of a sequential strategy to identify stable materials formulations and processing conditions. We are developing tables and graphs to make it easy for engineers to plan such multifactor experiments on their own. NIST research in the development of advanced ceramics will be the first to benefit from this work.

- Minisupercomputer for Computational Combustion: A C-120 minisupercomputer from the Convex Corporation was installed at NIST to support mathematical modeling in computational combustion. This was the first application of a minisupercomputer in the Department of Commerce. The machine has a throughput speed of about 1/4 to 1/3 that of the NIST Cyber 205 supercomputer in this application. Users also have the benefit of twice the addressable memory on this new machine than is available on the NIST supercomputer. This new machine enables efficient modeling of combustion processes that involve large systems of equations.

In collaboration with the Center for Fire Research, calculations of room fire flows considering separately the effects of stratification and swirl in the flow field and studies of vortex enhancement of combustion of a gaseous fuel and oxidizer are being performed using this new hardware facility.



Computer image of solutions to equations for reaction between fuel and oxidizer mixed in a vortex.

Trends...

We are focusing on increasing productivity by providing the mathematical and statistical tools necessary to improve the quality of manufactured goods and by providing researchers in the private and public sectors with the mathematical tools necessary to solve complex scientific computing problems. To meet this goal, we have increased and intensified our collaboration with industry to develop and implement emerging technologies. Mathematical modeling, statistical experiment design, and advanced scientific computing methods are essential tools both for research and development of new measurement technologies and for transfer of technology for designing quality into products and processes. CCAM staff makes available the best methods and tools of modern applied mathematics and statistics and collaborates with NIST scientists to ensure effective use of a modern computing, communications and data management environment, including telecommunications and resource-sharing with the technical community nationwide.

Proposed Funding for FY 1990

The FY 1990 budget continues this program at $5,661,000. Additional reimbursable support for the program in FY 1990 is expected to be about $1.0 million.

COMPUTING SUPPORT

The Center for Computing and Applied Mathematics is responsible for the Institute's computing environment. This includes the support of digital communications and networking (including the telephone systems at the Gaithersburg and Boulder sites), and administrative computing as well as the traditional role in scientific computing. We installed a T1 common carrier connection between Gaithersburg and Boulder to provide for a high-performance computing and communications environment common to both sites, and an optical fiber Backbone network to interconnect local Ethernets. For external communications, we have established a NIST-wide access to all parts of the DoD Internet, and a link to the Center for Advanced Research in Biotechnology, a cooperative activity between NIST, the University of Maryland, and Montgomery County. A Management Information Computer Facility (IBM 9375 Model 60 minicomputer) has been installed to serve NIST corporate information systems and databases and administrative communications.

The Consolidated Scientific Computing System is completing its fourth year of operation and serves NIST and several laboratories of the National Oceanic and Atmospheric Administration (NOAA). The system consists of a supercomputer (Cyber 205) and a mainframe front-end computer (Cyber 855) at Gaithersburg, a smaller mainframe (Cyber 840) at Boulder, superminicomputers at the NOAA sites, communications equipment to tie these machines together, and lots of peripherals. The system also has the staff necessary to support the equipment -- operators (contract), systems people (contract and in-house), and various specialists. This staff works with NIST scientists to develop faster algorithms for long-running problems, and provides easily-used vector software to exploit the capabilities of the supercomputer. In addition, scientists are being helped to use graphics facilities for visualization of the results of large-scale computations in order to plan and use computations efficiently. Through extensive and flexible networks, scientists have been enabled to use local minicomputers and workstations for portions of their work that do not require the full power of the supercomputer.

The use patterns on the system are as follows: the Cyber 205 is fully utilized most of the time, yielding an average of 85 percent to 90 percent of capacity on a three-shift 7-day-week basis, with a queue for large problems; the 855 and the 840 are operating at or near capacity in prime time when they are used interactively to prepare and receive supercomputer computations. Users of the 840 in Boulder, especially, find the available capacity inadequate. We are ahead of the estimated use level shown in the 1982 requirements study; in fact current usage is greater than forecast for the year 1991. The participating groups are using the machines in roughly the predicted ratio.

Proposed Funding for FY 1990

The FY 1990 budget continues this program at a level of $9,044,000 which includes an initiative of $3,122,000 for upgrading the Consolidated Scientific Computing System.

Increase for FY 1990

An FY 1990 budget increase of $3,122,000 is proposed for leasing equipment to upgrade the Consolidated Scientific Computing System. This is the first increment of a planned four-year program to upgrade the system to provide more computer power, expanded capacity, and greater flexibility to meet rapidly growing computational requirements.

These programs are totally supported on a reimbursable basis and will receive funding of about $4.3 million in FY 1990.

