2001 Annual Report

THE NIST VISITING COMMITTEE ON ADVANCED TECHNOLOGY

U.S. DEPARTMENT OF COMMERCE
TECHNOLOGY ADMINISTRATION
NATIONAL INSTITUTE OF STANDARDS AND TECHNOLOGY
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Preface

The Visiting Committee on Advanced Technology (VCAT) of the National Institute of Standards and Technology (NIST) was established in its present form by the Omnibus Trade and Competitiveness Act of 1988.

Each year, our Committee summarizes its findings in an annual report submitted to the Secretary of Commerce, for final transmittal to the Congress. The annual report addresses issues that affect NIST, its laboratories, programs, and facilities, or are of concern to the Committee in its role as NIST's private-sector policy advisor. This Fiscal Year 2001 annual report covers the December 2000 meeting through the September 2001 meeting.

In fulfilling its legislatively mandated advisory and oversight role, the VCAT complements the work of other NIST advisory groups, in particular, the National Research Council's Board on Assessment of NIST Programs, the Manufacturing Extension Partnership (MEP) National Advisory Board, and the Advanced Technology Program (ATP) Advisory Committee. The Committee studies the allocation of resources employed to achieve NIST's mission as well as the policies and processes employed by NIST management to optimize the overall effectiveness of the Institute's programs. Over time, the Committee seeks to cover the full spectrum of activity at NIST, including the Measurements and Standards Laboratories, the Manufacturing Extension Partnership Program, the Advanced Technology Program, and the Baldrige National Quality Program. This goal is pursued through management-level reviews of specific organizational units and of NIST-wide programs and issues, coupled with in-depth sampling of specific technical and functional activities. In order to obtain complementary perspectives, over the past few years the Committee has varied its focus from individual programs to operating units to cross-cutting topics. During 2001 the Committee completed a series of reviews of the major Operating Units and then concentrated on topics that cut across several units.

In addition to direct discussion with NIST leaders and professionals, the committee reviews reports from the National Research Council Board of Assessment (of the technical excellence of NIST's programs), the MEP Advisory Board, and the ATP Advisory Committee. In light of the broad experience represented by the VCAT and the other Boards, this approach delivers a reliable overview of NIST. Reactions and observations are discussed candidly with the NIST representatives involved at each meeting. This feedback is positively received, and we see much evidence of constructive response to it.

Regardless of the specific topics explored, the methodology, and the regular renewal of VCAT membership, the Committee's observations and recommendations have been generally consistent for several years. They are also consistent with in-depth studies by the Board of Assessment and the advisory boards for MEP and ATP. Therefore this year's report in part comments on the status of topics discussed in prior reports. The VCAT finds that significant progress has been made on important issues that deserve continuing attention.

Members of the Committee are selected on the basis of their backgrounds and experience and are appointed by the NIST Director to staggered 3-year terms. Four new members joined the Committee during 2001: Mrs. Deborah L. Grubbe, Dr. Lloyd R. Harriott, Dr. Masayoshi Tomizuka, and Dr. Wayne H. Pitcher, Jr. During 2001 I served as Chair and Caroline Kovac as Vice Chair.

This report focuses on findings and recommendations and does not provide detail concerning individual presentations. Copies of actual presentation material from all the speakers are available upon request from the VCAT office; copies of minutes of recent VCAT meetings can be found on the VCAT Web site: http://www.nist.gov/vcat/.

The last VCAT meeting covered by this report was held September 11-12, 2001, and the reporting period ended September 30. Since then, the context in which NIST operates has clearly changed. NIST has demonstrated its expertise and played a critical role in response to the September 11 disasters. NIST faces continuing challenges and opportunities in the newly prominent area of homeland defense. Although these areas are not discussed here, the findings and recommendations of this report, which deals primarily with the development of NIST to a position of even greater capability, remain valid.

Thomas Manuel, Chair

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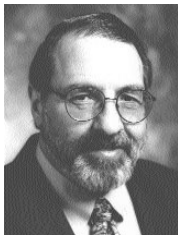

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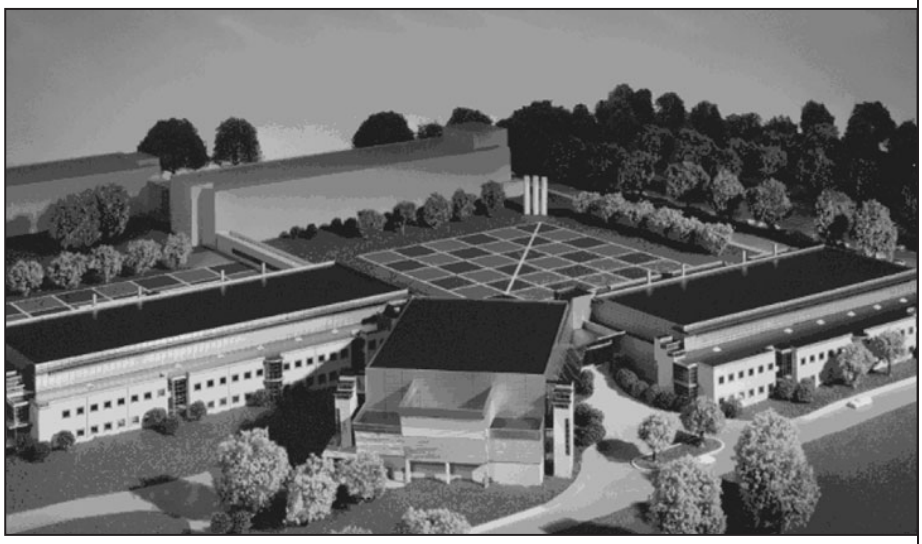
I. Overview and Executive Summary

The VCAT again finds NIST to be a significant national asset that is recognized as the world's leading measurement and standards organization. The Measurements and Standards Laboratories (MSL) of NIST provide irreplaceable services to U.S. business and industry by underpinning our measurement and standards infrastructure. This role is indispensable to maintaining and enhancing productivity and competitiveness, enabling international trade, and improving public health, safety and environmental quality. NIST enjoys an enviable reputation for scientific excellence, credibility and impartiality. NIST employees support an immense variety of technologies and industries through direct service at many points of contact with companies and through fundamental scientific research. NIST scientists and engineers are recognized worldwide for their impressive achievements and expertise in the science and technology underlying measurement. NIST contributes significantly to the national economy and well-being through additional high-quality programs beyond those of the MSL. The Manufacturing Extension Partnership Program provides key support to small companies throughout the United States. The Advanced Technology Program accelerates the development and commercialization of high-risk new technologies. The Malcolm Baldrige National Quality Program plays a key role in the competitiveness of U.S. organizations, not only in industry but also in health and education.



The Advanced Measurement Laboratory (artists rendering shown here) is expected to be occupied in 2004 and will enable NIST to undertake a whole new class of experiments that require extremely tight control of temperature, vibration, humidity, and/or air quality-experiments that could not be done in existing buildings.

The public investment in NIST is earning a handsome return through all of these programs. From our assessment of the external environment and the internal operations of NIST, we conclude that NIST is maintaining its traditional quality while evolving in positive directions that are consistent with our earlier recommendations. NIST leadership is to be congratulated for the demonstrated current value to the Nation, as well as the movement toward improvement. However, additional and accelerated change is required.

The demands upon NIST for services, and the opportunities for NIST to add value, have never been greater. Even with growing investment in NIST, appropriately balancing NIST's efforts and resources between traditional and emerging areas or between direct industry service and basic science, represent major ongoing challenges.

As noted in last year's report, the scientific and economic environment in which NIST must operate continues, and will continue, to be one of massive and accelerating change. New and disruptive technologies such as biotechnology, genomics, quantum computing, and nanotechnology are appearing and spawning new industries. In many cases, traditional disciplines and organizations no longer fit the situation and are mutating in response. In this environment NIST must become more flexible in developing and accessing new competencies and shifting resources to meet emerging opportunities. At the same time, older industries and technology bases that still play a major part in the U.S. economy and in international trade are under siege and require continuing support from NIST.

Measurements and standards are essential to facilitation of trade for both the "old" and "new" economies. NIST must remain a global leader in ways that broaden world trade and protect the interests of U.S. companies.

NIST has become the world's leader in measurements and standards through judicious investment in the basic science that forms the basis for continually improving standards and developing new ones. This investment must continue.

In order to fulfill its potential and to leverage fully its scientific excellence in today's rapidly changing environment, NIST must become more selective, more focused, more closely coupled to industry, and more agile, while maintaining a balance among the components of its mission. NIST's scientific and technical excellence needs to be accompanied by a higher level of excellence in external relations, internal functions and management processes. Additional public investment in NIST is warranted, but it is unlikely to be commensurate with the plethora of opportunities and requests for service.

