FY 2004 REPORT TEMPLATE FOR NSF COMMITTEES OF VISITORS (COVs)

Date of COV:	May 11-13, 2004
Program/Cluster:	**Nanoscale Science and Engineering FYs 2001, 2002, 2003**
Division:	(Cross-foundation Activity)
Directorate:	**NSF-wide**
Number of actions reviewed by COV: Awards: 86 **Declinations:** 72 **Other:** 0	
Total number of actions within Program/Cluster/Division during period being reviewed by COV: Awards: 420 **Declinations:** 1932 **Other:** 0	
Manner in which reviewed actions were selected: See Appendix A: Explanation of Sampling Strategy	

EXECUTIVE SUMMARY

Overview: The Committee of Visitors (COV) for the National Science Foundation's (NSF) cross-directorate program in Nanoscale Science and Engineering (NS&E) met in Arlington, VA, on May 11 - 13, 2004, to review the program. Appendix B shows the meeting agenda, Appendix C is the charge to the Committee, and Appendix D describes the qualifications of the Committee members.

The NS&E program involves all NSF directorates. The NS&E solicitations reviewed were from FY 2001 - FY 2003 and included four modes of support: the Nanoscale Science and Engineering Centers (NSEC), the Nanoscale Interdisciplinary Research Teams (NIRT), Nanoscale Exploratory Research (NER), and Nanotechnology Undergraduate Education (NUE). The solicitations addressed seven themes, including biosystems at the nanoscale; nanoscale structures, novel phenomena, and quantum control; nanoscale devices and architectures; nanoscale processes in the environment; multi-scale, multi-phenomena theory, modeling, and simulation; manufacturing processes at the nanoscale; and societal and educational implications of scientific and technological advances on the nanoscale.

Charge to the COV: The COV was charged to evaluate (a) the integrity and efficiency of the program's processes and management and (b) the outputs and outcomes of NSF's investments. The COV was also asked to (c) comment on other topics, and (d) comment on NS&E-specific issues with respect to people, ideas, and tools. The COV reviewed material related to the NS&E competition for all four modes of support. It did not review proposals or programs outside of the competition, i.e., activities supported by NS&E funds in the "core" programs.

The following discussion highlights the COV's main findings and recommendations. More detailed analyses are covered in the responses to questions in the COV template and in response to questions specific to the NS&E program (Section D).

The CoV found all aspects of NSF's performance to be of exceptionally high quality. NSF has done an extraordinary job in building nanoscale science and engineering, a nanoscience community, and the tradition of interdisciplinary collaboration. The NS&E program should be praised for setting the standard in this regard, and COV members used words like "off scale" and "outstanding job" to describe the overall impact of the NS&E program.

Two significant and enduring results have emerged from this investment, which may be viewed as over and above the usual measures of people, tools, and ideas. They are the creation of a nanoscale science and engineering community, and the fostering of a strong culture of interdisciplinary research. The strong interdisciplinary research community NSF has fostered will contribute to the next generation of work force, which will be extremely well equipped for our nation's next generation of industrial needs.

A. The overall integrity and efficiency of the program's processes and management meets the highest of standards. The COV observed that the distributed funding mechanism used for NS&E awards is very positive because it promotes collaboration between program officers and allows interdisciplinary proposals to come to the surface. Although the framework and context for review panels is provided by the program solicitations and the Management Plan, the COV recommends that more detailed and tailored review forms be used for the different solicitations. This would enable the review panels and program officers to better assess certain aspects of the proposal that are unique to its mode of support. The COV found that educational components for all modes of support were given great significance and all the reviewers commented positively on them.

The time to decision for all modes of support was close to the NSF goal of six months. The NSF staff should be commended for this, particularly since for most of them the NS&E proposals represented additional workload with no additional staff. The geographic diversity among awardees seems to be good, as does the balance between reviewers from different types of academic institutions.

However, there were some indications of risk aversion, even with the NER proposals. The COV questions the low number of industrial reviewers, particularly given the projected impact of nanotechnology on industrial innovation and economic development. Furthermore, even though the award rate was good for new PIs and for women PIs, it is still not high enough for underrepresented minorities.

Finally, most COV members identified research at the intersection between biology and nanoscience as a frontier that is not being sufficiently explored by the program. Many thought that this area would produce some of the future's most important innovations, yet this emerging opportunity was not well represented in the final awards. This finding is explained more fully in Sections C and D.

B. The outputs and outcomes of NSF's investments in NS&E are substantial. The NS&E programs have already had a profound impact on people and education. It is estimated that over 250 colleges and universities now have courses in nanoscale science and engineering, whereas there were none a decade earlier. Furthermore, during the FY 2001 – FY 2003 time period the conservative estimate is that 2,000 graduate students and 700 undergraduates have been directly affected by NS&E programs. It is estimated that another 3,500 to 7,000 other undergraduate and K-12 students have been reached through education and outreach programs. The NS&E program has been pivotal in developing a skilled workforce and a public that is informed about nanoscale science and engineering. The number of scientists working in this area and the amazing web of interdisciplinary connections established are some of the best outcomes to date. The skilled workforce and the web of interactions are critical for maintaining U.S. leadership in this area.

There are many significant and promising outcomes with respect to ideas. The ability systematically to control matter at the nanoscale has been a great success story. A growing set of nanoparticle synthesis strategies that didn't exist five to ten years ago now allow us to control size and composition and shape with precision and infinite variability. Some of these advances are described in "nugget" form in the body of this report. Overall, the quality and relevance of the NS&E portfolio is extremely high.

