2007 Annual Report

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

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VISITING COMMITTEE ON ADVANCED TECHNOLOGY
National Institute of Standards and Technology

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 2007 annual report covers the March 2007 meeting through the February 2008 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:

- Strategic direction and performance
- Infrastructure and process in support of strategic needs
- Outreach - Assessing and responding to external drivers
- Organizing and executing with excellence

Throughout the year, the Committee seeks to cover a significant portion of NIST programs through direct discussion with NIST leaders, scientists and engineers. Reactions and observations are discussed candidly with the NIST representatives and other guests at each meeting. This feedback is used to seed continuous improvement in key areas in the overall operation. The Committee also visits various NIST laboratories and discusses the research projects directly with the technical staff. These laboratory tours help the committee assess the relevancy of measurement technology research and NIST's progress against the strategic plan and the development of the NIST infrastructure.

Members of the Committee have careers in industry and in academia, and are selected solely on the basis of established records of distinguished service and eminence in their fields: research, engineering, business and other fields relevant to the NIST mission. Appointed by the NIST Director for staggered three year terms, the members have diverse backgrounds and provide a representative cross-section of traditional and emerging U.S. industries. Three new members joined the Committee during 2007: Dr. Vinton G. Cerf, Google; Dr. William Happer, Princeton University; and Dr. Elsa Reichmanis, Georgia Institute of Technology.

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. E. David Spong, VCAT Chair Boeing Company (retired)	Dr. William Happer Princeton University
Dr. Thomas M. Baer Stanford University	Dr. Lou Ann Heimbrook Merck & Co., Inc
Dr. John F. Cassidy United Technologies Corp. (retired)	Dr. Elsa Reichmanis Georgia Institute of Technology
Dr. Vinton G. Cerf Google	Dr. James W. Serum, Vice Chair SciTek Ventures
Dr. Paul A. Fleury Yale University	Mr. W. Wyatt Starnes SignaCert, Inc
Mr. Gary D. Floss Marvin Windows and Doors	Mr. Robert T. Williams Caterpillar, Inc.

1. Introduction

The VCAT formed three subcommittees to better focus our oversight and reviews. We selected the areas of Bioscience/Healthcare, Nanotechnology, and Information Technology (IT) since we believe that these are the high impact areas deserving of our attention. During 2008 we plan to review the effectiveness of these subcommittees to ensure we are covering all the important emerging areas of technologies.

The VCAT held four meetings over the past year in the Gaithersburg, MD, facility, the Boulder, CO, facility, and the Hollings Marine Laboratory in Charleston, SC. At each facility, we were pleased with the technology and relevancy of the research focus on industry and the enthusiasm of all the staff. Based on these visits and the interactions between the VCAT members and the NIST staff, we identified findings and formulated recommendations, as follows:

2. Overall Committee Observations on the FY 2009 President's Budget Request and NIST's Three-Year Programmatic Plan

- *The committee believes that one of the more important recent developments was the planned budget increase for NIST as part of the American Competitiveness Initiative (ACI) and the America COMPETES Act. We strongly support the proposed significant budget increases.*

- *The committee endorses the four pillars of strategic planning found in the three-year programmatic plan (pages1-4 and 3-6), namely:*

  (i)   Enhanced stakeholder outreach and identification of critical measurement and technology challenges;
  (ii)   Strategic, multi-year investment framework;
  (iii)   Development of infrastructure to optimize and support the Nation's technological and organizational innovation – and the staff and equipment so that NIST can succeed; and
  (iv)   Rigorous evaluation of all NIST investments

- *The committee agrees with the Core Competencies identified in the three-year programmatic plan (section 2.4), namely:*

  (i)   Measurement science;
  (ii)   Rigorous traceability; and
  (iii)   Development and use of standards

- *The committee agrees with NIST that biotechnology, advanced materials (including nanomaterials) and IT infrastructure and communications are areas in which strategic investments are needed (page 5-13 of the plan). We also endorse the plan's details of the construction and renovation needs described in Appendix D.*

- *The committee supports NIST's commitment to phasing in and phasing out of programs (section 5 of the plan) and agrees with NIST's investment posture in quantum science and atomic, molecular and optical physics.*

- *The committee concurs with NIST that it must be responsive to mandates (e.g., Help America Vote Act) and to other national needs in manufacturing; energy demand and supply; climate change measurement, modeling and analysis; and safety in commerce.*