Therefore it is critically important to develop and strengthen NIST-wide internal processes that enable prioritization among intrinsically attractive programs and increased focus on the most important ones. This urgent task of portfolio management requires, above all, a long-range strategic sense of direction. The specific excellence of NIST's individual units must be complemented and leveraged by more powerful, higher-level integration. We are pleased to note that former Director Kammer and Deputy Director Brown have launched key initiatives and made important progress in these directions since 1999. However, the challenge remains large, and sustaining the present momentum for change is essential, as the new leadership team takes over.

The VCAT's most important conclusions and recommendations are as follows.

1. The technical quality of NIST work remains excellent and is at the cutting edge in many important areas.
2. The highest priority for NIST leadership is to complete and implement the NIST 2010 Strategic Plan now under development.
3. New management initiatives and processes and positive cultural change are being generated by the Operating Unit (OU) Directors under the leadership of Deputy Director Brown. Improvements in such areas as program prioritization, human resource development, industrial liaison, and use of information technology must be aggressively pursued. While world-class technical competencies have been created under the traditional system, greater excellence in leadership and support capabilities will generate greater value from the capabilities of individual NIST scientists and engineers.
4. The scientific excellence of NIST could be better focused and more fully leveraged by more candid, higher-level input

from and closer coupling with industry. Moves in this direction are underway.

5. The opportunities presented by the rapidly changing technical and business environment call for speedier response and flexibility in augmenting resources for strategic areas.

6. NIST must maintain a balance that:
   - focuses extra attention on emerging, growing technologies and industries
   - supports vital areas of the "old economy"
   - provides timely and effective service to real-time commercial needs
   - invests in fundamental science related to its mission in order to develop the bases for updated and new measurements and standards

7. Additional public investment in NIST, particularly for equipment and facilities and cross-cutting program areas is recommended.

These interrelated points are discussed in more detail in Section II under the headings of Strategic Planning, NIST-Wide Work Processes, Organization, Industrial Relations, Collaboration, Resources, and Extramural Programs.

The VCAT is convinced of the great current value provided by NIST to its sponsors and constituencies. However, rather than celebrating at length the recognized excellence of NIST, the balance of the discussion reflects our belief that we can be of most assistance by focusing our attention on areas for improvement. The specific topics all bear on our general contention that higher-level integration of today's excellent but relatively autonomous units will produce greater impact.

Specific topics reviewed in the 2001 cycle are summarized in Section III.

II. Discussion of Key Issues

A. Strategic Planning

At this writing the VCAT has seen the general early stages of a strategic plan, NIST 2010. We applaud this effort and support it strongly. As noted last year, a broad, long-range perspective is required to develop the appropriate balance between conflicting demands and opportunities in a constrained budgetary environment and in face of the rapid and disruptive emergence of new technologies. The new strategic plan is desirably centered around the impact and value of NIST and identifies six strategic focus areas (that are consistent with the VCAT's recommendations): people, customer focus, IT infrastructure, health care, information/knowledge management, and nanotechnology. Importantly, NIST 2010 identifies value contributed as its key parameter—that is the impact of NIST's work, not the excellence of the work itself.

It is gratifying that these focus areas have been identified through participative exercises involving the entire NIST leadership team. Separate operating units have previously had strategic plans, but the step to NIST-wide planning is a major advance. These areas, and probably others to be identified in the future, will provide a template for NIST to develop and deploy its competencies to maximum effect.

We note that the planning exercise will be even more demanding as program details are developed, and areas for de-emphasis are identified. Despite the strategic highlighting of a few focus areas, it is clear that NIST will continue to serve diverse constituencies, and the plan must strike many balances, for instance, between old and new industries, and between basic science investment, industry-focused technology development, and specific customer service. Criteria must be developed as the basis for these choices. Finally, it is important to realize that in strategic planning the process is as important as the product, and that the plan itself needs to be a living document.

While admitting that effective functioning requires a real organization that is populated with real people and is therefore difficult to change, we emphasize that the goals and programs of the organization must set the parameters for the budget and organization, and not the other way around. We acknowledge that meaningful change requires not only formal processes, systems and organizations, but genuine cultural change in an organization that has a long and proud history of autonomy and self-direction. This change can be wrought only by exceptional leadership coupled with deep and wide commitment by the entire staff.

B. NIST-Wide Work Processes

It is necessary for NIST to become more effective and efficient and to act more as a whole than as a "thousand points of light." The rise of new industries that do not match the traditional technology classifications, and the accelerating rate of change, call for NIST to develop and employ NIST-wide work processes.

Although strategic plans and prioritization processes are used within the separate Operating Units (OU's), common prioritization criteria and processes are essential to implement the NIST-wide strategic plan. The needs of such dynamic areas as microelectronics, health care, biotechnology, and nanotechnology are best addressed by perspectives and programs that cut across the existing OU's. Additional individuals and funds must be accessed from all of NIST's existing competencies, and consequently other programs must be reduced. Without a NIST-wide system, there is no way to determine whether the least attractive (or most attractive) program within a given OU is less (or more) attractive than its counterpart in another OU. Maximization of value through program selection therefore is limited. Since each OU has traditional constituencies that rely on it and continually request more service, it is very difficult for the OU to reduce support for any of them. Although still difficult, the task will be easier on a NIST-wide basis.

The present accounting system provides detailed information within an organizational unit but is not well suited to determine the

total deployment of resources across NIST in support of a given industry or thrust, let alone to aid in reassigning them. NIST has recently initiated a KnowledgeNet program that will permit summarizing effort by industry or technology across the entire organization. This program will be highly valuable and is a necessary precondition to prioritization. We urge that completion and enhancement of the KnowledgeNet be pursued vigorously.

Measurement is a key element of all quality management approaches, including the Malcolm Baldrige National Quality Program, of which NIST is the highly successful steward. In view of the need for overall optimization of NIST's effectiveness, metrics limited to a single OU are insufficient, and NIST-wide ones are required. Individual OU's have identified measures for their success. However, the emphasis on these varies among OU's. In many cases the metrics lack sufficient emphasis on industrial impact and are overly tilted to scientific recognition and activity. We do not see sufficient evidence that the metrics are actually used in ways that lead to continuous improvement. They should be baked into plans and rigorously measured throughout the course of a program. As in any case, benchmarking with leading organizations outside NIST is needed to validate internal assessment. NIST has indeed benchmarked certain areas, but continued focus is needed.

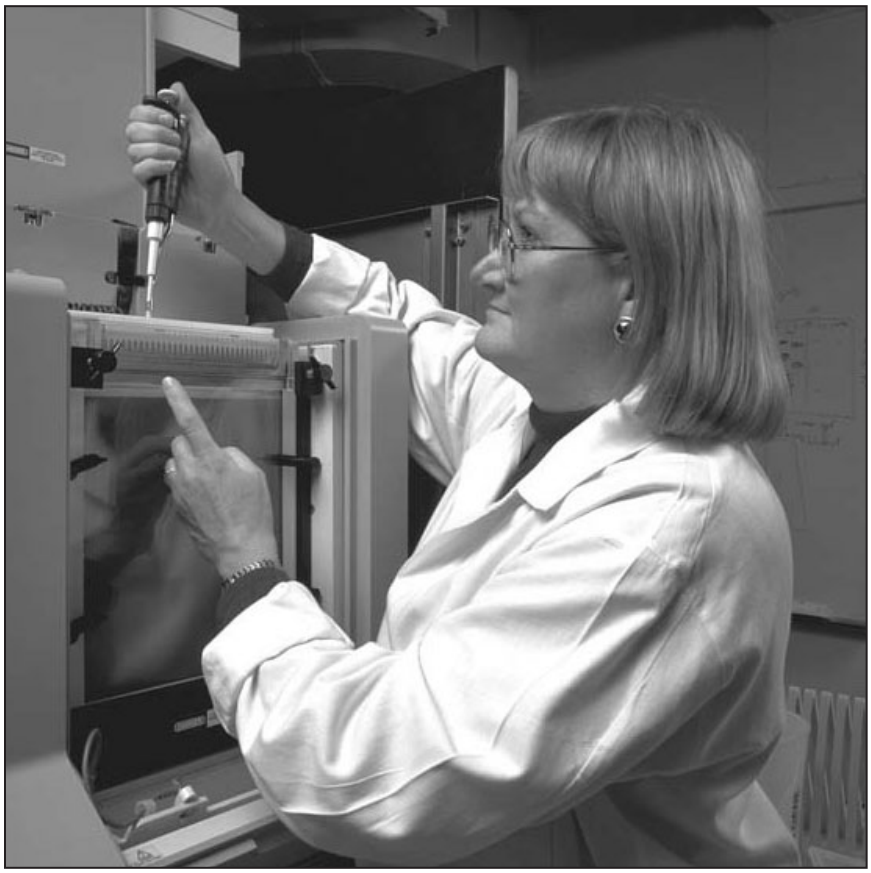
C. Organization

Since 1988 NIST has fulfilled its mission through Operating Units defined along discipline or technology lines (see table) although each Operating Unit includes staff from several disciplines. This "academic model has many strengths and has led to numerous areas of outstanding scientific expertise and technical excellence.

