2008 Annual Report

Visiting Committee on Advanced Technology of the National Institute of Standards and Technology

U.S. Department of Commerce

February 24, 2009

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 and updated by the America COMPETES Act. The VCAT charter includes reviewing and making recommendations regarding general policy for NIST, its organization, budget and programs within the framework of applicable national policies as set forth by the president and the Congress. In addition, the America COMPETES Act calls for the VCAT to comment on NIST's three-year programmatic plan in its annual report to Congress This 2008 annual report covers March 2008 through the February 2009 meeting.

The Committee reviews the Institute's strategic direction, performance and policies, and provides the Secretary of Commerce, Congress, and other stakeholders with information on the value and relevance of NIST to the U.S. science and technology base and to the economy. Over the past year, the Committee has been active in assessing NIST's progress in the following areas:

- Agency efforts to promote and support U.S. technological innovation and industrial competitiveness
- Strategic planning and performance

The Committee reviews a significant portion of NIST programs through direct discussion with NIST leaders, scientists, and engineers. Reactions and observations are presented candidly to the NIST senior management and other attendees at each meeting. This feedback encourages continuous improvement in key areas in the overall operation. The Committee also visits various NIST laboratories and satellite facilities to discuss the research projects directly with the technical staff. These laboratory tours help the committee assess the impact of NIST research, determine their progress towards meeting the goals of the strategic plan, and the efficacy of the facility infrastructure.

The charter of the Committee provides that the Director of NIST shall appoint the members of the Committee. Members shall be selected on a clear, standardized basis, in accordance with applicable Department of Commerce guidance. Members shall be selected solely on the basis of established records of distinguished service; shall provide representation of a cross-section of traditional and emerging United States industries; and shall be eminent in fields such as business, research, new product development, engineering, labor, education, management consulting, environment, and international relations. No employee of the Federal Government shall serve as a member of the Committee. Members are appointed for staggered three-year terms.

Four new members were appointed to VCAT during 2008: Dr. Peter F. Green (University of Michigan), Dr. Alan I. Taub (General Motors Corporation), Dr. Pradeep K. Khosla (Carnegie Mellon University), and Dr. Ruzena Bajcsy (University of California, Berkeley).

This report highlights the Committee's observations, findings and recommendations. Detailed meeting minutes and presentation materials are available on the NIST web site at www.nist.gov/director/vcat.

VCAT Members During the Period Covered by this Report

Dr. James W. Serum, Chair Scitek Ventures	Dr. Vinton G. Cerf, Vice Chair Google
Dr. Thomas M. Baer Stanford University	Dr. Ruzena Bajcsy University of California, Berkeley
Dr. Paul A. Fleury Yale University	Dr. Peter Green University of Michigan
Dr. Lou Ann Heimbrook Senior Business and Scientific Executive	Dr. Pradeep Khosla Carnegie Mellon University
Dr. Elsa Reichmanis Georgia Institute of Technology	Dr. Alan I. Taub General Motors Corp.
Mr. Robert T. Williams Caterpillar, Inc.	

Table of Contents

VCAT Focus in 2008

In 2007, the VCAT activities were primarily focused around three critically important industrial segments, namely Bioscience, Nanotechnology and Information Technology. The VCAT created three subcommittees and discussions included both VCAT member experts, members of the NIST staff, and at times representatives from these industries. The 2007 Annual Report describes the results of those reviews. Although these topics remained important for NIST, this past year (2008) the VCAT was asked to participate in a "dialog" on several important questions being considered by the NIST management.

The overarching NIST question to be addressed by VCAT in conjunction with NIST staff was:

"How can NIST best prepare for, deal with and adapt to changes in the scientific and technological enterprise and in the global economy and society in order to continue to effectively meet our mission?"