- *The committee endorses the articulation of the issues surrounding Nanotechnology Measurement Science (section 9.1.1.3 of the plan) and the movement of Nanotechnology from Discovery to Manufacture (section 9.1.2.2 of the plan). The importance of this field to both U.S. technological leadership and industrial competitiveness is clearly described.*

- *The negative impact of the FY 2008 budget on the important role NIST must play in the responsible development of nanotechnology cannot be overemphasized. We agree with the assessment of the importance of enhancing the NIST Center for Neutron Research (NCNR) (section 9.1.3.2 of the plan) but suggest that the case could be even stronger by enhancing the important symbiosis between NCNR and the Center for Nanoscale Science and Technology (CNST), as expanded upon in Section 3c of this report.*

- *The committee also strongly endorses NIST's evaluation strategy, in particular the seven Heilmeier questions from the Defense Advanced Research Projects Agency (DARPA) adapted to NIST's work:*

  (i)   What is the problem and why is it hard?
  (ii)   How is it solved today and by whom?
  (iii)   What is the new technical idea and why can we succeed now?
  (iv)   Why should NIST do this?
  (v)   What is the impact if successful and who would care?
  (vi)   How will you measure progress?
  (vii)   How much will it cost and how long will it take?

- *The committee is satisfied that NIST has a vigorous process for consulting with customers, industry and academia for purposes of formulating its strategic and tactical plans For example, see a summary of IT organizations inside and outside the U.S. Government in which NIST collaborates.* [1]

- *The committee notes the extensive collaboration undertaken by NIST[1] and recommends continued support for these wide-ranging activities.*

- *The committee commends the NIST staff for its responsiveness to questions posed about the nature of the NIST customer base and the mandates that it is required to fulfill*. [2]

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[1] *Interim report of the VCAT Information Technology Subcommittee, Wyatt Starnes, Chair, NIST VCAT IT Subcommittee, December 11-12, 2007, presentation available at* http://www.nist.gov/director/vcat/starnes_it_feedback_121207.pdf

[2] *"Information Technology Research at NIST", Cita Furlani, Director, Information Technology Laboratory, August 14, 2007, presentation available at* http://www.nist.gov/director/vcat/furlani_0807.pdf

3. Detailed Observations, Findings and Recommendations Developed from the Work of the Three VCAT Subcommittees

3a. VCAT Information Technology Subcommittee

Chair: Wyatt Starnes; Members: Vinton Cerf, Gary Floss, David Spong

The subcommittee identified a variety of high-level trends and technologies that are having or will have notable effects on NIST and its customers. These are summarized briefly below.

High Level Emerging Trends

The need for cyber security is increasing rapidly. Recent reports from the company AV Test reported that during 2007, five times as many novel samples of malicious software were detected (5.49 million in 2007 versus 972 thousand in 2006). Improvements are needed in software and systems quality, reliability and trustworthiness. There are deep questions about the vulnerability of browsers and other network-based applications, operating systems, and server systems on the Internet or in private enterprise networks. Ability to measure the risks and to find means to mitigate them will determine whether electronic commerce on the Internet, among many other applications, will survive.

It is also clear that data centers are among the most resource consuming systems in the ecology. They consume a lot of electrical power and consume a lot of water for cooling. As computing and storage demands increase, these problems will be exacerbated. NIST could help to establish profiles of Green Data Centers that operate in sustainable ways.

Digital Information is an extremely useful form of data but archiving and retrieval depend on timely indexing and ability to recover and interpret the stored information. This often means that the software that knows how to interpret the data must be available at retrieval time. This cannot always be guaranteed and steps are needed to assure that the bits we store today can be retrieved and interpreted a hundred or a thousand years from now. Standards for representing information are needed. Document references need to be permanent and usable for hundreds of years to come. Moreover data describing data is needed to allow for data retrieval at times long remote from the original capture. Standards are needed for this so-called "metadata" so that all forms of information can be correctly interpreted in the distant future. We are also seeing increasing levels of data mining in which digital information and metadata is searched for patterns and other indicators of economic, social or political trends.