NIST Operating Units

Operating Unit	Approximate FY2001 OU Spending ($M)
Building and Fire Research Laboratory	32.9
Chemical Science and Technology Laboratory	63.9
Electronics and Electrical Engineering Laboratory	62.1
Information Technology Laboratory	72.2
Manufacturing Engineering Laboratory	39.6
Materials Science and Engineering Laboratory	63.8
Physics Laboratory	55.5
Technology Services	33.1

As noted, NIST scientists are recognized as leaders and receive awards in many fields. In the most prominent recent example Dr. Eric Cornell of NIST shares the 2001 Nobel Prize in Physics with Dr. Carl Wieman of the



NIST researchers are investigating methods to measure and allow others to identify genetic mutations in DNA that can result in cancer and other diseases.

University of Colorado and Dr. Wolfgang Ketterle of MIT for creation of the Bose-Einstein condensate and early studies of its properties. We note that NIST workers have been honored with two Nobel Prizes in the last four years, a record unique among Federal laboratories. (The 1997 Nobel Prize in Physics was awarded jointly to Dr. William D. Phillips of NIST, Professor Steven Chu of Stanford University, and Professor Claude Cohen Tannoudji of Collège de France and École Normale Supèrieure, for development of methods to cool and trap atoms with laser light.) Benchmarking studies indicate that NIST is the world leader in most key areas of measurements and standards. Our limited sampling shows a consistent pattern of technical excellence.

The traditional OU definitions are built around internal skill sets, capabilities and interests. To complement this focus, the operating units have developed strong linkages with the industries and companies that they serve. Much emphasis is put on customer relationships. NIST sponsors many workshops that bring together industrial representatives to discuss new technologies and common needs. Individual scientists work closely with peers in industry.

An alternative mode is to build an organization from the outside in, and define units by the industries they serve. This approach emphasizes alignment with customers and focuses effort on impact on U.S. business interests. The Office of Microelectronics Programs is one successful model for this approach.

We encourage the initiation of additional industry-oriented, cross-cutting programs. Throughout most of NIST, programs in different OU's that serve the same industry are only loosely coordinated, and as noted for the KnowledgeNet, it is sometimes difficult to identify them. NIST needs a much stronger mechanism for cross-discipline, cross OU program linkage. More budget responsibility and authority needs

to be placed within the cross-cutting elements. A matrix organization or simply redefining some or all of the OU's on a customer or industry basis should be considered. While acknowledging that organizational change can be disruptive, the VCAT believes that recreating the organization around new priority objectives or focus areas would yield a burst of energy and creativity. We also note that the continuing environment of massive change calls for a willingness to form new units periodically. Certainly the current 13-year-old structure needs re-examination.

D. Industrial Relations

Although specific companies and industry sectors are its primary direct beneficiaries, NIST could benefit from improved marketing of its value and successes to a broader constituency. Successful outreach to higher levels of industry could generate greater support in the general public and among key decision-makers.

NIST has always recognized that its impact will ultimately be measured in the success of the American economy, and close linkages to industry have existed since NIST's founding. All of the operating units therefore work closely with industry through contact with individual companies, industry associations, workshops, publication of reports, and collaborative projects. NIST sincerely seeks input and feedback from its customers. However, in many cases the contacts, the input of needs, and the transmission of results occur directly between bench scientists at NIST and their peers in companies. Consequently, the value contributed by NIST is most appreciated at the working level, and senior industrial executives may not be cognizant of the value they receive from NIST. Additionally, NIST leadership may not get a broad, higher-level sense of the priorities among industrial opportunities.

The previously mentioned weakness of NIST systems that can summarize the support for a given company or industry compounds the problem. Spot surveys sometimes indicate that companies are unaware of NIST activities that benefit them. Again, the background of rapid change puts a premium on efficient need identification, response, and result communication. Therefore, there are major opportunities for improvement in the quality of the external input to NIST program planning, as well as the development of a senior industrial constituency appreciative and supportive of NIST. These areas were also highlighted in the VCAT's 2000 Annual Report.

In 2001, NIST has formed an Industrial Liaison Office (ILO), aimed at complementing the existing OU-centered, bench-level contact base with stronger linkages to a more senior tier of leaders in key industries. Success in developing a NIST-wide message targeted on a crosscutting industry basis, rather than an Operating Unit perspective, requires the completion of the KnowledgeNet. We applaud and encourage this initiative.

It may be necessary to go beyond the ILO as presently defined and directly fund industry-focused organizational units in addition to working through the present Operating Units. We note that as the message is developed, and contacts move up the industrial hierarchy, direct involvement of NIST, and possibly Department of Commerce leaders, will be needed at higher levels. The first efforts of the ILO focus on two key industries, automotive and health care. Their selection points out that the identification of target industries must be done in full coordination with the strategic planning and prioritization activities. Since NIST cannot be all things to all people, it must be wary of arousing unrealistic expectations in lower priority industrial sectors.

E. Collaboration

It is axiomatic now that research, development, science, and technology require collaboration across boundaries between disciplines, functions, organizations, economic sectors, and nations. NIST has

long collaborated with industry through formal agreements, lectures, workshops, exchange of researchers, and personal contacts. But while collaboration is not a new concept, it is one that needs renewed emphasis in a world of limited resources, increasing demands, and rapid change. The previous discussion of industrial linkages is pointed at collaboration with that sector.

Additionally, NIST has prospered through collaboration with academic institutions, as in the Center for Applied Research in Biotechnology (CARB) and JILA. As previously mentioned, JILA, a collaborative enterprise between NIST and the University of Colorado, was the site of the work leading to this year's Nobel Prize in Physics to Dr. Eric Cornell and Dr. Carl Wiemann.

The VCAT's emphasis on cross-NIST systems, processes, and organizations is intended to increase collaboration among the Operating Units. The emergence of new technologies that may not align cleanly with the strong disciplines at NIST means that NIST must collaborate with other institutions which already have the relevant competencies. The time scale for response simply does not leave enough time to develop every new capability internally. For example, closer ties to NIH, FDA and other agencies should be cultivated in health care and biotechnology. We believe that a similar case, although perhaps less dramatic, could be made for NIST collaboration with other Federal mission-driven agencies. All bureaucracies initially prefer to do things themselves, and NIST is no exception, but the times no longer allow for that luxury. The search for partners must be a part of NIST becoming a more outward-looking and impact-driven agency.

Although NIST's technical center will stay on measurements and standards issues, where NIST has unique competencies, NIST must also pre-invest in science, based to some extent on its own perception of trends. For instance, anticipating trends in genomics and biotechnology, NIST began to develop skills in these areas some years before they became household words. This can lead NIST into unsettled areas with policy implications, such as stem cell research. While NIST is not a political or policy organization, we support NIST's development of relevant knowledge in such sensitive areas. Any policy decision on a controversial issue will be better made with understanding of the measurements and standards possibilities.

The international aspects of NIST's mission are of growing importance in a truly global economy. Agreed measurements and standards are critical to trade and product acceptance. The downside is that rational standards can be vulnerable to political influence and can become barriers to free trade. NIST strives and must continue to strive to be the world's leading organization in critical areas. NIST must ensure that standards are scientifically valid, fair, and needed. The stance of NIST representatives in international standards bodies must preserve credibility and impartiality. However, in some cases, neutrality may not be adequate. Where not all parties are fully aware of the state of the art, it may be necessary for NIST to recommend not only the test, but the appropriate standards level, i.e., be somewhat proactive.