There has also been some interesting new tool development to date from the NSEC, NIRT, NER, and NUE programs. It should be noted that the projects under review correlate well with the broad NNIN (Nanotechnology National Infrastructure Network) and NCN (Network for Computational Nanotechnology) programs and take advantage of them from a "tools" point of view. However, the COV posits that there are many facilities, tools and infrastructures yet to be developed, and that these developments will be forthcoming in future years of the NS&E program. We must also look for connections with industry for near-term projects.

C. Other topics: The award rate for nano-bio proposals is very low. The high proposal pressure from the community and the small amount of funding available from the BIO Directorate conspire to create very low award rates for the theme area "Biosystems at the Nanoscale." This is particularly troublesome, as many COV members identified the nano/bio area as one in which breakthroughs will occur and major advances will be made. This situation places a heavy burden on proposers.

D. The NS&E program, as structured, includes a few areas that are not as well addressed as others. These gaps include biosystems at the nanoscale (identified in C, above); nanoscale architectures that are embraced by an industrial "pull"; nanoscale processes in the environment; manufacturing processes at the nanoscale, and societal and educational implications of NS&E.

To the credit of the NS&E program, steps have already been taken to address a number of these gaps. For example, a new research and education theme on nanomanufacturing was added in the NSE program solicitation since FY 2002, and 28 NIRT and 29 NER awards were made in this theme area in FY 2002 and FY 2003. The success rate for this theme was higher than the average success rate for both NIRT and NER in FY 2002 and FY 2003. In FY 2002 there was a special NSEC solicitation dedicated to manufacturing processes at the nanoscale and two awards were made. Results are only now beginning to emerge from these awards. Furthermore, most of the NSECs have added components on societal implications to their portfolios, and several NIRTs have been awarded in this area.

The gap for nanoscale architectures, nanoscale processes in the environment, and societal and educational implications was in the number of proposals received, but the success rate for all of them was higher than the NIRT and NER average for FY 2001-FY 2003. In order to stimulate more proposals in the areas of environment, and societal and educational issues, each institution was allowed in FY 2004 to submit additional proposals for NIRT and NER as compared to the general limit if those proposals address environment or societal and educational implications.

Technology transfer industrial interactions have been good. There have been a number of successful spin-off companies from NS&E funded projects. However, the COV expected to see a stronger participation of large industry and government labs, especially in the NSECs.

THE NS&E COV PROCESS

The COV for NSF's cross-directorate program in Nanoscale Science and Engineering (NS&E) met in Arlington, VA, on May 11 - 13, 2004 to review the program. Prior to the meeting, members had received the three solicitations, accompanying management plans, the charge and template, proceedings of the NS&E grantees meetings, the 2002 NRC evaluation report of NNIN, and other relevant documents. In addition, SRI International provided analyses of program data, a list of all proposals under consideration, a list of proposals in the sample, and a description of the sampling strategy. Members were also sent conflict of interest forms, which they signed and returned.

At the start of the meeting Dr. John Brighton, Assistant Director for Engineering, and Dr. Michael Reischman, Deputy Assistant Director for Engineering, spoke with the Committee about the importance of COV reports. The Committee then heard a presentation from program coordinator Mike Roco about the NS&E program in the context of NSF and overall Federal support for nanoscale science and technology. The COV was also briefed on NSF's conflict of interest policy and shown how to find documents within a file jacket.

Each COV member was assigned responsibility for gathering data for either a mode of support (NSEC - Farquharson and Yardley, NIRT - Hochella, NER - Muzzio, NUE - Nordell and Sheares-Ashby) or a theme (biosystems at the nanoscale - Makowski; nanoscale structures, novel phenomena, quantum control - Shimizu; nanoscale devices and architecture - Theis; nanoscale processes in the environment - Michalske; multi-scale, multi-phenomena theory, modeling, simulation - Puszynski; manufacturing processes at the nanoscale - Lyons; and societal and educational implications of scientific and technological advances on the nanoscale - Thursby). Martin was responsible for crosscutting areas and Hu served as overall consultant to the COV.

The COV members spent the rest of the day examining jackets associated with their respective assignments. At the end of the day the COV members reconvened and met with program directors. They then spent several hours as a group and provided input to Sections A and C.

Much of the second day was spent with the jackets and writing individual paragraphs for the report. After lunch the COV members reconvened and worked as a group on Sections B and D (which were somewhat redundant).

The morning of the third day was spent reviewing a preliminary draft of the report and providing feedback to program officials.

The COV is especially grateful to the very helpful NSF staff who ensured that the operations were smooth, including Joanne Culbertson, Gwen Owens and Tyffani Smith. The COV also appreciates the work of Susan Russell and Jim McCullough of SRI International, who compiled large amounts of data and assisted with the meeting.

PART A: INTEGRITY AND EFFICIENCY OF THE PROGRAM'S PROCESSES AND MANAGEMENT

At the outset the COV wishes to express their sincere appreciation for the formidable job the NSF is doing in organizing and administering the NS&E program. Review of the documentation consistently reveals that NSF professional staff goes to enormous lengths to ensure a review process that is as fair, thorough, and conscientious as humanly possible. Despite being severely understaffed, they have succeed in creating an impressive in-house multidisciplinary process that accomplishes the task of reviewing an immense number of proposals in a dazzling range of topics, while maintaining high scientific standards, and responding to broader needs to ensure equal opportunity across gender, culture, type of institution, race, and geography.

As with any human endeavor, the review process can be improved. Comments provided by the COV are offered in this spirit. They are not meant as criticisms, but rather as an attempt to assist this highly capable and enormously caring group of professionals in reaching their goals in an even more impressive manner.