Relative to this general question, VCAT was specifically asked to work with the NIST team during its meetings to address the following questions:

- What are the most productive kinds of interactions and relationships between NIST and other institutions – including industry, academia, and state/regional organizations -- in a time of change?
- What steps can NIST take to guard against technological surprise and to ensure that we continually identify and work on novel areas of technology?
- Considering recent developments in science, technology and global conditions, what changes should NIST consider in order to best support the nation's needs in:
  - manufacturing,
  - the service sector, including healthcare,
  - sustainability, including energy and the environment?

Our 2008 VCAT Annual Report addresses our observations, findings and recommendations for these topics as well as some comments about the NIST budget, management and staffing, and NIST's approach to strategic planning.

NIST Enabling Partnerships

NIST has developed a wide array of approaches for creating, transferring, and encouraging the effective use of the technical knowledge needed for innovation. Many of the discussions of the Committee this year were directed at creating effective partnerships through diversity, focused purpose, and careful selection of partners. The Committee notes that NIST continues to create productive new or continuing technology partnerships including:

- The Joint Quantum Institute
- Technology Innovation Program (TIP)
- Hollings Manufacturing Extension Partnership (MEP)
- Program for Regional Innovation: Nanoelectronics Research Initiative Model
- A revised Center for Advanced Research in Biotechnology (CARB) agreement with University of Maryland Biotechnology Institute (UMBI)
- Hollings Marine Laboratory (with NOAA)

NIST has been lauded by the University of Colorado for its successful and longstanding JILA partnership and by the Semiconductor Research Corporation for its technical and financial contributions to the Nanoelectronics Research Initiative partnership. The Committee encourages NIST to continue this tradition of innovative partnering while being careful not to overextend and to ensure the geographic diversity of its partners (i.e., not be too limited by proximity).

NIST has done a good job of leveraging its 2,800 employees, using resources across the nation. NIST is applauded for its efficient and national level of interactions and use of local, state, regional, and national experts and partners (see Figure 1).

Figure 1
People: NIST Staff and Partners in 2007 (over 12,000)
(Includes NIST Employees, Associates, Facility Users, MEP Field Staff, Co-authors, NQP Examiners and Others, NVLAP Assessors, and Weights and Measures Officials)

- ✓ **Recommendation:** NIST has a highly respected and successful program to bring in researchers to NIST facilities. This has a significant impact on outside organizations learning about NIST and leveraging their internal facilities for the benefit of U.S. industry. We would encourage the management team to also consider the reverse, sending its own resources to industrial facilities. The benefit to the organization is that the individual is able to work with many of his/her peers in industry rather than gaining insight from one individual coming to NIST.

- ✓ **Recommendation:** Although NIST is highly leveraged with many successful partnerships, it is the general view of VCAT members that the partnerships are often created because of proximity to a NIST facility or based on some other factor. We encourage NIST to seek out the "best" partner (academic, industrial, government) in the country regardless of geography or other association.

NIST Role in Economic Growth in the United States

In this time of rapid technological change and economic distress, the VCAT believes that NIST has a very important role to play in the economic well-being of the nation. NIST is the only Federal research agency specifically focused in its mission on promoting U.S. economic competitiveness and that has U.S. industry as its primary stakeholder. NIST strives to provide a comprehensive and highly productive toolkit of products and services in support of technological innovation. It is technological innovation that has been responsible for about half of the growth in U.S. GDP since WW II. The need for economic growth through innovation has never been greater.