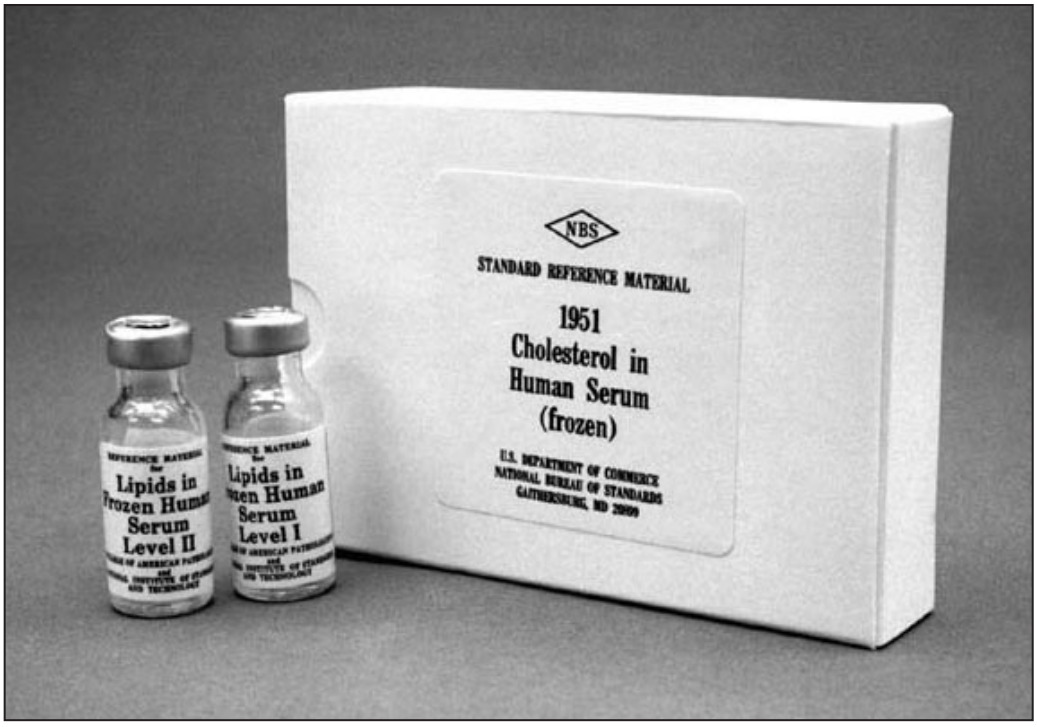
F. Resources

The VCAT is pleased that the resources available to the Measurements and Standards Laboratories for their core mission through the STRS budget have recently grown somewhat. For some years, debates over and variations in the additional mandates given to NIST, especially the Advanced Technology Program, have obscured and complicated funding for the core mission. As the cost of doing research and providing services has grown, NIST has (correctly, in our opinion) held staffing to a constant or slightly declining level. However, as the BOA and the VCAT have previously noted, staffing and funds in some technical areas are nearing

minimum critical mass, below which first-class capability cannot be maintained. Much of this report is dedicated to our belief that better NIST-wide integration of resources will generate greater impact for the present investment. This integration will require more flexible budgeting approaches, so that the leadership can more readily shift resources among operating units and fund new challenges. Since anticipated internal gains in efficiency and effectiveness will not fully compensate for the rapid growth in the needs for NIST services, further funding increases are recommended.

Funding is most critical in the area of facilities and equipment. The VCAT applauds the commitment in the past several years to two world class, state-of-the-art new facilities, the Chemical Sciences Laboratory (occupied in 1999) and the Advanced Measurement Laboratory (to be occupied in 2004). The VCAT has reviewed progress on the AML and is impressed with its design and execution, including its outstanding safety record. However, most NIST workers still occupy 30- to 50-year-old facilities. Advances in design, changes in need, heightened sophistication and sensitivity of tests, all call for improved laboratories. NIST has effectively and efficiently upgraded selected older labs to meet more demanding standards. However, preventive maintenance has been deferred, and much of the physical infrastructure (water, electrical, etc.) is deteriorating. A recent assessment placed the maintenance backlog at $800 M. If this is not addressed, at some point effectiveness will be seriously jeopardized.

We have specifically investigated the situation at the Boulder Laboratories. These include unique equipment, such as atomic clocks and semiconductor lithography and deposition apparatus that are essential to NIST's mission. Efficient utilization is already hampered by excessive vibration,



NIST's SRM 1951, cholesterol in human serum frozen, was developed jointly with the Center for Disease Control in 1987 and has contributed to an improvement in laboratory measurement accuracy by nearly a factor of eight since then.

for example, which impedes and slows sensitive measurements. We strongly support the plan for investment in Boulder's infrastructure. Finally, we note that the cost of scientific equipment has increased and will continue to increase dramatically, especially at the cutting edge, which is where NIST's mandate lies.

As in any organization, NIST's key asset is its people, so recruiting, compensation, and development are critical issues. NIST has adequate human resource systems, but needs better, higher-level integration beyond the bounds of the OU's.

NIST has wisely used its salary system (more flexible than some Federal systems) to maintain an outstanding staff. Although compensation and career potential are somewhat limited at the top levels, it appears that in most cases the intrinsic appeal of a career at NIST outweighs external material lures. Nevertheless, in some of the most active fields, such as information technology, it is increasingly difficult to retain outstanding people, since the nature of their work exposes them to many potential employers. It is critical to maintain and enhance the work climate for all of the people at NIST.

It is essential that personnel evaluation and development be conducted uniformly across NIST. For individuals to reach their full potential, they must have access to the fullest range of opportunities. Open systems must clearly identify patterns for growth and specific opportunities to develop the leaders of the future. Current leaders must identify and cultivate those with outstanding potential for higher-level positions within NIST. We are pleased that recent initiatives to open up management's positions through town meetings and other interactive sessions are bearing fruit and that by and large NIST staffers are satisfied with their work environment.

G. Extramural Programs

In addition to the core mission of NIST addressed primarily through the Measurement and Standards Laboratories, NIST holds additional important mandates that support the national economy and well-being. These areas were not specifically reviewed during the 2001 cycle, but were in 2000 and will be again in 2002. However, presentations by Deputy Director Brown and informal contacts with the leaders of these efforts give us confidence that they are continuing as well-managed and effective programs.

The Baldrige National Quality Program provides standards and processes that form a template for enhanced performance for industrial and service companies, education and health-care organizations, and in fact any group. This program represents a very small expenditure and has extremely high leverage throughout the Nation.

The Manufacturing Extension Partnership addresses the needs of small businesses throughout the country. It operates a network of centers that provide rapid response to problems and access to modern technologies for enterprises that otherwise would lack this support. The MEP draws where appropriate on the entire scientific and technical resource base of NIST. Federal funding of this effort provides the necessary core, but the centers are self-funded through grants and service fees to a significant extent.

The Advanced Technology Program funds applications development and feasibility demonstration for emerging technologies that are beyond the risk profile of private investors, either corporate or venture capital. Grants are cost-shared. Applications are rigorously reviewed for technical soundness and commercial logic. Careful follow-up has given a unique and valuable data base on the characteristics of successful entrepreneurial technology developments. The commercial impact of only a few of these high-risk ventures will pay back the entire cost to the taxpayers. The VCAT finds this program to be a sound, well-managed investment

that addresses a legitimate government function of accelerating the movement of radical new technologies into the market place. However, we believe that it would be desirable to modify the program to emphasize its strong points and minimize its deficiencies. The VCAT notes and endorses a recent study by the National Research Council, "The Advanced Technology Program: Assessing Outcomes," published in 2001, which also finds the program valuable and makes several recommendations for its improvement.

The VCAT is aware that this program has been a lightning rod for criticism of NIST. We are concerned that the controversy over ATP has hindered recognition and support of NIST's primary mission and value. We therefore support the attempt to redefine the ATP in a way that preserves its essential value while correcting some of the aspects that have been heavily criticized. At the time of writing, no details of a proposed restructuring are available to us.

III. Committee Review Activities

This section provides only highlights of presentations and discussions. More complete reports are found in the speakers' slides and the minutes of each VCAT meeting, filed on the NIST Web site at www.nist.gov/director/vcat/.

A series of Operating Unit reviews concluded in December 2000 with a review of the Physics Laboratory, reported here. Reports from prior reviews of other NIST Operating Units are included in the 2000 Annual Report of the NIST Visiting Committee on Advanced Technology.