Office of Energy Related Inventions (OERI)

OERI receives all of its funds from Department of Energy (DOE) and is responsible for evaluating all energy-related inventions submitted by individual inventors and small businesses for technical validity, potential energy impact, and commercial feasibility. Since 1975, OERI has recommended more than 450 inventions to DOE for support out of 25,000 evaluated. DOE has awarded more than $21 million in grants for over 290 of these inventions. Statistics show that only 15 to 20 inventions are recommended to DOE for every 1,000 inventions submitted for OERI's review. Of these, about one-third become commercial successes. For example, a computerized sensor system for automobiles which adjusts the spark advance of individual cylinders to improve power and mileage was recommended by OERI and licensed to both the Ford Motor Company and Chrysler.

In addition, OERI has sponsored over 50 innovation workshops throughout the U.S. to provide inventors with practical guidance for commercialization of inventions. About 10,000 people have attended these workshops. NIST recently entered into a cooperative agreement with the Association of Small Business Development Centers that will enable the centers to forward promising ideas for new technology to OERI for evaluation.

Under the Technology Competitiveness Act, the OERI program will be expanded to include non-energy related inventions. Also, many of the OERI external activities are planned to be the core of the newly assigned extension services.

Law Enforcement Standards Laboratory (LESL)

LESL receives most of its funds from the National Institute of Justice (NIJ) and is responsible for developing performance standards to assist State and local governments in the cost-effective procurement of equipment suitable for the needs of law enforcement. LESL utilizes many of the technical personnel and facilities throughout NIST to carry out research in such areas as communication systems, weapons, protective equipment, forensic science, vehicles, and security systems. In FY 1988, NIJ published performance standards developed by LESL for mobile digital equipment and for fixed and base station FM transmitters.

LESL also assists NIJ grantees in the administration of an equipment testing program through which selected items of equipment are tested annually by independent testing laboratories for conformance to NIJ standards. The test results are disseminated to Federal, State, and local agencies.

APPENDIX A

NEL'S INDUSTRIAL RESEARCH ASSOCIATE SPONSORS -- FY 1988

ADVANCE TECHNOLOGY LABORATORIES

AMERICAN ASSOCIATION OF STATE HIGHWAY & TRANSPORTATION OFFICIALS

AMERICAN SOCIETY FOR TESTING AND MATERIALS

ARTHUR ANDERSEN & CO.

CASE CONSULTING, INC.

D. APPLETON CO.

E. FJELD CO., INC.

ELECTRONIC MEASURING DEVICES, INC.

FACTROL

GCA CORPORATION

HEWLETT-PACKARD

INTERNATIONAL BUSINESS MACHINES CORPORATION

LIGHTING RESEARCH INSTITUTE

MANAGEMENT COLLABORATIVE GROUP

MARTIN MARIETTA, BALTIMORE AEROSPACE

MERIDIAN CORP.

NATIONAL FOREST PRODUCTS ASSOCIATION

NATIONAL TOOLING AND MACHINING ASSOCIATION

PARAMETER GENERATION AND CONTROL, INC.

TEXAS INSTRUMENTS

UNDERWRITERS LABORATORIES, INC.

VLSI STANDARDS, INC.

APPENDIX B

EXAMPLES OF NEL'S COLLABORATIVE/COOPERATIVE RESEARCH WITH INDUSTRY- FY 1988

CENTER FOR ELECTRONICS AND ELECTRICAL ENGINEERING (CEEE):

Semiconductor Research Corporation (SRC)

External Participants:
- National Science Foundation
- National Security Agency
- Department of Defense
- SEMATECH
- 35 Semiconductor Industries

SRC was established by the Semiconductor Industry Association to enhance the competitive position of the U.S. semiconductor industry through directed, integrated research primarily in universities. Through memberships on SRC Advisory Boards, NIST is providing a technical link between the participating government agencies and the SRC research program.

Expert Systems for Semiconductor Processing

External Participants:
- Westinghouse -- provides special devices and test structures
- IBM -- provides database and computers

In this cooperative project, NIST is developing an expert system to help process engineers pinpoint probable causes for errors in semiconductor processing.

High Temperature Superconductors

External Participant:
- Westinghouse

This collaborative project has resulted in three joint NIST-Westinghouse patents being sought for a technique of making very low resistance-electrical connections to a new class of high-critical-temperature superconductors and additional improvements in the processing steps. This technique represents a hundred-million-times improvement over contact resistances that could be achieved before this work. Researchers at Cornell, AT&T, Bellcore, and IBM, among others, are using the new technique in their work on thin-film applications.