The subcommittee also sees substantial degrees of collaborative, online activity, aided by tools for visualization and modification in real time and often in the presence of voice or video conversation. Resources are becoming virtualized so that physical facilities can be assigned and re-assigned freely to meet demands, without dedicating them unnecessarily. IT is becoming pervasive and increasingly mobile. Laptops and mobiles have become powerful computing engines in their own right with substantial memory and communication capacity. All of this increased information technology use is increasing demand for human capital resources for research, development and operation. This puts stress on the national educational system and in the global competition for work in the IT space.

As IT becomes more pervasive, it is also playing a role in software-assisted devices (for example, measurement devices that report their condition and data online or accumulate it for pickup later). This increases the need for standards of data identification, calibration of measurement equipment, and global agreement on metrics. Some of the economic and ecological challenges in this century as well as the challenges of operating extremely large scale systems have increased the need for predictive modeling and measurements to validate the models. As the information ecology expands, the nation is in need of greater risk mitigation. We want to avoid technological surprise (e.g., someone else comes up with the first workable quantum computer). We want to protect our democratic roots

with secure and efficient electronic voting by mitigating risks inherent in online voting systems. And we want to limit the risks of nanomaterials that could pose health, safety or environmental hazards.

State of the Art in Technology

The state of the art of IT is also evolving significantly. The Internet will be adding IP version 6 (IPv6) with its vastly increased address space. It will also expand the use of digitally-signed Domain Names that can mitigate various forms of fraud, for example misdirecting users to the wrong web site. Non-Latin domain names will also be added to the Internet at the top levels during 2008. There are risks for ambiguity and confusion and it will be important to mitigate that risk as much as possible.

The so-called "Web 2.0" technology will add virtual data centers and virtual personal computing to the array of tools already available to today's modern Internet user. Contributing to this virtualization are "service oriented architectures" that render virtual the physical resources needed to put up web based services. Multi-core chipsets are driving the need for new pipelining and parallelization algorithms. Finally, the subcommittee sees rapid evolution of robotic devices, telepresence and automation in general, some of which will color the workload and opportunities of NIST and also its set of tools for carrying out its work.

The subcommittee also observes that there are significant IT implications for nanotechnology. New nanotechnologies can influence the development of new computing capacity (e.g., quantum computing) on the one hand and on the other, developing nanotechnologies of all kinds can be accelerated with the use of large scale computing capacity to design and analyze the physical properties of nanomaterials and structures. Quantum computing, if successfully implemented, could vastly improve our ability to model, analyze and even predict the effects of climate change and natural disasters. Even in the absence of prediction and modeling, the ability to amass and present large quantities of geographically indexed information (e.g., Google Earth, Virtual Earth) can be highly beneficial in natural disaster mitigation including medical epidemics.

NIST has cited biotechnology, advanced materials and IT infrastructure and communications as key priorities for the agency. The IT subcommittee agrees and believes that computing and networking capabilities are essential for the support of biotechnology research, materials research and modeling, and the use of IT in collaborative research work. Sharing of large databases and large scale computing capacity will be the key to advances in these three areas. IT standards for format and communication are key to the development and use of personal and interoperable health records and the analysis of aggregate health records for purposes of detecting and reacting to potential epidemics or identifying general population health risks. Clearly, initiatives in these areas require advances in techniques to support confidentiality of personal health records.

Recommendations

- Basic and applied research work is vital to maintaining NIST's ability to deliver new and needed measurement capabilities in nanotechnology, biotechnology and information technology spheres. NIST needs to maintain a vigorous program of research to support evolution of the U.S. Measurement System (USMS) as dictated by the strategic planning, consultation and outreach programs.

- NIST could materially assist the IT industry through the development of multi-core chip performance metrics and measurement.

- NIST could materially assist the IT industry through development of standards in software measurement and metrics to assess the proactive readiness and security of IT systems at all levels. This idea could be extended through research on ability to assess and maintain the integrity of software as deployed and to validate the provenance, pedigree and lineage of software used in systems critical to national security and IT infrastructure. This is not only crucial to create

social trust with electronic voting systems, but increasingly necessary to positively affirm that the software used in the National infrastructure remains trusted and reliable over usage lifetime.

- The subcommittee recommends that NIST consider investigating computing requirements and algorithms used for climate and natural disaster modeling with the objective of validating them. There seems to be a gap between fine-grained models (e.g., of buildings) and large scale models. The gap inhibits efforts to provide predictability and validation of models.