In Annual Report	Operating Unit Reviewed
2000	Manufacturing Engineering Laboratory
2000	Materials Science and Engineering Laboratory
2000	Building and Fire Research Laboratory
2000	Information Technology Laboratory
2000	Electronics and Electrical Engineering Laboratory
2000	Chemical Science and Technology Laboratory
2000	Technology Services
2000	Administration
2000	Baldrige National Quality Program
2000	Manufacturing Extension Partnership Program
2000	Advanced Technology Program
2001	Physics Laboratory

Cross-Cut Area Reviewed	
Operations Cross-Cut	**Customer Cross-Cut**
Human Resources	Microelectronics
Communication Strategy	Law Enforcement
Patent Policy	Health Care

Having concluded this series, the committee proceeded with reviews of some common NIST-wide processes and systems. The flexibility and quick response needed to adapt to future changes will call for more such "cross-cutting" processes to facilitate prioritization and resource shifts. Deputy Director Brown has had some success in changing the traditional NIST "stovepipe" organization culture of past decades by encouraging work that cuts across Operating Units. The Committee supports this effort and focused on reviewing the progress of some of these processes during the past year.

The normal review schedule of the Committee was somewhat curtailed this year by participation in the NIST Centennial celebration. VCAT members participated in a special program entitled "NIST and Industry: Teaming Up in the New Century." They also attended the NIST Centennial Gala held in downtown Washington, DC. Finally, on Wednesday, March 7, 2001, VCAT members met in closed session with Secretary of Commerce Evans.

A. Physics Laboratory (PL)

(Katharine B. Gebbie, Director of PL, described the Laboratory's organization, people, programs, challenges, and recent changes.)

- **Mission and Industries Served**

The Laboratory provides measurement services and research for the electronics, health care, and optics industrial sectors, as well as for government and the scientific community. Representative programs address ultraviolet optics, radiometry and photometry, laser cooling and trapping, diagnostic medical imaging, time and frequency services, and laser metrology. Two offices within the Laboratory are responsible for review and dissemination of the fundamental constants, and the dissemination of PL databases over computer networks.

- **Priority Setting**

PL gains input from its constituents primarily through industry organizations such as CORM, the Council for Optical Radiation Measurements, and CIRMS, the Council for Ionizing Radiation Measurements and Standards. Organizations like CORM and CIRMS carry out regular surveys of their members to identify priorities. CORM speaks for about 150 companies, 35 Government agencies, and 25 universities in identifying priority items. PL reassesses its priorities based on this input and responds in writing to each report. Also, the Laboratory regularly interacts directly with individual companies that express their needs to NIST and seek advice on specific measurement problems.

Input from the National Research Council Board on Assessment is another important element of the Physics Laboratory's priority setting process. Surveys are also conducted of users of the Laboratory's time and frequency services. And staff continuously interacts with, and brings back comments from, industry, government, and academic colleagues though interactions at technical and professional meetings.

- **Impact**

The Laboratory measures its impact and effectiveness through:

- benchmarking vs. counterpart laboratories
- soliciting feedback from customers of calibration and measurement services
- in-depth economic impact studies of particular projects
- feedback from PL's Assessment Panel
- national and international awards and invitations to give invited talks

- **Program Highlights**

Current thrust areas within the Laboratory are: developing quantum information devices and optical frequency standards to support improved information technology; single molecule measurement and manipulation techniques to develop useful nanotechnology devices; and optical probes of biomaterials and medical physics to support an emerging biophysics industry. These thrusts are consistent with the National Research Council Board on Assessment recommendations to provide funding for new areas of quantum information, nanotechnology, and biophysics.

In addition to health-related radiation measurements, industry today is keenly interested in precision measurement related to fields such as lighting, xerography, paint and coating, and light-emitting-diodes (LEDs).

- **Issues and Challenges**

The most important issues for the Physics Laboratory are:

Balancing the Portfolio — PL is exploring methods to provide flexibility to support new, rapidly emerging ventures that fit with its strategic vision, while ensuring national needs are met through PL core measurement services.

Patenting — PL subscribes to the view that while patents are expensive and time consuming, NIST patent policy can have an important role in attracting and retaining scientists.

Increasing Diversity — The Laboratory considers it vitally important to increase the numbers of women and minorities in the field of physics, first for the health of the field, second for equity, and third because we will only achieve a scientifically literate society

NIST's one hundred years of service to the Nation were denoted by Centennial celebration activities in 2001.

when women and minorities see themselves participating in the scientific endeavor, as researchers, as scientific leaders, and as policy makers.

• Comments and Discussion

The VCAT commended the PL for the quality and merit of the work, noting that it is world-class (as exemplified by the recent receipt of a second Nobel Prize), but expressed a desire to see it presented more from the point of view of the value and leverage as seen by the industry, than built on the science and skill base of the lab. In addition, the Committee would like more detail on the industry feedback that guides the priority setting process.

• Laboratory Tour

We toured the Physics Laboratory and the Chemical Science and Technology Laboratory (CSTL) laboratory working on temperature measurements for rapid thermal processing in semiconductor manufacturing. As wafer sizes increase to 300 mm, the problems of precise process control become even more acute. As specified in the International Technology Roadmap for Semiconductors, industry needs to rapidly measure the temperature of semiconductor wafers during manufacture. These measurements must be traceable to the International Temperature Scale (ITS-90) to within ±2 °C at 1000 °C. NIST is collaborating with SEMATECH, the University of Texas, and industrial companies to develop procedures to:

- fabricate and calibrate thin-film thermocouples and demonstrate their reliability;
- characterize lightpipe radiation thermometers to provide a well characterized thermal environment to evaluate candidate temperature sensors;
- develop modeling tools to characterize the rapid thermal processing environment; and
- collaborate with equipment manufacturers in implementing new methods for reliable and traceable temperature measurements.

The laboratory tour exemplified how two NIST Laboratories have worked together to solve this problem and create suitable calibration tools.

B. Office of Microelectronics Programs

(William E. Anderson, Director of EEEL, and Stephen Knight, Director of the Office of Microelectronics Programs, reviewed the Office, its history, and current status.)

- **Mission and Program Scope**

The Office of Microelectronics Programs (OMP) was founded in 1991 following industry requests to Congress to respond to potential competition from abroad. It was, and is, focused on silicon semiconductor industry roadmap priorities. The Office, NIST's first cross-cut initiative, has grown to a $12 M multi-disciplinary program, working with six of the seven NIST technical Operating Units.

The Office of Microelectonics Programs assists NIST management and staff to plan, execute, evaluate, and deliver technical results to the semiconductor industry, and manages OMP-funded NIST semiconductor-related activities. OMP staff focus on determining industry needs, with research project management the responsibility of the relevant Operating Unit.

- **Impact**

There is substantial evidence of the impact of the program. Early work on measurement of resistivity of silicon wafers resulted in Standard Reference Materials that are now universally used worldwide. An independent assessment concluded that NIST's resistivity work saved the industry as much as $300 M from 1967 to 1976. More recently, research for Deep Ultra Violet (DUV) lithography systems is helping to produce the next-generation transistors. NIST-determined optical properties of lens and mask materials for DUV at 157 nm are the world's only accurate measurements, and have proven critical to the development of improved systems. A 1981 impact study concluded that NIST's tiny semiconductor program provided four percent of the total industry productivity from 1973 to 1977.

- **Issues and Challenges**

In light of the accelerating pace of technology and a change in industry focus from overseas competition to one of advancing performance through collaboration, NIST is revitalizing the OMP. OMP is formalizing communication with industry and within NIST, taking a more active management of all semiconductor projects, and funding projects for success, i.e., to meet industry's deadlines. However the increasing cost of processing equipment and measurement tools is moving them out of the reach of NIST, since items larger than $1 M are difficult to obtain. Therefore NIST is trying to increase its equipment budget, as well as exploring new ways to collaborate with industry and academia to obtain access to such tools.

- **Comments and Discussion**

The Committee likes the OMP model and the fact that it provides a sharp focus on industry needs as well as a vehicle for mobilizing NIST's broad skills to help a particular industry. However, the Committee notes that the globalization of the processing industry makes it less meaningful to speak of "national" advantage with respect to semiconductor processing. Today innovative chip design seems to be the competitive advantage rather than processing.

C. Health Care

(Dr. Bert Coursey, Chief, Ionizing Radiation Division, Physics Laboratory, summarized current trends in health care in the United States and globally, and the economic implications of these trends. Dr. Willie May, Chief, Analytical Chemistry Division, Chemical Science and Technology Laboratory [CSTL], described the work underway in the clinical chemistry area. Dr. Eric Amis, Chief, Polymers Division, Materials Science and Engineering Laboratory [MSEL], described NIST's work in materials science as applied to health care.)