Integral Surge Protection of Electronics

External Participants:
- Building Industry Consulting Service International
- Basic Measurement Instruments
- General Electric Co.
- TII Industries, Inc.
- Pass and Seymour
- General Semiconductor Industries
- Current Technology, Inc.
- EDCO
- Electric Power Research Institute
- Raychem

NIST established this consortium to investigate possible solutions to the potentially destructive effects from electromagnetic interference to computers and other equipment. CEEE has completed three research papers for improving and understanding the application of surge protective devices. Further work is under consideration.

Center for Commercial Development of Space Power

External Participants:
- NASA
- Strategic Defense Initiative Office
- Auburn University, Alabama
- University of South Carolina
- University of Tennessee
- AT&T Bell Laboratories
- Ford Aerospace
- Maxwell Laboratories
- Rockwell International
- Westinghouse

This Center was established by Auburn University to develop and commercialize space power technology. NIST serves on its Advisory Committee to help solve the measurement problems associated with the space environment to assure reliable space power. In the future, NIST plans to receive funds to conduct related research projects.

NSF/University of Colorado Center for Microwave/Millimeter-Wave Computer-Aided Design (MMICAD)

External Participants:
- NSF
- University of Colorado
- U.S. Army (LABCOM)
- Ball Aerospace
- Boeing Electronics
- General Electric
- Hewlett-Packard
- Hughes Microwave

ITT's Gallium Arsenide Center
Texas Instruments Equipment Group
TRW (Electronic Systems)
Teledyne
Westinghouse/Defense Electronics Center

This Center was organized by NSF and the University of Colorado to develop strong interactions among university scientists and researchers in industry. NIST has representation on the Policy and Scientific Advisory Board for overseeing and reviewing the Center's research activities in microwave/millimeter-wave computer-aided design.

Electromagnetic Properties of Materials at Microwave Frequencies

External Participants:
Murata Erie
Hewlett-Packard
Dielectric Laboratories

NIST began to organize this industry consortium in 1988 to accelerate the development of methods needed by industry to characterize dielectric materials, especially in advanced applications, and to provide NIST with guidance in selecting projects and evaluating results. NIST is pursuing additional membership.

CENTER FOR MANUFACTURING ENGINEERING (CME):

Automated Manufacturing Research Facility (AMRF)

External Participants:
U.S. Navy
39 private sector companies

The U.S. Navy and the private sector are working with CME to provide key elements necessary for the development of automated manufacturing of discrete parts using the AMRF. Since 1982, 39 different companies have donated or loaned about $5.8M worth of equipment and more than 70 research associates have worked at NIST in the automation program.

CENTER FOR BUILDING TECHNOLOGY (CBT):

Punching Shear Behavior in Offshore Structures

External Participants:
Minerals Management Service, Department of Interior
Chevron Corp.
Mobile R&D Corp.
Standard Oil Production
Shell Oil Company
Exxon Production Research Company

CBT has completed a four-year cooperative research project dealing with punching shear behavior of thick lightweight concrete walls used in offshore structures. The data from this project is being used by oil companies to design concrete offshore structures that can resist concentrated forces, such as ice.

Construction Materials Reference Laboratories (CMRL)

External Participants:
American Society for Testing Materials (ASTM)
American Association of State Highway and Transportation Officials (AASHTO)

The CMRL consists of the Cement and Concrete Reference Laboratory sponsored by ASTM and the AASHTO Materials Reference Laboratory.
The Research Associates in these two programs promote improvement in the quality of standard testing of major construction materials in U.S. laboratories by inspecting laboratories on a voluntary basis and distributing proficiency test samples. To date, over 800 construction materials testing laboratories have participated in these programs.

CENTER FOR FIRE RESEARCH (CFR):

Carpet Test Improvement Consortium

External Participants:
Carpet and Rug Institute
American Textile Manufacturers Institute
Man-Made Fiber Producers Assoc.

Three trade associations are funding this project in CFR to improve the widely used test method for estimating flame spread of carpets in corridors and exitways. CFR will study all factors which might influence the test and recommend changes in the apparatus, test procedure, and/or interpretation of the results.

Smoke Control Consortium

External Participants:
- Veterans Administration
- Bell Atlantic
- Bell New Jersey
- Bell West IDC
- American Society of Heating Refrigeration and Air-Conditioning Engineers (ASHRAE)
- Architect of the Capitol

NIST is conducting full-scale smoke control experiments in a seven-story building to evaluate current design standards and practices.

Carbon Monoxide and Hydrogen Cyanide Interactions

External Participant: Society of the Plastics Industry

The objective of this project is to explain the toxicity of gases produced in fires through the individual effects and interactions of typical fire gases. Failure to explain the toxicity of the gases produced by a burning material by accounting for the effects of typical combustion products could indicate the presence of unusually toxic gases. The model developed in this work is capable of predicting the toxicity of a gas mixture containing four typical combustion products and has been incorporated into a fire hazard assessment method, HAZARD I.