A.1 Questions about the quality and effectiveness of the program's use of merit review procedures.

Is the review mechanism appropriate? (panels, ad hoc reviews, site visits)	Yes

Comments: Review panels were the primary mechanism for reviewing the NERs, NIRTs, NUEs, and NSECs for FY 2001 – FY 2003, although *ad hoc* reviews were obtained when deemed necessary to resolve split decisions or to bring in additional expertise. The NSEC reviews included panels for the preproposals, panels for the proposals, and reverse site visits. The extensive reviews for the NSECs ensure that successful proposals have been extensively examined. As large, multi-investigator grants, NSECs represent a more substantial investment of NSF resources and require a more extensive review process. Although this level of review is necessary, the process places a significant burden on the community of reviewers and on the NSF staff.

The program solicitations and management plan describe very well the process for reviews, and the process employed matches that which was outlined in the solicitations. People selected for the review panels were necessarily generalists and/or highly interdisciplinary and were chosen with input from all seven directorates.

The COV concluded that the quality of the review process from a panel is generally of higher quality than if one relies solely on mail-in reviews. However, it was noted that mail-in reviews might provide critiques from four to six experts, whereas the panel may contain only one expert for an area under scrutiny. The panel allows for debate and usually reaches consensus through an iterative process. Panels are important for interpreting and normalizing an individual reviewer's rating. However, panels run the risk of having a ‘toxic reviewer’ who may try and in some cases succeed in single-handedly killing a proposal. It appears that the program officers have done a good job in avoiding or managing these situations if or when they arise. In such cases, other reviews may be solicited if expertise is insufficient for final decision.

It would be beneficial to develop a more comprehensive and/or tailored reviewer's form, which would address key issues related to Criteria 1 and 2. This issue is discussed in later sections of this report.

Is the review process efficient and effective?	Yes

Comments: See Section C.3 for a detailed description and analysis of the review process.

COV members originally expressed concern that some proposals may “fall through the cracks” because funding is highly distributed. They questioned what happens if a top ranked proposal is not aligned with a core program. Program officers, Foundation wide, seem to be very aware of this possibility and take great efforts to ensure that the top science is funded. Last year, for example, four different program officers contributed an additional $25K each to fund some of the NERs. The NIRTs are a little more difficult because they require the commitment of substantially more money. Nevertheless, for FY 2003, program officers spent an additional $19M of core money on the NIRTs. The COV finds that the funding mechanism is very positive because it requires collaboration between program officers and this allows interdisciplinary proposals to come to the surface. Furthermore, if a NIRT is not interdisciplinary enough there might be a problem getting sufficient funding --- which is exactly how the system should work.

Some COV members questioned the efficiency of the NSEC review process, with three panels (one preproposal, one proposal, and one reverse site visit). Is this process efficient? On the other hand these are large grants involving a large number of people, and the mean time taken to reach a decision on NSEC proposals is about the same with that for NIRT and NER proposals. A concern might be that we are overusing potential high quality reviewers. Another issue was the following: with a large number of applicants, can NSF locate sufficient quality reviewers that do not have some form of conflict of interest? The overall sense of the COV is that NSEC reviewers are of high quality.

For the Societal and Education proposals, the tendency to hold virtual panels by teleconference was efficient given the small number of proposals. For example, in FY 2002 of the 387 NIRTs, four were in SE and of the 80 NUEs, only four fell in this category.

The COV questions whether the NSF-wide metrics for measuring review efficiency are adequate and efficient. For example, could one use reviewer hours/funding dollars as a metric?

Are reviews consistent with priorities and criteria stated in the program's solicitations, announcements, and guidelines?	Yes

Comments: The framework and context for review panels is provided by the program solicitations and the internal management plan. Uniform instructions are provided to the panels by the NSE program officers. However, panel members seem to have an immense amount of latitude in judgment in how these criteria and priorities are interpreted. In some cases, the COV recommends that more guidance would be appropriate.

The COV also felt that a great deal of uncertainty could be hidden in the phrases in the Form 7 summary of the review process. The fraction of proposals funded by program directors from those recommended for funding by the external peer review panels in the interval FY 2001-2003 was 158 funded / 284 recommended for NIRT (55%), and 222 awards / 310 recommended for

NER (71%). Initially, NSF asked the panels to recommend a number of proposals that would insure a rate of about 50% if the funds committed in the NSE Management Plan would have been used. The actual award rates were higher than 50%, due to the additional contributions made by program officers from core funding, i.e., in competition with proposals received in the respective core programs.

Additional criteria for the evaluation of NIRTs, NERs, NSECs and NUEs as compared to the NSF general criteria are provided in the program announcement and management plans, and the panels were required to follow them. It was noted that one panel member developed his/her own numerical scale for two review areas. Would a finer-grained review scale be appropriate? Is it possible to tailor review forms for specific solicitations? This is especially true for the NERs, where one questions whether "impact on education" is relevant for a one-year exploratory research program.

There were also questions about how panel members reviewed the broader impacts of the NUEs. For example, in one case the impact was for 20 students at a small liberal arts college whereas another proposed program impacted 1,700 students at a large university. It may be the case here that quality was emphasized rather than quantity. Nevertheless, how does one make the criteria flexible and yet specific enough?

Educational components for all modes of support appear to have been given great significance and all reviewers commented on these components. In general, both *ad hoc* and panel reviewers considered the stated criteria.

There were some indications of risk aversion, even with the NER proposals. For example, a COV member noted that a NER was awarded even though the panel indicated as to intellectual merit that "The general idea of this proposal is not new or very high risk." Overall, however, it seems that the level of risk is appropriate.