- **Mission and Program Scope**

The NIST Measurement and Standards Laboratories are currently investing roughly $7 million per year in health care related projects. This research impacts the process from the early

stages of R&D, through maintaining quality control for well-established products. There is no single office responsible for coordination of this diverse topic, but activities are widespread in OU's, particularly Physics, CSTL, and MSEL. Representative research areas include:

- prevention – food safety (detecting small amounts of contaminants), radiation sterilization, and indoor air quality,
- diagnosis – clinical chemistry, imaging, and genomic/proteomic markers,
- therapy – pharmaceuticals, radiation therapy, gene therapy,
- quality of life – implants and hearing aids, prosthetics, pain relief, and software accessibility, and
- infrastructure – quality systems for health care, bioinformatics, and information security.

In addition, the Advanced Technology Program (ATP) has funded a large number of projects related to health care, totaling nearly $500 M over the past decade. These projects have often been in new and exciting areas such as DNA diagnostics and tissue engineering. Patient safety issues are currently addressed through the Baldrige National Quality Program in its effort to promote quality in the health care industry.

- **Impact**

NIST currently provides roughly 90 different health-related standard reference materials. For example, NIST provides calibration standards and enables traceability for photon, electron, and proton beams used in radiation therapy and mammography. It also provides standards for radioactive seed implants used in treating prostate cancer, and for radiopharmaceuticals. (All the prostate seed manufacturers around the world depend on NIST to a greater or lesser extent for establishing and maintaining dose accuracy.) Information technology tools from NIST help industry develop image registration for hybrid systems involving both PET and CT imaging.

NIST's program on clinical diagnostic markers is now over 35 years old. For one example, laboratory measurement accuracy standards for cholesterol testing has improved during that time by nearly a factor of eight, due in large part to NIST's series of Standard Reference Materials. Today many different kinds of important clinical tests rely on NIST standards. However the mere existence of such clinical diagnostic standards does not mean that every laboratory achieves sufficient accuracy. Examples were provided of how College of American Pathologist proficiency testing has disclosed discrepancies among laboratories, and how poor measurements can result in unnecessary treatments and costs. Even more troublesome, inadequate accuracy can result in failure to properly treat disease. One of NIST's roles is to teach laboratories how to use best practices and modern quality control. NIST is looking into a program to "credential commercial instrument calibrators."

NIST has had a successful cooperative relationship with the American Dental Associaton (ADA) since the 1920s. ADA and the National Institutes of Health (NIH) fund a research center at NIST, and NIST provides access to its facilities to ADA guest researchers. This has been a fruitful relationship resulting in many breakthroughs in dental science. Examples include the high-speed drill, panographic x-rays, fluoride rinses, and new composite filling.

NIST's Center for Neutron Research is increasingly serving the biomedical community, with biomedical applications quadrupling in the last decade. Users involved in biological studies represent the fastest growing set of users of this special facility. NIST provides the only state-of-the-art U.S. resource for cold neutron research for biomolecular systems. A consortium involving five universities, NIH, and NIST is devel-

oping a membrane structure station. This capability will provide researchers with a fundamental understanding of protein and molecular transport in cells. Results should be quickly commercialized because of strong support from, and direct involvement of, NIH.

- **Issues and Challenges**

The European Union is tightening standards on medical products imported into Europe. Increasingly, measurement issues can become barriers to trade, so NIST's role in protecting American interests in such situations is likely to increase.

Micro-array-based diagnostics are going to replace some current clinical tests, but repeatability may be a problem. NIST is working on rate-based measurement regimes and fluorescence standards to address some aspects of this new technology.

Tissue engineering, in general, is a fast-growing area that requires interdisciplinary efforts by biologists and materials scientists. For example, the effect of process variables on the growth of cells on a polymer matrix scaffold is not well understood. Bone repair and regeneration and implant augmentation are areas where a stream of new products will be entering clinical trials over the next decade. The Food and Drug Administration (FDA) does not currently know how to deal with manufacturing quality control related to such issues. If new products are to receive FDA approval, data will be needed to help ensure that products can be manufactured in a reproducible manner. To help meet this challenge, NIST will be putting competence funding into tissue engineering, and the ATP has allocated intramural funds for it.

- **Comments and Discussion**

The Committee was impressed with the projects and impacts described. We applaud the selection of health care as a strategic focus area for the future. The Committee believes that with the small commitment of resources, compared to the magnitude of the problems and opportunities, NIST should seek ways to continue to work effectively with other involved Federal agencies such as NIH and FDA.

D. Office of Law Enforcement

(Ms. Kathleen Higgins, Director, Office of Law Enforcement Standards, discussed the need for OLES programs and their accomplishments in saving the lives of criminal justice and public safety officials.)

- **Mission and Program Scope**

In the late 1960s, following a presidential commission study, the Department of Justice (DOJ) recognized the need for better technical information on topics such as protective clothing and firearms. The National Institute of Justice (NIJ), the research arm of the DOJ, came to NIST for help, and in 1971 OLES was formed. OLES is a matrix-management organization receiving technical challenges from its sponsors, and assembling research teams and resources from within NIST as well as external to NIST.

Through its programs, OLES helps criminal justice and public safety agencies acquire, on a cost-effective basis, the high-quality resources they need to do their jobs. The primary focus of the Office is on the development of minimum performance standards, which are promulgated by the sponsoring agency as voluntary national standards. But OLES also undertakes studies leading to new technology development and evaluations, new measuring science protocols, new standard reference materials and standard reference collections for application to the criminal justice system, and the issuance of technical reports and user guidelines.

- **Impact**

NIST/OLES is proud of the fact that hundreds of law enforcement personnel (2500+) are alive today because of work by OLES in areas such as standards and test methods for body armor. Over 230

standards, guides, and technical reports have been published in areas critical to criminal justice and public safety officials.

But technical needs continue to evolve. For example, today cyber crime is an increasing concern, and domestic preparedness against terrorist attacks is critical. Software is now available to retrieve all the data from a computer hard drive. OLES is funding the development of evaluation protocols to validate the accuracy of that software, which will serve to provide acceptance for the data in legal proceedings. Microbolometers for detecting concealed weapons are just one example of a currently topical new technology under development at NIST. A 5-year interagency project is also underway to develop chemical and bio-protection equipment standards, which is starting by identifying baseline hazardous human exposure levels to chemical and biological agents.

Finally, increased cooperation between local, state, and Federal law enforcement and public safety agencies has been undermined by their use of incompatible communication systems. The National Telecommunications and Information Administration is working with industry on an OLES-managed project, Advanced Generation of Interoperability for Law Enforcement (AGILE) to develop, adapt, or modify standards for voice, data, image, and video communications.

- **Issues and Challenges**

OLES does not receive funding from NIST. Its funding comes from a variety of external sources, primarily NIJ. The primary challenge facing the organization is ensuring basic operating funds from year to year. With a total budget in FY2001 of $12.4 M, OLES funded 51 research projects in six NIST Operating Units, universities, and other outside laboratories.

- **Comments and Discussion**

It is clear to the Committee that there is a role for NIST in this area, and we urge NIST to strengthen the budget and clarify responsibilities for it. We think it would benefit from its own share of NIST funds, and a more prominent position within the NIST organization.

D. Human Resources

(Ms. Marilia Matos, Deputy Director for Management Services, gave a presentation describing the responsibilities of the Human Resources office under NIST's unique personnel system. In addition, a panel of Operating Unit Directors, Dr. Katharine Gebbie, Dr. Hratch Semerjian, and Dr. William Mehuron, described their human resource strategies.)

- **Mission and Program Scope**

The Human Resources Management Division (HRMD) is responsible for working closely with the Office of Personnel Management and the Department of Commerce to tailor Federal human resource policies for NIST. The Division maintains those policies and procedures and ensures their consistent NIST-wide application. While basic human resource systems are common to all of NIST, Operating Units, in consultation with HRMD, make most of the key individual decisions.

NIST operates under a successful demonstration project that provides more flexibility than the traditional Federal personnel system, and also makes hiring easier. However, the wage grade employees at NIST are not included in the demonstration project. A series of charts summarized demographic data for the NIST workforce.

- **Issues and Challenges**

Retention – NIST has relatively low turnover compared to many organizations – just a few percent in a typical year. People stay at NIST because of a passion for their work. They can engage in research that cannot be done anywhere else, and perform it with a high level of collegiality. It is somewhat difficult for NIST to compete for entry level technical

people, particularly in "hot" areas like information technology (IT), but with the problems of many dot-com startups, the drain on NIST information technology workers has decreased. It becomes somewhat easier to attract people for IT at the higher levels. Average wages at NIST for a variety of technical specialties are roughly comparable with prevailing wages in the Washington Metropolitan area with the exception of systems analyst where NIST has a $15,000 advantage, and physicist where NIST is at a $9,000 disadvantage. Benefit packages in the Federal government compare favorably with many industrial firms. Policies such as allowing telecommuting and flexible work schedules help NIST recruit and retain high-quality staff.