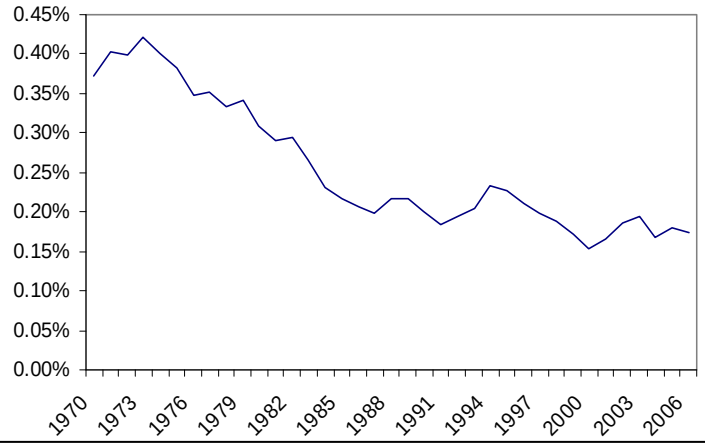
Furthermore, NIST provides the framework to perform high quality, accurate measurements which are an essential ingredient for supporting U.S. innovation. NIST is uniquely charged with developing measurement standards to support and promote U.S. competitiveness. NIST also plays a crucial role in helping to develop physical standards and voluntary consensus documentary standards to benefit industry and the work of the Federal government.

NIST's portfolio of products and services include technology research, the development of advanced measurements, the creation of standards, and programs that promote quality, enhance manufacturing efficiency, growth and technological innovation. The NIST Laboratories, Technology Innovation Program, Hollings Manufacturing Extension Partnership, and Baldrige National Quality Program are uniquely positioned to:

- Increase the speed and breadth of economic growth by delivering research results at the cutting edge of technology and providing the tools needed to develop and fully exploit opportunities for new and improved products in manufacturing and service industries
- Increase industrial productivity and lower service costs by attacking some of the largest inefficiencies in the economy from improvements in the quality of most technology sectors in the U.S., from health care to energy efficiency.

The VCAT believes that support for a vibrant NIST is critical to developing and maintaining a stronger economy and a more competitive U.S. industry. Federal support for NIST has been falling relative to U.S. GDP and industry research for many decades (see Figure 2). As technology has become more and more important to the U.S. economy, the federal infrastructural support that NIST provides has been severely challenged for lack of funding.

Figure 2
NIST Laboratory Budget Relative to Industry-Funded R&D



NIST Role in Technological Innovation and Industrial Competitiveness

The Committee examined the function and impact of many NIST programs. These programs cover a broad spectrum of technologies, industrial segments and NIST services:

- The NIST Laboratories continue to be the premier measurement and standards laboratory in the world with the highest level of expertise. The measurement science performed at NIST is considered by VCAT as "state of the art" in many areas and this provides the foundation to enable many new technical innovations. NIST believes that it is only through measurement that one can see that an innovation is of real value and the level of true contribution. It is only through measurements that an innovation can be understood, improved, and made effective. We, the VCAT, strongly agree with this perspective. The advanced measurements and standards developed by NIST enable innovations to work in the framework of existing technology allowing new products to be commercially successful. The Committee believes that the NIST laboratories are the technical core of the whole agency and researchers are "world class" as evidenced by their awards both nationally and internationally, their publications, and their alliance partnerships.

  Their contribution has also been corroborated by economic impact studies to measure the effectiveness of their programs. A selected set of 19 economic studies show an average 44:1 return on investment. While not all programs exhibit the same returns, some exceed this average and indicate the potential value of well-chosen efforts.

- The Technology Innovation Program (TIP) is a new program this year and a significant departure from its predecessor. The new TIP program was formed as part of the America COMPETES Act for the purpose of assisting U.S. businesses and institutions of higher education or other organizations, such as national laboratories and nonprofit research institutions, to support, promote, and accelerate innovation in the United States through high-risk, high-reward research in areas of critical national need. TIP has implemented a system to identify and fund high-risk, high-reward research in areas of critical national need to address societal challenges. We commend TIP's process including the use of the National Academies and the Science and Technology Policy Institute for identifying critical national needs. Their prescient selection of research to support infrastructure monitoring and inspection technologies matches the new Obama Administration's priorities and economic incentive approaches.

- The Hollings Manufacturing Extension Partnership (MEP), which serves approximately 28,000 clients, continues to focus on helping small and medium manufacturers in critical ways during this time of extreme economic duress. MEP programs on both improving the efficiency and growth of manufacturers positively impacts the employment and profitability of this important part of the U.S. economy.