- The subcommittee strongly endorses the research program in quantum computing and communication. This is a high risk, high payoff area. While there is serious quantum computing and communication work in progress in the private and academic research sectors, it is often the case that only governments can afford to make the sustained investments needed to achieve results. NIST has been at the forefront of work in this area and should continue its efforts.

- NIST has made a very strong case for the importance of outreach in the development and focus of the USMS (see section 4 of NIST's three-year programmatic plan). While the text focuses on physical measurement, it is important to recognize the need for IT-related metrics that reveal computing and communications capacity, security, compliance and reliability.

- The United States is lagging in broadband capacity and better data is needed on national access to and use of high capacity data communications capabilities. The subcommittee recommends that NIST consider possible measurements and metrics to assist in the assessment of broadband access to Internet and related services in the United States.

- The United States may be lagging in its production of technically trained and qualified IT workers. NIST should consider working with other U.S. and international agencies to characterize U.S. performance in comparison with other countries. Other approaches to measure, quantify and improve IT management efficiency could offset demand for lower level IT maintenance personnel, providing a competitive advantage to government and industry.

- Congress should support the President's FY 2009 budget proposals for NIST and the general plan for multi-year budget growth. NIST works with many agencies, and coordinates much of that work through interagency organizations and plans. Still, there is opportunity to better coordinate the NIST budget allocations with other U.S. government agencies whose research interests overlap those of NIST. It is recommended that coordinated investments in facilities, staffing and programs can have multiplier effects across agencies with related agendas.

- NIST needs to be salary and benefit competitive with industry, especially in new areas of nanotechnology, biotechnology and information technology.

- NIST will need breakthrough levels of research results to keep up with the measurement needs of the research community and industry.

- NIST needs more flexibility in hiring of non-U.S. citizens. A significant fraction of American university degrees are granted to non-U.S. citizens and many of them could be highly productive working in areas of importance to NIST. We should be taking advantage of the available workforce in IT and others areas of specific relevance to the NIST programs.

3b. VCAT Bioscience/Healthcare Subcommittee

Chair: Thomas Baer; Members: Lou Anne Heimbrook, Jim Serum

Since Bioscience/healthcare was identified as a major investment/growth area by NIST, a VCAT subcommittee was formed in 2007. NIST management requested the VCAT subcommittee to work with the organizational unit (OU) directors to evaluate existing programs and to work with the OU directors in developing an overall NIST wide strategic plan for Bioscience and Healthcare (BHC). Over the past year the VCAT has participated in a series of meetings with OU directors from the Chemical Science and Technology Laboratory (CSTL), the Materials Science and Engineering Laboratory (MSEL), the Physics Laboratory (PL), and the Information Technology Laboratory (ITL) where the majority of the Bioscience and Health Care (BHC) programs are located. These meetings have been focused on developing an Institute wide strategic plan for this industrial sector. The NIST senior management team and VCAT subcommittee members have agreed that the following strategic planning process is appropriate:

- Identify industry sectors where measurement science plays a key role
- Review NIST programs in these areas
- Organize outreach to stakeholders in these areas to solicit industry input
- Formulate institute wide BHC strategic plan
- Circulate this plan to stakeholders for feedback
- Recommend budget and structure to implement plan.

The NIST senior leaders and the VCAT team are currently focusing on the third step in this process, and the subcommittee is working with the OU managers to help NIST to solicit input from the BHC industry.

History and Background in Healthcare

NIST has a long history of specific initiatives which have developed useful standards as well as making significant contributions to measurement science for the BHC industry. For example, in 1918, NBS launched a dental materials group that has made numerous important contributions to this area throughout many decades. In the 1920s, NIST helped to establish x-ray radiation exposure limits, which were quickly adopted nationwide and prevented significant harm to x-ray imaging technicians. Some of the current NIST programs evolved from these early efforts and are still producing useful Standard Reference Materials (SRMs) and contributing to measurement science in this area today. However, historically the fraction of NIST resources devoted to supporting the BHC sector is minute considering the size of the healthcare industry, currently estimated at approximately $2.2 trillion dollars, or roughly 20% of our gross domestic product.

Although considerable progress has been made in recent years in understanding the cause of disease and the development of therapies to improve health and increase the quality of life, these advancements are limited by our ability to measure trace levels of biological materials in serum or blood, to image tissue and organ systems at resolution levels that distinguish healthy and disease states, and to understand disease from a systems perspective. In addition, the Bioscience industry has rapidly expanded to include not only healthcare areas but also energy, food products, forensics and biohazards. The current need for development of advanced measurement technology to support the U.S. BHC industries is critical.