Do the individual reviews (either mail or panel) provide sufficient information for the principal investigator(s) to understand the basis for the reviewer's recommendation?	Yes

Comments: Individual reviews and panel reports provided sufficient information for the PI, particularly when revisions were suggested. This comment also applies to proposals recommended as inappropriate for a particular program or solicitation. The declined proposals had very detailed reviews.

The COV also noted anecdotal evidence of Program Managers spending time via e-mail to clarify questions from the PIs.

Do the panel summaries provide sufficient information for the principal investigator(s) to understand the basis for the panel recommendation?	Yes

Comments: Most panel summaries captured the consensus of the panelists and were especially useful if there were divergent panel views. It was evident that the program officers critically read the reviews to fairly interpret the ratings. The COV saw documentation that program officers weigh panel ratings by a number of methods, including evaluating the panelists' expertise, and inviting additional reviews both internally and externally.

The COV discovered examples where the program officers went to great lengths to ensure that the proposals were fairly reviewed and that sufficient information was transmitted to the PI.

Is the documentation for recommendations complete, and does the program officer provide sufficient information and justification for her/his recommendation?	Yes

Comments: In general the documentation for recommendations is very good, especially for unfunded proposals. Some COV members would like to have seen a stronger summary from the program officer for funded proposals, as well.

A general context statement for the NSE competition has been developed by the NSE Group each year in order to be inserted in each jacket. It would also be desirable to have a matrix in the jackets so one could see explicitly how the process went (only one or two of the jackets examined had this).

Is the time to decision appropriate?	Yes

Comments: The following table lists the mean time to decision for the random sample of grants for FY 2001 – FY 2003. These numbers are very close to the NSF goal of six months to decision. This is highly laudable considering the number of reviewers and the amount of work involved.

	Months to decision (mean)
NER	Accepts 6.0 – 7.6 Declines 5.0 – 6.1
NIRT	Accepts 6.5 – 8.3 Declines 5.2 – 6.2
NSEC	Accepts 6.2 – 7.1 Declines 3.1 – 6.3
NUE	Accepts 6.4 Declines 5.0

Source: SRI analysis of FY 2001 – FY 2003 data from NSF records.

Given the complexity of the review process for NSEC's and the large number of people involved it is extraordinary that the process was accomplished on schedule. The NSF staff should be commended for this, particularly since for most of them this represented additional workload with no additional staff.

A2. Questions concerning the implementation of the NSF Merit Review Criteria (intellectual merit and broader impacts) by reviewers and program officers.

Have the individual reviews (either mail or panel) addressed whether the proposal contributes to both of the merit review criteria?	Yes

Comments: In general, the trend between FY 2001 and FY 2003 is that reviewers are increasingly likely to consider both review criteria in their reviews. Furthermore, the PIs are becoming more sophisticated in addressing Review Criterion 2, and the reviewers are better able to make substantive remarks on this. For FY 2003 for the random sample, the numbers were:

	% of reviews in FY 2003 in which the mail reviewer considered both criteria
NER	67%
NIRT	72%
NSEC	64%
NUE	64%

Source: SRI statistics for FY 2001 – FY 2003 data from NSF records.

<u>Note:</u> The COV notes that the statistics in the table above were not borne out by inspection of the jackets; for those jackets examined, the compliance was much higher.

Have the panel summary reviews addressed whether the proposal contributes to both of the merit review criteria?	Yes

Comments: This was done in all of the panel summaries examined.

Have the review analyses (Form 7s) addressed whether the proposal contributes to both of the merit review criteria?	Yes

Comments: This was noted in all of the jackets examined.

Discuss any issues or concerns the COV has identified with respect to NSF's merit review system.

In light of the recent addition of more detailed review criteria for specific programs provided to panel members prior to the panel review process, the COV recommends that the review forms themselves be tailored to the more specific review criteria. In a few cases, the jackets revealed that panel reviewers were designing their own "review rubrics." While this is interesting, how are these reviewers making judgements about the interpretation of the criteria?

See also suggestions, above.

A.3 Questions concerning the selection of reviewers.

Did the program make use of an adequate number of reviewers for a balanced review?	Yes

Comments: The following table captures the average number of reviewers per proposal for various modes of support for FY 2001 – FY 2003. These numbers are well above the NSF requirement of at least three reviews per proposal.

	Average number of reviewers
NER	5.9 – 6.3
NIRT	6.4 – 7.3
NUE	4.7

Source: SRI analysis of FY 2001 – FY 2003 data from NSF records.

Note: The above table may not be accurate, as far fewer reviews were observed in some of the jackets that were examined by the COV. It may be possible that the above statistics pertain instead to "reviews solicited." Furthermore, the statistics are exacerbated by the review panel mechanism, where it is difficult to enumerate exactly how many people "reviewed" a proposal. Statistics are not provided here for the NSECs because of the preproposal and proposal stages of review.

The COV noted that obtaining the right expertise on a panel might be a problem. This was particularly a problem for the proposals on societal implications, where scores given by physical and biological scientists were high whereas social scientists gave much lower ratings. An issue with the NIRTs is that reviewers must cross several disciplinary areas, and there is a small pool of reviewers who can do this well.

It was also suggested that the minimum of three reviews might be increased for really interdisciplinary proposals, especially the NUEs. The NUE jackets examined by the COV had only three.

Finding appropriate reviewers for the NSECs is a nontrivial issue since many different institutions are involved and they include many of the leading researchers in nanotechnology.

Did the program make use of reviewers having appropriate expertise and/or qualifications?	Yes

Comments: The COV was impressed with the very high quality of the NER reviewers and the outstanding quality and diversity (sex, geographical, institution size) of the NIRT and NUE reviewers.