- The Baldrige National Quality Program encourages, educates, and rewards performance excellence in manufacturing, service, education, health care, small business, and nonprofit organizations. This NIST program provides an integrated approach towards delivering ever-improving value to customers and stakeholders, which is a key driver of U.S. competitiveness and innovation.

NIST Strategic Planning and Performance

NIST has long participated in planning exercises with industry, federal agencies, measurement science and standards organizations and other stakeholders, and within NIST using economic planning studies. NIST has developed many excellent planning tools in recent years and they have done a good job of annual planning. We observe an ever increasing orientation toward gaining customer and industry segment input for helping to evaluate program priorities. This is fundamental to a good foundation for a comprehensive strategic plan. The VCAT is pleased to observe the beginnings of good strategic planning processes in various departments and labs. We commend the Deputy Director for embracing the importance of doing strategic planning throughout the organization and we understand that the implementation will take time.

We support the work in 2008 to establish clear priorities for the organization and to evaluate how these priorities fit with the priorities of the new Administration (see Figure 3).

Figure 3
NIST Addresses National Priorities

	Priorities in President Obama's Agenda				
NIST Investment Priority Areas	Economy	Technology	Energy and Environment	Homeland Security	Defense
Energy	●	●	●		
Environment	●	●	●		
Manufacturing	●	●	●	●	●
Health Care		●		●	
Infrastructure	●	●	●	●	
Information Technology	●	●	●	●	●

- ✓ **Recommendation:** We encourage NIST management to begin the process to incorporate an Institute-wide integrated vision, to prioritize the industrial segments they will service, identify clearly NIST's core competencies and areas of weakness, and to develop appropriate implementation plans and budgets that are incorporated into a NIST Strategic Plan.

We applaud the efforts of the Director of the Chemical Sciences and Technology Laboratory (CSTL) for his leadership and implementation of a Bioscience plan that provides the foundation for a Bioscience strategic plan. In collaboration with the VCAT Bioscience subcommittee, the CSTL Director organized a process to identify customer and industry segment "critical measurement needs" for bioscience applications. This effort was launched by the recent bioscience international conference that was jointly hosted with UMBI titled, "Accelerating Innovation in 21st Century Biosciences: Identifying the Measurement, Standards, and Technological Challenges." The proceedings from this joint conference will provide an excellent foundation for developing a more comprehensive strategic plan. An initial draft of a document "Measurement Challenges to Innovation in the Biosciences: Critical Roles for NIST" has already been produced. The organization plans to use this to continue its interaction with technology and industry experts to further refine their determination of the most critical needs in Bioscience. We support this approach for NIST program prioritization, given the complexity and breadth of possible bioscience applications and emerging technologies.

- ✓ **Recommendation:** We urge the organization to continue its work on Bioscience strategic planning and to use this excellent work as a model for expanded work throughout the NIST laboratories.

As indicated in the NIST Three-Year Programmatic Plan section, the Committee supports the new investment priorities of Energy, Information Technology, Health Care, Environment, Manufacturing, and Physical Infrastructure. NIST has established these priorities based on urgent, compelling national

needs; demonstration of a compelling innovation or competitiveness issue; presence of a coordinated national policy focus; and clear alignment with the NIST mission and goals.

- ✓ **Recommendation:** NIST does not have the resource bandwidth or technological expertise to address all of these areas with equal emphasis nor do they have equal potential for contribution in all areas. We recommend that the organization evaluate its competencies in each area; determine its intended role as leader, coordinator, or facilitator; and then develop a plan for each area based on this assessment. We consider this an integral part of a normal strategic and programmatic planning activity.

Specific planning comments for previous areas of prioritization are listed below.