The sector has witnessed rapid development of quantitative molecular diagnostic and high resolution imaging technologies. These technologies complement the long standing qualitative, primarily observational, diagnostic methods previously used by physicians; providing revolutionary methods for early diagnosis and precise prescription of personalized therapies for patients. However, these methods often lack sufficient reproducibility, sensitivity, resolution, or measurement precision to achieve their full impact on the practice of medicine and meet the ever growing needs of the medical

practitioner. These new quantitative molecular diagnostic and imaging methods could be dramatically improved by implementing focused standards and measurement science programs at NIST which will have immediate impact on the quality of life of U.S. citizenry.

Findings

- Despite NIST's successful historical record with a number of specific initiatives in this area and the enormous size of the industrial sector, there is no laboratory specifically devoted to supporting the BHC industry and technology sector. The existing programs are limited in scale and scope, and are located in multiple laboratories across many different sites. Although the majority of these separate programs are well managed by the individual labs, they are not part of an overriding strategic plan to provide coherence, systematic program prioritization or organizational effectiveness in looking for synergism between the different projects. Bioscience/Healthcare projects often reflect specific requests external to NIST or are due to individual researcher interest or expertise. In spite of these organizational obstacles and the limited resources available, we believe that the staff has recognized these challenges and is making efforts to cross fertilize program and leverage expertise across laboratories. However, significantly increased efforts are needed to adequately service the needs of the BHC sector. The BHC strategic plan now being developed is an important step and must be pursued aggressively.

- The NIST management team is becoming more proactive in soliciting "customer" needs. We are also quite pleased to note over this past year increased dialog and cooperation between laboratories to explore needs in Bioscience and Healthcare. We fully support these trends and encourage the team to expand their efforts

- The three-year programmatic plan and proposed budgets for NIST should more specifically emphasize the importance of this BHC area.

- We strongly support NIST's recognized role in the America COMPETES Act and the American Competitiveness Initiative (ACI) and we believe that funding of BHC programs will greatly enhance U.S. competitiveness and encourage innovation in this critical industrial sector.

- The NIST management team identified five areas of focus in 2007; Biospectroscopy, Cell and Tissue Measurement, DNA Technology, Structural Biology, and Quantitative Imaging. In most of these projects, NIST lacks sufficient funding resources and applications expertise to be successful or to have a major impact.

- NIST's FY 2009 budget proposal appropriately identifies characterization and measurement of proteins as a critical need for the sector. However, most of the effort will need to be further defined and would still remain underfunded.

- The NIST management team has identified Bioimaging as one of its key opportunities. We support a significantly greater effort in this area. We believe that increased understanding of the measurement science underpinning this field will yield improvements in imaging resolution and sensitivity, enabling this field to contribute significantly not only to the field of diagnostics for early diagnosis of diseases like cancer, but also for the monitoring of biomarkers to predict disease recurrence and play a major role in speeding drug development, enhancing the competitiveness of the U.S. pharmaceutical industry.

- Many of the VCAT findings and recommendations are recognized by the NIST management team and they have requested assistance from the Bioscience/Healthcare subcommittee to assist in addressing the first of the foundation pillars in 2008, "outreach and identification of critical measurement and technology challenges" for Bioscience and Healthcare.

Specific goals and recommendations for CY 2008

- We recommend that the OU directors and NIST senior management develop a comprehensive Bioscience/Healthcare Strategic Plan during 2008.

- We recommend that the management team explore establishing additional strategic alliance partnerships in order to gain application expertise for implementation of its strategic plan.

- The subcommittee recommends that NIST staff organize a series of small workshops consisting of five to ten scientific and technology leaders in key industries within the BHC sector. Several key industries that could be included in this outreach effort are: diagnostics, drug discovery, BHC related information technologies such as electronic medical records, consumer and food product safety, and medical devices and materials. A primary goal of these workshops would be to identify critical measurement challenges and standards needs for the BHC industry. A secondary goal of these workshops is to educate the BHC sector about NIST capabilities, since most commercial organizations active in this sector are unaware of NIST.

- We support the efforts by NIST staff to organize a conference which will cover the long- term needs and priorities in Bioscience which will help to identify strategic thrusts and programs for NIST.