Recruiting – For ensuring a supply of qualified workers, the best recruiting tool for some Operating Units has proved to be the National Research Council (NRC) Postdoctoral Program. A similar Boulder program called PREP (Professional Research Experience Program) has been particularly successful in bringing women and minorities into the Boulder laboratories. A Gaithersburg program called SURF (Summer Undergraduate Research Fellowship) has been equally successful in bringing young women and minorities to Gaithersburg. Some Operating Units initially hire staff only on term appointments, providing an extended evaluation period, before making a long-term commitment. All Operating Units bring in large numbers of students and guest researchers to provide "new blood" and fresh ideas.

NIST researchers are preparing sources to be used in the development of transfer standards of the medical radionuclide Ho-166. These transfer standards will allow manufacturers and researchers to make NIST-traceable radioactivity measurements of radiopharmaceuticals—thus ensuring that patients receive the dose prescribed.

Reasonable opportunities for advancement are provided through on-the-job training, executive education programs at universities, rotation of assignments, assignments at other agencies, and industry sabbaticals.

- **Comments and Discussion**

The committee was pleased with the apparent success of the human resources systems in recruiting, compensation, and retention. The committee was particularly inter-

ested in diversity and leadership development and expressed a desire for more detailed reviews on progress in these areas.

E. Communication Strategy

(Mr. Mat Heyman, Chief, Public and Business Affairs Division, described NIST's communication strategy with an emphasis on how the Centennial is being used to increase awareness of NIST and its impact on the nation. Mr. Michael Newman described in more detail NIST's dealings with the media.)

- **Mission and Program Scope**

The Public and Business Affairs Division (PABD) serves to provide communication support for NIST activities:

- to help NIST share its research results and services and commercialize its technology with industry,
- to educate policymakers about NIST's role and activities, and
- to advise NIST managers on public affairs, marketing and policy strategies.

Although PABD provides liaison with the media as well as trade associations and higher level contacts within companies, the individual Operating Units typically directly interact with users of their products and services and other interested technical parties.

- **Issues and Challenges**

NIST is large compared to most industrial R&D laboratories both in terms of staff and funding, but NIST is a small agency within the Federal government, with a very diverse range of programs. Still, NIST must maintain capabilities in chemistry, physics, biology, materials, information technology, a plethora of engineering disciplines, fire science, building technology, and more. The infrastructural nature of much of NIST's work makes it difficult to explain to external constituencies in a few words. People in industry and elsewhere may be aware of one part of NIST that addresses their special interests, but relatively few people outside NIST are aware of the breadth of NIST's work and its impact. In fact, many top industry officials are not aware of their companies' reliance on NIST.

NIST has made an important step by identifying its diverse audiences (industrial R&D managers, researchers, trade and professional associations, policy makers including Congress, the news media, community representatives, students, and the general public). NIST recognizes that it must reinforce relationships with them, build on its reputation, focus on the impact on NIST's work, and tailor the message to the particular audience. NIST has worked to build a rapport with reporters from all types of media, and has established an enviable reputation for being unusually responsive and helpful when dealing with reporters.

NIST has been striving to achieve "one face for NIST." The goal is to present an integrated user-friendly view of the Institute to the outside world. As an example, in the past when someone wanted to find out from the NIST Web site what NIST was doing for the automotive industry, that individual would have had to browse through the postings for the various Operating Units. Tracking down all relevant projects was not easy since several NIST Operating Units have work underway that supports the auto industry. Now, those who use the NIST Web site can check under pre-organized industry sector pages without having to understand the intricacies of the NIST organization chart. Ultimately this external framework should be integrated with the KnowledgeNet.

- **Comments and Discussion**

The Committee views NIST's public relations effort as excellent and important and encourages continued measurement of the impact of the program. The Committee also sees the NIST Centennial as a helpful vehicle for increasing awareness of NIST.

F. Patent Policy

(Dr. Bruce Mattson, Director, Office of Technology Partnerships, summarized the history of Federal patent policy in general, and NIST's patent policy and strategy in particular.)

• Mission and Program Scope

The Office of Technology Partnerships (OTP) facilitates commercialization activities between NIST and the private sector, in part by managing NIST's Patents and Licensing Program. The Office evaluates the commercialization potential of invention disclosures through direct industry contact, with particular emphasis on whether obtaining patent protection would best enhance commercialization; prepares a commercialization analysis and recommendations for the OU director, and, if appropriate, administers the patent application process. The relevant Operating Unit decides whether to initiate and proceed with the patent process or not. OTP also handles marketing for licenses of patents and administers the license fees and maintenance fees for issued patents.

NIST currently has the rights to 289 patents and patents pending which generated an income of averaging around $200 K to $300 K per year for the past six years. Although the income from patent licenses seems rather small for an institution the size of NIST, it is explained by NIST's policy of patenting primarily to speed commercialization rather than to generate income.

• Issues and Challenges

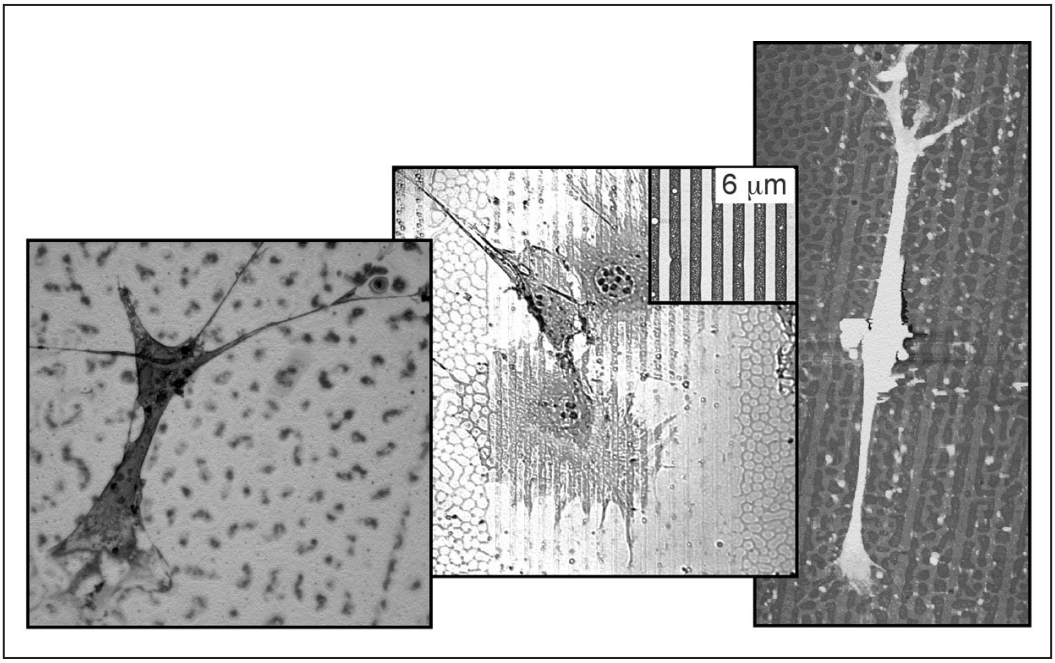
Prior to 1980 there was no authority for Federal agencies to grant exclusive licenses to inventions. The Bayh-Dole Act allowed both for Federal funding recipients to retain ownership of their inventions and for Federal agencies to license Government inventions. For Federal agencies, the largest change in policy came with the Federal Technology Transfer Act of 1986, which made technology transfer a responsibility of all Federal laboratory scientists and engineers, consistent with the mission responsibilities of the agency. In 1995, the U.S. Patent and Trademark Office introduced provisional patent applications which make it very easy and inexpensive to stake a claim to potentially patentable inventions. NIST uses applications extensively as part of its approach to commercial assessment, commercialization, and filing for non-provisional patents.

NIST policy encourages broad use by U.S. industry of mission-related inventive activity. Frequently, this is best accomplished by putting the invention in the public domain. However, where substantial investment is required on the part of the private sector, it is usually necessary to provide the benefits offered by patent protection to secure that investment. In these cases, the Operating Unit Director may request that patent protection be sought. NIST inventors are eligible to receive the first $2000 per year of royalties from a licensee, plus 30 % thereafter, up to a maximum of $150,000 per year, but they may not participate in "marketing" or licensing their inventions. NIST has a budget of about $200 K per year for patenting which pays for patent prosecution costs, filing, and maintenance for 289 active cases. NIST does not market or price its patents as aggressively as some universities or companies.