Bioscience – The Committee finds that the Bioscience and Health Care planning process was productive, and the VCAT strongly supports NIST's plans to incorporate the International Conference results into a bioscience/health care strategic plan and to discuss their proposed plan extensively with companies in the Bioscience and Health Care sector.

- ✓ **Recommendation:** It should be recognized that Bioscience as it has been discussed represents only one segment of health care. We encourage the organization to expand its strategic thinking and to incorporate other segments, technologies and applications into an overall Health Care Plan. For example, Health care IT is recognized both by the President's priorities and industry issues as a critical priority. NIST has an excellent opportunity to make a major contribution in this area both for technological leadership as well as documentary standards coordination.

Nanotechnology – NIST's plan is to understand the measurement challenges and opportunities in a wide variety of energy related nanotechnology areas, such as fuel cells, storage batteries, and photovoltaics. The Committee congratulates NIST on the successful creation of the Center for Nanoscale Science and Technology (CNST) and for bringing coherence to the rapidly growing and multidisciplinary field of nanotechnology. The Committee also strongly supports the nanotechnology environmental health and safety research program that was launched last year. Feedback from external sources has verified the critical importance of this research for enabling nanotechnology to continue to evolve and mature while assuring its safe use. VCAT also endorses the ground-breaking efforts by NIST to facilitate research into and standards for assessing the biological hazards of nanomaterials.

The CNST NanoFab facility has been structured and staffed with the goal of providing broad and diverse nanofabrication capability to external and internal government users. To accomplish this, it is necessary to develop a portfolio of robust processes that can be customized to meet the needs of particular users. We are pleased that the CNST has adopted a "flexible" fabrication structure that is well suited to meet the goal of serving a diverse customer base.

- ✓ **Recommendation:** Although the CNST NanoFab facility has nearly doubled its "customer" base in the past year, we encourage the CNST group to continue a vigorous outreach program to external customers.

- ✓ **Recommendation:** Last year, we encouraged the team working on Nanotechnology environmental health and safety to align with a partner that has toxicology application expertise. NIST has accepted the VCAT's advice to focus on external partnerships to address nanotoxicity issues. To our knowledge, they have not yet completed these partnerships. We encourage them to do so as soon as is practical in order to appropriately leverage resources within NIST.

Information Technology – NIST has many roles and some mandates in Federal cybersecurity technology and policy, which also affect the broader national information technology infrastructure, and NIST has growing programs in health care information technology. NIST also conducts world-class research in new information technology areas such as quantum measurement, cryptography and communication. It is becoming clear that current standards for digital signatures and communication security are at risk in the face of potential quantum computing developments as well as revealed weaknesses in earlier standards. Cybersecurity and health care information technology are priorities for the new Administration. NIST work is productive and effective in these areas, but is significantly under-resourced for the magnitude of the national needs. The Committee also strongly supports NIST requests for additional resources to support information technology programs.

- ✓ **Recommendation:** The Committee encourages NIST to continue its strategic planning efforts in information technology to address the most critical national needs with limited resources and to strengthen its productive interactions with industry and other Federal agencies.

- ✓ **Recommendation:** The Committee notes that NIST has key roles in coordinating and in some cases leading the development of documentary standards. These are enablers for assuring the interworking of competitive products and services. The Committee strongly encourages NIST to continue efforts to clarify and define its roles in national and international documentary standards development.

Manufacturing – The mission of NIST is "To promote U.S. innovation and industrial competitiveness by advancing measurement science, standards, and technology in ways that enhance economic security and improve our quality of life." The pace by which change is occurring today in our global economy makes one wonder how competitive U.S. industry remains. This rapidly changing environment is an appropriate time to assess "how competitive manufacturing and U.S. industry are in this global economy." To help NIST focus its core competencies in the areas that U.S. industry requires for the future, it is an appropriate time to assemble manufacturing industry representatives and establish a current baseline. NIST, through its collaborative efforts, is in a unique position to assist industry in determining where it needs to apply the most focus to obtain the most benefit.