- Reports from these workshops and conference should be used to prepare a preliminary strategic plan which will be distributed to workshop and conference participants for comment.

- We recommend that the strategic plan be revised as appropriate to incorporate these comments and then be used to develop an infrastructure plan and corresponding budget to support the strategic initiatives in the BHC area.

3c. VCAT Nanotechnology Subcommittee

Chair: Paul Fleury; Members: John Cassidy, Elsa Reichmanis, Robert Williams

The National Nanotechnology Initiative (NNI) was reviewed under Congressional mandate in 2006 and judged to be on track in its responsibilities to communicate and coordinate among the more than two dozen Federal Agencies engaged in nanoscale research and education. The U.S. government invests over $1 billion annually in these efforts, has initiated dozens of centers and institutes across the country, and supported thousands of researchers and students over the past half decade or more. The VCAT Nanotechnology Subcommittee has reviewed NIST's roles and participation in the NNI with special attention to those aspects that intersect the NIST mission most strongly. The 2006 NNI review endorsed the seven major program component areas (PCAs) of the NNI: Fundamental nanoscale phenomena and processes; *Nanomaterials*; Nanoscale devices and systems; *Instrumentation research, metrology, and standards for nanotechnology*; Major research facilities and instrumentation acquisition; *Nanomanufacturing*; *Societal dimensions – Education; Environmental, health and safety (EHS); and Ethical, legal and other societal issues (ELSI).* We found those PCAs in italics to be particularly relevant to NIST. From this list the critical importance of NIST to the NNI and the country's global position in nanotechnology is both obvious and compelling.

Prominent among the recommendations of the NNI Report was to "expand research on the EHS effects of nanotechnology including effects of exposure on humans, wildlife and other ecological receptors; characterize and manage risks associated with exposure." NIST must play a leading role in meeting the challenge of the responsible development of nanotechnology. We are pleased to report below that they are well launched on this path.

Specific Findings and Recommendations with respect to Strategic Planning

Findings

- Nanotech research is widely distributed at NIST with several OUs participating. The total level of activity is estimated to be of order 20% of NIST effort. In line with earlier directives and briefings to the VCAT, the Nanotechnology Subcommittee focused on the specific strategic planning efforts in the new Center for Nanoscale Science and Technology (CNST) and the activities of the new NanoEHS program. While both have had input from and interactions with the other relevant OUs, the roles of the latter in the strategic planning processes were not explicitly reviewed by this subcommittee.

- The role of CNST is to provide measurement methods, standards and technology to support all phases of nanotechnology development from discovery to production; develop and maintain a national shared use facility, the Nanofab, with state-of-the-art, nanoscale fabrication and measurement capabilities; apply a multidisciplinary approach to problem solving that involves partnering with industry, academia, and other government agencies; serve as a hub to link the external nanotechnology community to the vast measurement expertise that exists within the NIST Laboratories; and help to educate the next generation of nanotechnologists.

- The three part structure of the CNST plan centers upon its Nanofabrication Facility; its Research Program; and its intellectual infrastructure including key partnerships. Near term goals are to fully establish the Nanofab facility, broaden its capabilities, and expand its user base. For the Research Program, the goals are to determine the community's research needs, determine core competency requirements and major new program areas. The intellectual infrastructure building requires recruiting the best talent, as well as establishing key partnerships with the NIST OUs and with both external academic, government and industrial players.

- Concerning CNST, we find that with respect to both the Nanofab and the research programs residing in CNST, there has been significant progress in planning and execution. During the past year, the VCAT has received detailed briefings on this progress from Dr. Robert Celotta, Director of the CNST. The acquisition, installation and commissioning of the major equipment for CNST is essentially complete. Approximately 85% of the planned technical personnel have been hired or authorized under existing funding. Completion of the personnel and equipment ramp-ups will require restoration of the funds deleted from the FY 2008 budget to at least the level in the President's proposed FY 2009 budget. Still developing are NIST internal partnerships, which involve the following OUs: MSEL (Nanomagnetics; thin film nanostructure, bistable switch; probe beams); Electronics and Electrical Engineering Laboratory (EEEL) (Nanomagnetics; low noise sensors; theory; magnetization dynamics); ITL (Nanomagnetics; domain properties); CSTL (Atomic Scale Measurement; atom switching dynamics); PL (Nanofabrication; edge roughness); and the NIST Center for Neutron Research (NCNR). Other connections and projects are under consideration.