Fire Risk

External Participants:
- National Fire Protection Research Foundation (over 25 private sector companies)
- Benjamin Clarke Associates
- National Fire Protection Association

The objective of this project is to develop a generally applicable methodology for the evaluation of the expected life-safety risk associated with the fire performance of new and existing products in a specified occupancy. CFR is using its newly-developed fire hazard assessment method, HAZARD I, to determine the consequences of all potential fire scenarios involving the product in the specified occupancy.

Heat Release Studies

External Participant: National Forest Products Association

In collaboration with a Research Associate from the National Forest Products Association, CFR is conducting heat release studies on wood materials. This includes full-scale studies, computer fire modeling and bench-scale studies using the calorimeter. The objective of this project is to simulate and develop room fires numerically, using data obtained in bench-scale testing.

CENTER FOR CHEMICAL ENGINEERING (CCE):

Flow Meter Installation Effects

External Participants:
- Ametek-McCrometer
- Chevron
- Dow Chemical
- DuPont
- Gas Research Institute
- Gas Unie
- Instrument Testing Service
- ITT-Barton
- Kimmon Manufacturing
- Rockwell International

How well a flow meter works can depend on where it is installed in a configuration of pipes. The purpose of this five-year-old consortium is to produce installation specifications through the measurement of pipeline profiles (using laser Doppler velocimetry) and use of the resulting data to predict meter performance.

Modeling of Carbon Dioxide-Rich Supercritical Fluids

External Participants:
- Air Products
- Atlantic Richfield
- Gas Processors Association
- Mobil
- Phillips
- Shell

The original purpose of this consortium was to develop predictive models for supercritical fluids in connection with the recovery of oil from petroleum reservoirs. The consortium was extended in 1986 to develop models for carbon dioxide-rich supercritical fluid mixtures.

CENTER FOR COMPUTERS AND APPLIED MATHEMATICS (CCAM):

Process Design for Ceramic Cutting Tools

External Participant: ISCAR Co.

In this collaborative project with the Institute for Materials Science and Engineering and a Research Associate from ISCAR Co., CCAM is participating on the statistical design of experiments for evaluating the processing factors in cutting tool performance to optimize quality.

NBS-114A (REV. 2-8C)

U.S. DEPT. OF COMM. BIBLIOGRAPHIC DATA SHEET (See instructions)	1. PUBLICATION OR REPORT NO. NISTIR 89-4060	2. Performing Organ. Report No.	3. Publication Date MARCH 1989

4. TITLE AND SUBTITLE

National Engineering Laboratory National Institute of Standards and Technology 1989 Report to the National Research Council's Board on Assessment of NIST Programs

5. AUTHOR(S)

Gail Ehrlich, Editor

6. PERFORMING ORGANIZATION (If joint or other than NBS, see instructions)

NATIONAL BUREAU OF STANDARDS
DEPARTMENT OF COMMERCE
WASHINGTON, D.C. 20234

7. Contract/Grant No.

8. Type of Report & Period Covered
NISTIR
April 1988-April 1989

9. SPONSORING ORGANIZATION NAME AND COMPLETE ADDRESS (Street, City, State, ZIP)

10. SUPPLEMENTARY NOTES

☐ Document describes a computer program; SF-185, FIPS Software Summary, is attached.

11. ABSTRACT (A 200-word or less factual summary of most significant information. If document includes a significant bibliography or literature survey, mention it here)

The 1989 report to the National Research Council's (NRC's) Board on Assessment of the National Institute of Standards and Technology (NIST) programs provides an overview of the National Engineering Laboratory (NEL). It describes the climate that influences NEL's work, program and budget trends, and the external interactions with industry, academia, and trade and professional organizations. Descriptions of NEL's program activities with accompanying lists of recent accomplishments, trends, and significant budget changes are also included. The programs described are Electronic and Electrical Measurements, Manufacturing Research and Standards, Building Research, Fire Research, Chemical Engineering Metrology, Mathematical Sciences, Computing Support, Energy Related Inventions and Law Enforcement Standards. The impact of the recently enacted Omnibus Trade and Competitiveness Act of 1988 is discussed.

12. KEY WORDS (Six to twelve entries; alphabetical order; capitalize only proper names; and separate key words by semicolons)

building research; chemical engineering, computing support; electrical measurements; electronic measurements; energy related inventions; fire research; law enforcement standards; manufacturing research; mathematical sciences; National Engineering Laboratory

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[X] Unlimited

[ ] For Official Distribution. Do Not Release to NTIS

[ ] Order From Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402.

[X] Order From National Technical Information Service (NTIS), Springfield, VA. 22161

14. NO. OF PRINTED PAGES
45

15. Price
$12.95

USCOMM-DC 6043-P80