Since NIST inventions conceived under intramural funding (funding received by other NIST organizational units from the Advanced Technology Program) are to be made broadly available, patent protection is usually not sought. When patent protection is obtained, only non-exclusive licenses are made available.

• Comments and Discussion

The Committee concludes that NIST is managing its patents appropriately, and that the strategy of using patents to aid technology dissemination, rather than as a way to generate revenues, is correct for NIST.



Patterned surfaces mimic naturally occurring structures in growing tissue, which will provide standard templates for investigations in tissue engineering.

H. The Industrial Liaison Office (ILO)

(Mr. James St. Pierre, Director, Industrial Liaison Office, described the reason the ILO was formed, and provided an update on its current activities and plans.)

- **Mission and Program Scope**

The Committee has repeatedly suggested that NIST put more emphasis on customer focus. The 2000 Annual Report of the VCAT stated:

"NIST needs to increase its efforts to work cooperatively with industry and to communicate its value to key stakeholders. Serious consideration should be given to some structural overlay complementing the present Operating Units with a customer-driven focus on industries served."

The Industrial Liaison Office and the KnowledgeNet database have been created in response to this need.

The mission of the ILO is to enhance the industrial impact of the NIST programs. It will strive to improve communications between NIST and higher levels of industry. The ILO does not replace the long-standing and successful contacts between NIST bench-level scientists, managers and engineers and their industrial counterparts. It seeks to enhance existing contacts and establish new contacts at higher levels within industry.

The ILO is now staffed for pilot programs in two areas for 2001: the auto industry and health and medical products and services. The initial goals are to establish industry feedback mechanisms, and to provide additional feedback to the relevant Operating Units regarding their current research project in the focus areas.

- **Issues and Challenges**

Clearly demonstrating the benefits of the ILO to the Operating Units and the staff members (and getting buy-in) is recognized as important to the success of the office. Also

significant is how to address complex industries that are not particularly structured, such as health care. To identify NIST's impact on an industry, rather than individual companies, requires developing an understanding of which companies are players in the industry and how they work together. Developing such an understanding also facilitates identifying appropriate individuals to contact.

The effort will be evaluated after its first year based on the two initial focus areas. Success will be measured through customer surveys, some done in conjunction with external industrial organizations. Ways to improve the process will be studied, and if the ILO is judged to be successful, additional focus areas will be explored.

- **Comments and Discussion**

The Committee and ILO staff recognize that interfacing with multiplayer industries and/or industries with disparate elements, and getting the appropriate level of industry participation, will be a challenge. The ILO intends to address this issue by communicating with a representative sample of large companies that are leaders in the field, small innovative companies, and various industry organizations and associations. The Committee supports the concept of the ILO, is pleased to see it being initiated, and believes it should benefit all stakeholders.

I. The KnowledgeNet (KN) database

(Mr. James St. Pierre, Director, Industrial Liaison Office, presented an overview and status of the database.)

- **Mission and Program Scope**

The KnowledgeNet is a Web-based database of NIST projects that will help NIST managers as well as NIST staff learn about ongoing NIST work. Ultimately, external individuals, who have an interest in NIST programs, will have access to a limited set of this information. The intent is to foster cooperation within NIST and between NIST and other agencies. The categories in the KN have been defined by the Operating Unit directors.

- **Issues and Challenges**

Although rudimentary compared to some of the state-of-the-art knowledge management systems used in industry, this is a necessary first step to encourage information sharing at NIST.

- **Comments and Discussion**

The Committee pointed out that much more advanced systems are used in industry. The Committee urges NIST to benchmark such systems and be more aggressive in building the system and keeping the information up-to-date.

J. Maintenance and Replacement of Facilities

Construction of the Advanced Measurement Laboratory

(Mr. Robert Moore, Deputy Director for Safety and Facilities, presented an overview and update on the construction process.)

- **Mission and Program Scope**

The Advanced Measurement Laboratory (AML) is the culmination of a 10-year facilities improvement plan first produced in 1992. Industrial demand for increased factory-floor measurement accuracy requires improved measurement accuracy from NIST. This, in turn, requires improved NIST laboratory facility conditions, particularly for air quality, temperature control, vibration control, and humidity control.

Specific NIST activities requiring improved conditions were identified by a committee, with members drawn from all the technical Operating Units. The project requirements were then developed in conjunction with the relevant research staff, technical management, and the architectural firm Earl Walls Associates, which specializes in laboratory planning and design. With the completion of the laboratory, there will be an approximately 18 % increase in laboratory space for NIST's Gaithersburg site. This new labo-

ratory will enable NIST to undertake a whole new class of experiments that require extremely tight control of temperature, vibration, humidity, and/or air quality-experiments that could not be done in existing buildings at NIST.

- **Issues and Challenges**

The design specifications were completed in 1996, but the program was put on hold from 1997 until 1999 when sufficient funding was accumulated for complete construction. A fixed price contract was awarded September 2000 for construction of this state-of-the-art laboratory complex. The building should be completely occupied by June 2004.

The contracting process was designed to reach out to minority and women-owned small business subcontractors (and was highly successful in that regard). Safety is a high concern. The safety manager on the site has the authority to shut down the project and reports to a company official at a higher level than the site manager.

- **Comments and Discussion**

This new laboratory complex will be an important asset to NIST in carrying out its mission during the first part of the 21st century. It appears that NIST is managing this project well. Beyond construction, we are concerned that NIST must have sufficient funds to equip the building with state-of-the-art equipment.

Boulder Facilities

(Ms. Susan Sutherland, Director of NIST Boulder Laboratories, briefly described the laboratory activities and the maintenance problems and proposed solutions. Mr. Steve Salber, Chief, Engineering, Maintenance, Safety, and Support Division, gave a tour of the facilities, highlighting the changes to be made.)

- **Mission and Program Scope**

NIST is addressing high-priority facilities needs in Boulder, including upgrades to electric service, improvements to the central utility plant, and renovation of certain buildings. These improvements and renovations are designed to meet the highest priority strategic research needs, to minimize costs by renovating where possible, and to tailor environmental control to specific program needs.

- **Issues and Challenges**

It is clear that NIST needs continuing funding for the upgrading of Boulder facilities. The approximately 400 NIST employees in Boulder plus approximately 300 guest researchers and students occupy 550,000 square feet of space. Most buildings in Boulder were built during the Eisenhower Administration and are showing their age. Fortunately, they are solidly constructed, and when subjected to renovation, can provide many additional years of good service. However, funds for these projects, while necessary, tend to be less glamorous than some other budget requests, and therefore are more difficult to obtain, typically requiring a lengthy approval process.

A high priority for Boulder is to build a central plant for heating and cooling. This will greatly reduce vibration in the laboratories caused by HVAC and other noisy mechanical equipment currently located within the laboratory complex. The Committee expressed interest in seeing more detailed specifications for this new plant and additional information on how the upgraded facilities would permit new work to be carried out, or present work to be done more effectively.

- **Comments and Discussion**

The Committee supports continuing funding for the upgrading of the Boulder facilities. The Committee is actively seeking information on how the upgraded facilities would increase the speed and efficiency of current work, and how new or upgraded facilities would permit the carrying out of new work that cannot be undertaken in the existing facilities.

K. Laboratory Tours

To gain an appreciation of the technical excellence of NIST research, at each meeting the Committee visits a laboratory that is related to one of the presentations. The following areas were toured in the 2001 cycle. The meeting minutes available on the VCAT Web site include descriptions of each tour. (The first tour listed, Rapid Thermal Processing of Semiconducors, is also summarized in the Physics Laboratory Operating Unit Reviews section above.)

- Rapid Thermal Processing (RTP) of Semiconductors — David DeWitt, Physics Laboratory and Dr. Kenneth Kreider, Chemical Science and Technology Laboratory (December 2000 meeting)
- Center for Advanced Research in Biotechnology — Dr. Edward Eisenstein (June 2001 meeting)

L. VCAT Member Presentations

During his or her term on the VCAT, each committee member makes a presentation about a topic of general interest. The member talks presented during the past year are listed below. In order to achieve better coordination with the National Research Council's Board on Assessment's technical review of NIST programs, an NRC/BOA representative makes a presentation on his or her findings each year. The meeting minutes available on the VCAT Web site include descriptions of each presentation.

- "The Chemical Industry — Fossil or Phoenix?" — Dr. Thomas Manuel (December 2000 meeting)
- "Becoming a Customer Focused Organization" — Dr. April Schweighart (June 2001 meeting)
- NRC Board on Assessment Findings — Dr. Ross Corotis (September 2001 meeting)