- In response to a widespread concern about the responsible development of nanotechnology as well as a recommendation by the VCAT, NIST initiated in 2007 a program to develop standards and metrics associated with the responsible development of nanotechnology, which we refer to here as NanoEHS. At the NIST December 2007 meeting, a full briefing on the plans and activities of this initiative was provided by Dr. Laurie Locascio, Chief of the Biochemical Science Division and NIST NanoEHS Coordinator. She noted the on-going active participation by members of several OUs in NanoEHS, including: MSEL, PL, the Manufacturing Engineering Laboratory, and CSTL - with growing participation from the CNST and EEEL.

  Dr. Locascio noted several aspects of NIST's outreach, planning and participation in key standards and coordinating bodies such as: participating in the Nanotechnology Environmental and Health Implications (NEHI) Working Group of the Nanoscale Science, Engineering, and

Technology (NSET) Subcommittee, the coordinating office of the NNI; participating in and leading efforts in ISO, IEC, ASTM, IEEE; hosting the NNI-sponsored workshop to initiate interagency, academic, industrial cooperation and consensus building; developing first nanoscale reference materials; developing analytical methods to characterize nanomaterials; and developing high-throughput multiplexed screening methods for quantitative, reliable toxicity measurements. She also noted that all of these efforts were seeded by funds from other programs in prior years. The deletion of this item from the FY 2008 budget was a setback that needs to be rectified at least to the level of the FY 2009 President's budget.

- Despite the positive progress in strategic planning for both CNST and the NanoEHS program, and the participation of several OUs in both, we find that the coordination and planning of nanotechnology on a NIST-wide level is not optimal.

Recommendations

- The natural differences in responsibilities, funding and resources between line organizations and lab wide programs are evident in all broad organizational strategic initiatives. Nanotechnology at NIST is no exception. These differences and their associated issues need to be addressed if NIST and the nation are to take full advantage of the opportunities presented by nanotechnology.

  While the EHS aspects of nanotechnology illustrated these issues to some degree, there seems to be general agreement that the de facto point person in this area is Dr. Locascio. And for the moment, no action might seem to be needed. But there are several cross-cutting issues in nanotechnology such as manufacturing, electronic applications, energy problems, etc that highlight the absence of and need for a higher level structure in carrying forward the formation and execution of a NIST strategy for Nanotechnology.

- We recommend that the Director establish a Nanotechnology Coordinating Council to develop a NIST-wide strategic plan, to establish appropriate points of contact for both internal and external stakeholders, and to help coordinate and prioritize nanotechnology programs within NIST.

Infrastructure and Process

Findings

- Because of our strong focus on the CNST and NanoEHS, we do not know how all of the OUs involved in nanotech go about meeting their challenges relative to either physical or intellectual resources or infrastructure. However, following our investigation of the start-up of CNST, we have a fairly complete picture of how the CNST is addressing these issues.

- As noted above, the physical infrastructure for the CNST is on track, as is the recruiting of technical personnel. They are now developing the methods and metrics related to their outreach and collaborative interactions. In particular, they and the NCNR are beginning to build mutually beneficial new programs. The NCNR has been widely recognized as the leading neutron scattering facility in the United States for several years, and is expected to remain in that position for at least the next decade, even with the operation of the new Spallation Neutron Source at Oak Ridge. Because of the importance of materials in nano and biotechnology, the NCNR should give NIST a prominent role in the development of both. The CNST is critical to NIST's exploiting that opportunity.

Recommendations

- We recommend that NIST follow through on plans to complete ramp-ups for the CNST and NanoEHS programs as well as the Nanotech measurement science and other priorities as described in sections 9.1.1.3 and 9.1.2.2 of the three-year programmatic plan. Funding increases for these programs were not provided as requested in the FY 2008 President's budget.

- We recommend that the proposed Nanotechnology Coordinating Council work to enhance collaborations among all the relevant OUs involved in NIST nanotechnology.

- NIST participation on a myriad of standards bodies is applauded and their continued partnering with industry particularly on international standards bodies is strongly urged.

- We believe there is need and opportunity for a more strategic approach to such partnering when it comes to Nanotechnology in particular to help ensure a level playing field for American industry in this arena. To this end, we suggest that the VCAT receive a briefing on this issue from Dr. George Arnold and his colleagues in Technology Services at a subsequent VCAT meeting.