For the NSECs there was the concern expressed above about finding qualified reviewers with so many applicants. Nevertheless, the quality of the NSEC reviewers was judged to be very high.

Did the program make appropriate use of reviewers to reflect balance among characteristics such as geography, type of institution, and underrepresented groups?	Yes

Comments: The geographic diversity seems to be good, as does the balance between reviewers from different types of academic institutions. Out of 1183 reviewers for the sample proposals, there were 645 unique reviewer ID numbers.

The COV questions the low number of industrial reviewers, particularly given the projected impact of nanotechnology on industrial innovation and economic development.

	% Academic	% Industry	%Government
NER	75 – 85%	0 – 7%	0 – 3%
NIRT	80 – 85%	2 – 5%	0 – 4%
NSEC	42 – 82%	5 – 8%	0 – 33%

Source: SRI analysis of FY 2001 – FY 2003 data from NSF records.

Note: The above numbers do not add up to 100% because the affiliation of some reviewers was not reported.

The COV suggests that it is very important to keep bringing new reviewers into the stable. One learns a lot from being on a panel, and revolving panel memberships ensure an important degree of corporate memory about the process and ensure uniformity over time. The following table suggests that not enough new reviewers are being incorporated into the process in the NS&E programs. This may be a function of the heavy use of panels as the primary mechanism for review of the NIRTS, NERs, NUEs, and NSECs.

	% New Reviewers
NER	1 – 3%
NIRT	0 – 1%
NSEC	0 – 4%
NUE	0%

Source: SRI analysis of FY 2001 – FY 2003 data from NSF records.

Note: Whether these low figures are accurate is questionable, as the NSF-wide average of new reviewers is 7% (NSF report on FY 2003 Merit Review Process, NSB 04-043). The COV recommends that NSF explore the possible reasons for these figures. NSF program officers pointed out that a better statistic might be "assistant professor" or perhaps people within five years of receiving their Ph.D.

Only 11.3% of the 645 reviewers provided racial/ethnic data, so there are no statistics for this indicator.

Did the program recognize and resolve conflicts of interest when appropriate?	Yes

Comments: Issues pertaining to conflicts of interest were very well handled and very well documented. A very positive example was during the review of an NSEC, where a new partner had been added. The reviewer and the program officer took care to resolve the conflict once it was recognized.

Discuss any concerns identified that are relevant to selection of reviewers.

See comments above. In addition:

For the NSECs: One would like reviewers who are well-versed in reviewing large scale and complex programs. The reviewers must be sophisticated in technical issues and also have experience in program management. It takes considerable maturity and ability to think on a macroscale to properly evaluate proposals of this type. Although this does not necessarily correlate with age and/or years of experience, it is laudable that reviews consistently included some senior scientists with years of involvement in or experience with successful large-scale programs.

A.4 Questions concerning the resulting portfolio of awards under review

Overall quality of the research and/or education projects supported by the program.	Appropriate

Comments: The research and education projects in the NER, NIRT, NSEC, and NUE programs are consistently of very high quality.

Are awards appropriate in size and duration for the scope of the projects?	Appropriate

Comments: In general, the NERs received the funds they requested. This was not true for the NIRTs and NSECs, which received less than expected. The COV noted that program officers handled the reduction professionally, asking the PIs to justify how the budget change would impact the scope of the proposed work. It was interesting to note that the financial allocations for the NSECs were made fairly evenly (awards were approximately 50-60% of the maximum amount indicated on the solicitation). One comment suggests that the awards were somewhat uniformly distributed rather than based on actual program needs. However, NSEC funding levels were generally consistent with panel assessments and recommendations.

The scope of many NERs exceeded what could be accomplished in a year with $100,000. It is important that the panels recognize that “proposal inflation” should not motivate funding the ones that promise the most and are thus set up for failure. On the positive side, one NUE examined was rejected because it proposed more than feasible. (Note that the change from one to two years' duration in the FY 2004 NUE solicitation was considered a very favorable and important change. This is probably the minimum time frame to expect implementation of an educational program. The increase of funding level of NERs to $130,000 in FY 2004 was well received because of the interdisciplinary characteristic of the awards, even if the the number of proposals accepted per university was reduced from 4 to 3).

Does the program portfolio have an appropriate balance of: • **High Risk Proposals?**	Appropriate

Comments: The NSEC proposals are very long range and are driven by a compelling vision. The risk for achieving the ultimate objectives is in many cases quite appropriately high, although with the broad definition and long time scales it is likely that interesting science will result. Ultimately this is a cost/benefit issue. The seed project aspect of the NSECs is an additional mechanism to encourage risk.

The NERs are typically high risk due to the exploratory nature. The high-risk/high-reward projects, as well as the additional criteria of evaluation to be used for NER, are defined in the program solicitations (Sections IIB and VIB, respectively). However, the program needs to further clarify the concept of risk so that the reviewers can apply the idea in a more enlightened fashion. The NERs are short term and should use a fine-tuned definition of risk. The COV noted that the funded NER proposals represented some of the more conservative ones. There was evidence within the jackets of a tendency towards risk-aversion in the review of proposals submitted to the NER Program.

It was noted by some members of the COV that mathematical modeling projects aren't as risky as experimental ones; and that we should call them exploratory instead. It seems to be more difficult to assess the risk in such proposals. This underpins the need to clarify the definition of "risk."

The reviewers of declined NIRT proposals more often discussed "risk" than did the funded ones. Does project composition (and if one person is riskier that the rest) have an impact? The focus on core teaming is good in the NIRT proposals.