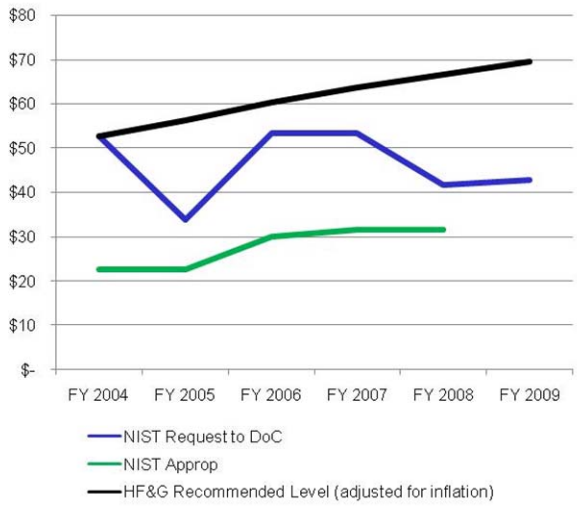
- ✓ **Recommendation:** Since NIST has established a priority for enabling innovation in U.S. manufacturing, we encourage NIST to establish a benchmark for ways to measure current "competitiveness" in U.S. manufacturing relative to the global industrial environment.

Facilities – NIST managers provided the Committee with several convincing examples where critical research has been delayed due to the poor condition of the facilities.

The Committee believes that the funds for maintaining the facilities at NIST are currently inadequate and encourages the Department of Commerce and Congress to increase Safety, Capacity, Maintenance and Major Repairs funds (see Figure 4).

The Committee notes that NIST proactively outsources research as a solution to inadequate facilities. Given the current state of its facilities, the Committee encourages NIST to continue its external collaborations, but in addition to seek support for significant facilities construction, refurbishing and repair.

Figure 4
NIST Safety, Capacity, Maintenance and Major Repair Funding ($ in millions)



NIST Three-Year Programmatic Plan

The Committee has read and reviewed the latest draft NIST three-year programmatic plan ("Plan") as of February 3, 2009 and commends NIST management for its preparation. While not intended as a substitute for a strategic plan, the committee finds that the Plan provides useful input to that process and is a very useful vehicle for reporting NIST's near term intentions to VCAT, Congress and the Administration.

The Committee found it important to keep in mind the ongoing programs at NIST while reading about the new ones emphasized in the Plan. Perhaps a brief programmatic view of NIST (i.e., "NIST at a Glance") would aid readers less familiar with the full scope of ongoing NIST programs.

The Committee was struck by the wide range of roles played by NIST. It is a facilitator responding to business needs; it is a leader, pursuing programs in anticipation of need or in response to Administration or Congressional mandates; and it is a coordinator of standards and standards-related development in intra-governmental and multi-stakeholder environments. Broader appreciation for this dynamic range of roles might increase the effectiveness and impact of NIST's work.

NIST has an important role in catalyzing both the domestic and international competitiveness of America's businesses. The Committee found it helpful in reading and discussing the Plan to keep in mind the international aspects of NIST's work.

The Committee strongly supports the priorities outlined in the Plan. They are broad in scope and the Committee found it valuable to recall that the effectiveness of the NIST programs depends on NIST's careful choice of specific work to pursue in each priority area.

The Committee also recognizes the centrality of measurement and standards in the NIST portfolio of activities and would like to emphasize the enabling power of NIST's basic research projects and the necessity for the associated infrastructure required for its support.

In considering the new areas of focus outlined in the Plan, the Committee believes it will be very helpful for NIST to review and evaluate the skills that will be needed to carry out the Plan, especially in the new areas of focus. Such a review will inform NIST planning with regard to full-time employees, visiting staff, and partnership or collaboration plans.

In summary, the Committee concurs with the three-year programmatic plan and encourages NIST management to pursue further development of a longer-term strategic plan to provide a framework for organizational evolution, and selection and prioritization of its work.