There is not a great deal of risk with the NUE proposals. The top-reviewed proposals were the least risky because they fed into an existing infrastructure. This is a sensible way to evaluate the NUE proposals, but the COV noted that even in the NUE program, funding some risky proposals would be valuable.

Does the program portfolio have an appropriate balance of: • **Multidisciplinary Proposals?**	Appropriate

Comments: By definition the NSECs, NERs, NIRTs, and NUEs under review are multidisciplinary. These proposal modalities have had a very positive impact on the community.

Does the program portfolio have an appropriate balance of: • **Innovative Proposals?**	Appropriate

Comments: They are uniformly innovative.

Exceptions were the proposals on societal implications, which were inaugurated in the solicitation for FY 2001 and showed few innovative proposals for research on societal implications early in the process. However, by FY 2003 the quality of proposals on societal implications in the NIRT sample seems to have improved. Increased awareness contributed to the rise in both the number and quality of proposals on societal implications of nanotechnology by FY 2003.

The program officers are cognizant of this and have given considerable thought to mechanisms to improve quality and quantity. These include a workshop in 2002 together with the European Commission, and another in 2003 (at NSF) to increase awareness among researchers in the social sciences community, and consideration of the possibility of an NSEC focussed on societal issues.

Does the program portfolio have an appropriate balance of: • **Funding for Centers, Groups and Awards to Individuals?**	Appropriate

Comments: The programs under review include a good balance between centers, teams, and individuals. At some later date one may want to study the outcomes and make recommendations as to whether the balance between funding of Centers and teams and individuals should be modified.

Does the program portfolio have an appropriate balance of: • **Awards to New Investigators?**	Appropriate

Comments: It appears as though the award rate for new investigators for NERs is quite high. It was not clear whether this is by design, or if NERs simply make more sense for new faculty members.

	Award Rate for All Proposals	Award Rate for New PIs
NER	19 – 22%	33 – 40%
NIRT	12 – 16%	16 – 25%
NUE	43%	42%

Source: SRI analysis of FY 2001 – FY2003 data from NSF records.

Does the program portfolio have an appropriate balance of: • **Geographical Distribution of Principal Investigators?**	Appropriate

Comments: The geographical balance of PIs tracks fairly well with the populations of the states. However, there is strong representation among the NSECs from major research universities in the Northeast (Columbia, RPI, Cornell, and Harvard out of six initial awards and out of 8 total awards for the two year period).

Does the program portfolio have an appropriate balance of: • **Institutional Types?**	Appropriate

Comments: Except as noted above, the balance among institutional types is fairly good, especially for the NUEs.

While apparently not intentional, there was a nearly equal distribution of funded NUE proposals for small undergraduate colleges and large research universities. Without specific guidance the panels seemed to reach consensus about which were the highest merit proposals. Large schools partnered with existing programs to augment and enrich undergraduate curriculum, while smaller schools initiated new programs or created new interdisciplinary connections using the same amount of money. In this case it appears that not favoring proposals based on geography, institution size, or PI experience accomplished the goal of broadly enhancing undergraduate education in innovative and diverse ways.

Does the program portfolio have an appropriate balance of: • **Projects that Integrate Research and Education?**	Appropriate

Comments: The proposals in this sample, particularly the NSECs, do a good job integrating research and education. However, within the societal and educational theme, the education proposals in the sample appear to be better defined than the societal ones.

For NSECs the integration of research and education was a requirement. Panels correctly judged any proposal not exhibiting this balance, giving them poor ratings. There is a question regarding the extent to which this balance is needed for short-term NER projects.

Does the program portfolio have an appropriate balance: • **Across Disciplines and Subdisciplines of the Activity and of Emerging Opportunities?**	Appropriate

Comments: The COV examined the original focus areas identified by NSF. In general it found a good balance between disciplines and subdisciplines, and of emerging opportunities. However, nano-bio elements are represented as primary only in 13 NIRTs, 23 NERs and partially in two NSEC centers (RPI and Rice) and societal implications were only a primary theme in 2 NIRTs, 2 NERs, 2 NUEs and 1 NSEC (Rice). The focus of NSECs is distributed among molecular electronics (Columbia), molecular selfassembling and nanobiomaterials (RPI), sensors and patterning on surfaces (NU), and electronic and photonics devices (Harvard, Cornell). Rice covers nano-bio and environmental aspects (about equally distributed). The two centers awarded in FY 2002 are on nanomanufacturing.

Most COV members identified research at the intersection between biology and nanoscience as a frontier. Many thought that this area will produce some of the future's most important innovations. Yet this emerging opportunity was not well represented in the final awards. This concern is discussed more quantitatively in Section C3.

Does the program portfolio have appropriate participation of: • **Underrepresented Groups?**	Appropriate

Comments: The following table lists the award rates for FY 2001 – FY 2003 according to gender. The table shows that the award rates for women PIs are similar to, and in some cases notably higher than, the rates for all proposals.

FY	Mode	Award Rate All Proposals	Award Rate Female PI	Award Rate Female PI or co-PI
2001	NER	19.0%	22.7%	20.0%
	NIRT	11.9	17.8	17.9
2002	NER	22.0	19.0	19.0
	NIRT	14.1	16.7	13.7
2003	NER	20.7	37.5	23.7
	NIRT	16.4	27.8	19.7
	NUE	43.4	50.0	46.7

Source: SRI analysis of FY 2001 - FY 2003 data from NSF records.

The following table shows that award rates for minority PIs. Except for the NUE awards, the award rates for minority PIs are significantly lower than for the overall proposals. Note that there are many PIs who do not indicate their minority status in the proposals, and this makes it difficult to have reliable statistics.

FY	Mode	Award Rate All Proposals	Award Rate Minority PI	Award Rate Minority PI or co-PI
2001	NER	19.0%	10.0%	7.1
	NIRT	11.9	7.7	11.1
2002	NER	22.0	0.0	11.1
	NIRT	14.1	0.0	10.5
2003	NER	20.7	12.5	21.6
	NIRT	16.4	10.5	18.5
	NUE	43.4	50.0	66.7

Source: SRI analysis of FY 2001 - FY 2003 data from NSF records.

Is the program relevant to national priorities, agency mission, relevant fields and other customer needs? Include citations of relevant external reports.	Appropriate

Comments: The Program has done a remarkable job involving the community and shaping research priorities, mainly through workshops and symposia and meetings, and developing a long term strategic plan and an annual plan in collaboration with other agencies. The Chair of the NSE Group is also chairing the interagency Subcommittee on Nanoscale Science, Engineering and Technology (NSET) in the US National Science and Technology Council (NSTC). NSET coordinates the National Nanotechnology Initiative (NNI). The Office of Management and Budget (OMB) has a special crosscut for nanotechnology following the implementation of the annual plan. The PCAST (Presidential Council of Advisors for Science and Technology), NRC (National Research Council) and OMB periodically evaluate the NNI.

a. The following is a list of publications and reports:

NSF-Sponsored Workshops/Conferences/Reports

"Nanoscale Science and Engineering Grantees Conferences" (Arlington, 2001, 2002, 2003)

"Societal Implications of Nanoscience and Nanotechnology" (March, 2001)

"NSF/DOC Workshop on Converging Technologies for Improving Human Performance" (NSF, 2001; Los Angeles, 2002; New York, 2003)

Workshops on Nanomanufacturing (NSF, series of three workshops with various partners, 2002 and 2003)

Workshop on new directions for "Nanostructured catalysts" (NSF, 2003)

Workshop on new directions in nanotechnology for "Mechanical Engineering" (NSF, 2003)

Workshop on "Emerging Issues in Nanoparticle Aerosol Science and Technology" (UCLA, 2003)

Nanogeoscience Workshop (Berkeley, 2002)

Series of thematic workshops co-sponsored by NSF and European Union in 2002: Nanomanufacturing (San Juan), Societal implications (Lecce), Instrumentation and tools (Grenoble) and Nanostructured Materials (Boston)

NNI- Sponsored Workshops (in collaboration with other agencies)

"Nanotechnology: Opportunities and Challenges" (Southwest Regional Workshop, UCLA 2001)

"From the Laboratory to New Commercial Frontiers" (Southeast Regional Workshop, Rice University 2002)

"Nanotechnology Innovation for Chemical, Biological, Radiological and Explosive Detection and Protection" (2002)

Nanoscale Science and Engineering for Agriculture and Food Systems (Washington, D.C. 2002)

"Buildings for Advanced Technology Workshop" (NIST, 2003)

"NNI Grand Challenge Workshop on Nanomaterials" (NSF, 2003)

"NNI Grand Challenge Workshop: Nanoscale Processes for Environmental Improvement" (NSF, 2003)

"NNI Workshop on Nanobiotechnology" (Arlington, 2003)

"NNI Grand Challenge Workshop on Nanoelectronics, Photonics and Magnetics" (NSF, 2004)

"NNI Grand Challenge Workshop on Instumentation\ and Metrology in Nanotechnology (NIST, 2004)

"NNI Grand Challenge Workshop on Nanoscience Research for Energy Needs" (Alexandria, 2004)

Societal Implications of Nanoscience and Nanotechnology II (NSF, 2003)

Other Reports

*Small Wonders, Endless Frontiers: Review of the National Nanotechnology Initiative (*National Research Council, Washington, D.C. 2002)

Implications of Emerging Micro and Nanotechnology, Air Force Science and Technology Board (Washington, DC 2002)

Chemical Industry R&D Roadmap for Nanomaterials by Design: From Fundamentals to Function, Chemical Industry Vision 2020 (Technology Partnership 2003 in collaboration with industry and AIChE)

National Nanotechnology Initiative: R&D Supporting the Next Industrial Revolution, Supplement to the President's FY 2004 Budget (National Science and Technology Council Committee on Technology, Subcommittee on Nanoscale Science, Engineering, and Technology; Washington, D.C. 2003)

b. Citation from relevant external reports: the Academy (NAS/NRC) review of NNI in 2002: "Small Wonders, Endless Frontiers: Review of the National Nanotechnology Initiative" (http://www.nsf.gov/home/crssprgm/nano/smallwonders_pdffiles.htm); Citation from the Executive Summary of the evaluation report:

"During the course of its evaluation, the committee was impressed with the leadership and the level of multiagency involvement in the NNI. Specifically, the committee commends the leadership of the NSF in the establishment of the multiagency National Science, Engineering and Technology (NSET) as the primary coordinating mechanism for the NNI. The committee finds that the leadership and investment strategies established by NSET have set a positive tone for NNI. The initial success of the NNI can also be measured by the number of foreign governments that have established similar nanoscale science and technology research programs in response."

Discuss any concerns identified that are relevant to the quality of the projects or the balance of the portfolio.

How do we determine the correct balance between “sexy, cutting edge, glamorous but maybe unnecessary” and “incremental but needed” proposals?

It would be desirable for NSF ultimately to create a number of Centers that serve as building blocks for all identified major theme areas. Thus NSF might direct future NSEC solicitations toward those areas that are not being covered. Nano-bio and nano-environment are two obvious examples; societal impact might be another, and is apparently being considered for FY 2005.