NIST Management, Leadership and Staffing

The Committee finds that the recent frequent changes in leadership at NIST have produced significant strain in the management, long-term planning and implementation of important programs.

From the founding of NIST in 1901 (then NBS) to 1990, the average tenure of the Presidentially-appointed NIST Director was approximately 11 years. From the year 2001 until present, the average tenure of the Presidentially-appointed NIST Director has been approximately 2.5 years. Since 2000, the tenures of Presidentially-appointed NIST Directors have been interrupted by relatively lengthy tenures of Acting NIST Directors, with those Acting tenures averaging about one year. Since 2000, the Acting Directors have been NIST Deputy Directors (members of the civil service, not politically appointed). For various reasons, each of the Acting Directors basically lost his or her job at the conclusion of the Acting

tenure. Since 2000, if both the tenures of the Presidentially-appointed and Acting NIST Directors are averaged together, the average tenure has been approximately 1.5 years. Such a short tenure – either for the Presidentially-appointed Director or for the Acting Director – makes it very difficult for the Director to establish and implement strategic directions for the organization.

The Committee recommends that the Department of Commerce and Congress help define a more stable approach to key NIST leadership positions. We commend the NIST Deputy Director, Dr. Pat Gallagher, for establishing an organizational structure that is more conducive to this stability and for his proactive behavior in seeking out VCAT input on important issues recognized by NIST as priorities.

NIST Budget

NIST management once again faced the difficult challenge in 2008 to accomplish their goals and commitments under the budget pressure of a "Continuing Resolution Budget". We applaud the team for maintaining a strong positive spirit and a "can do" attitude throughout this difficult year. The VCAT is encouraged that the America COMPETES Act, intended to double the NIST budget in ten years remains a goal priority. We should emphasize, however, that a budget that doubles in ten years represents only approximately 7% per year increase. This growth is not enough beyond inflation to produce significant technological advances in new programs.

- ✓ **Recommendation:** We believe that NIST has achieved major accomplishments both in standards activities and in technological innovation given its constrained budget. However, even with a budget-doubling plan, we encourage NIST staff to leverage its resources through very proactive partnering in coming years, especially in areas where it does not have internal competencies. We are satisfied that NIST staff recognizes the importance of this and assume that they will make it an even greater part of their ongoing activities in the coming years. In addition, we encourage the NIST management to be proactive in deciding what programs should NOT be continued (sunset planning) based on changing need, lack of progress, or insufficient critical mass to achieve goals.

Safety at NIST

Although the NIST management and employees have been safety conscious with numerous training programs for laboratory safety, it is evident from the Plutonium incident this past year that safety is not uniformly pervasive throughout the organization. The VCAT commends the NIST management for its aggressive approach to addressing this problem, including its transparency in communication of its findings, the creation of a Blue Ribbon Panel and its cooperation with the Nuclear Regulatory Commission investigation team. Because there were many panels and experts assembled to investigate this safety incident, the VCAT did not see any utility in conducting its own study. However, it did provide input for identifying expertise and membership of the panels.

The Committee members commend NIST for its renewed focus on safety. We strongly concur with Dr. Gallagher's acknowledgement of the central role that leadership plays in integrating safety into the organization, as well as his recognition of the many benefits associated with becoming a high performance safety organization. We commend the NIST leadership for reacting quickly to the recent safety incident and also strongly encourage it to expand on the planned actions to increase safety consciousness within the culture of the laboratories. In recent discussions, the leadership planned a safety benchmarking exercise of comparable government and private laboratories. This is an excellent first step.

- ✓ **Recommendation:** The NIST management is constantly faced with providing facility and laboratory tours for outside organizations. Some laboratory environments may be considered "safe" for the experts that are working in the facility, but may not be considered safe for visitors who are not familiar with the lab surroundings or with good safety practices. We encourage management to evaluate the openness of some laboratories to outside visitors and to incorporate this consideration into their overall safety program.