A.5 Management of the program under review.

Management of the program.

The NS&E program is complex, highly distributed, involves program managers from seven Directorates, and requires coordination with other Federal agencies. The management of the program is guided by the concise and complete internal NSF document, "Management Plan," in which responsibilities are clearly delineated.

Given the expected budgetary constraints predicted out to FY 2009, the strategic plan to be finalized in 2004 for all NNI agencies where NSF is the lead investing agency should be used for continued investment in nanoscience and engineering for the next five years. The NNI strategic plans are comprehensive, and NS&E operates fully within them. The first long term plan was published in 2000 (“Nanotechnology Research Directions I”). Each year NSF and all agencies prepare an Annual Plan that is reviewed and approved by OMB, OSTP, and ultimately Congress. NNI had about 10 topical workshops in the last 10 months, and in September 2004 NNI will have the Research Directions II meeting (for setting priorities for five years ahead). In addition, NSF has topical workshops in most promising areas such as Catalysts (in 2003), Nanomechanics (2002, 2003), Selfassembling (2003), and others.

It is laudatory that some program directors in core programs have received awards for their collaboration and cooperation with the NS&E program. This is very positive and further encourages NSF-wide cooperation.

The COV had an initial concern that because money is so highly distributed over the seven Directorates, no one person has control. This concern was addressed by learning additional details on how one program officer took the lead for identifying other program officers who had an interest in a Center. This process requires significant individual and collective efforts and has produced a greater sense of community within NSF. It appears that the process is effective, with the possible exception of the BIO Directorate. See Section C.3.

In response to a set of concerns regarding the NSEC programs the COV recommends that an analysis of the review process should be performed across NSF.

1. Because the NSEC program has been administered through multiple branches of NSF there are a number of non-optimal management experiences. A few are listed here:

a. While the general guidelines are the same for NSECs, there is significant non-uniformity in the actual management process. Thus programs administered after awards by the MPS Directorate seem to follow a process influenced by the MRSEC protocols; those by Engineering are influenced by the Engineering Research Centers protocols; those by Chemistry have been indirectly guided by MPS staff.

b. The reporting protocol is not well defined and constantly seems to change.

Responsiveness of the program to emerging research and education trends.

Although one must guard against excessive responsiveness – overemphasizing "sexy, new, newest" at the expense of necessary work to make technology useful and robust – it appears the program has struck a very good balance.

The broadly based long-range nature of NSEC program concepts clearly allows for significant evolution as the field and directions of the general research area change (through both internal progress and external events). Similarly there is plenty of room for experimentation and variation in the educational activities of NSECs. Posting Center-related work on the web for student and general public access is a good example of adjusting to educational trends.

Program planning and prioritization process (internal and external) that guided the development of the portfolio under review.

The development of the entire NNI program and of the specific NSF research programs under discussion represents a model for the conception, creation, and execution of a major national research initiative. More than two years of careful, broadly based, and strategically developed program planning went into the creation of the NSEC program and its original solicitation. The solicitations are well written and well defined.

Discuss any concerns identified that are relevant to the management of the program.

Missing documentation: Sixteen (16) of the 171 randomly selected jackets were not readily located. Of these, half could have been sent to the Federal records repository. That leaves eight jackets, or a little over 4%, that may be simply missing. This number seems very high and raises a red flag. One may want to consider bar-coding the jackets or otherwise implanting them with locating devices, or better yet, going to a completely paperless system.

Low award rate areas: Regarding the nano-bio issue (see Section C.3) and any other low success-rate areas, it would be a good idea to notify the community regarding the success probability. It appears that over 157 NIRTs were originally coded "BIO", yet only 13 were funded. There was an 8.2% success rate for the Biosystems at the Nanoscale proposals, compared to an overall success rate for NIRTs of 13.8%.

PART B: RESULTS: OUTPUTS AND OUTCOMES OF NSF INVESTMENTS

Please provide comments on the activity as it relates to NSF's Strategic Outcome Goals. Provide examples of outcomes (nuggets) as appropriate. Examples should reference the NSF award number, the Principal Investigator(s) names, and their institutions.

B.1 OUTCOME GOAL for PEOPLE: Developing "a diverse, competitive and globally engaged workforce of scientists, engineers, technologists and well-prepared citizens."

Comments: The NS&E programs have already had a profound impact on education. It is estimated that over 250 colleges and universities now have courses in nanoscience and engineering, whereas there were none a decade earlier. Furthermore, during the FY 2001 – FY 2003 time period the conservative estimate is that 2,000 graduate students and 700 undergraduates have been directly affected by NS&E programs. It is estimated that another 3,500 to 7,000 other additional undergraduate and K-12 students have been reached through education and outreach programs. These figures attest to the impact that the NS&E programs are having. It is important to note that these figures do not include the first round of NUE awards, which will greatly increase the preparation of undergraduate students. See Part D for a discussion of specific 'nuggets.'

The NS&E programs have also had a major impact on creating an interdisciplinary culture of research. It is anticipated that this impact will be long-lasting. This issue is discussed more fully in Section D.

The NS&E programs have also created a community of nanoscale researchers, where none existed before. See Section D.

B.2 OUTCOME GOAL for IDEAS: Enabling "discovery across the frontier of science and engineering, connected to learning, innovation, and service to society."

Comments: If one looks at the entire NS&E portfolio, there are many significant and promising outcomes. These are discussed in detail in Part D, below.

B.3 OUTCOME GOAL for TOOLS: Providing "broadly accessible, state-of-the-art S&E facilities, tools and other infrastructure that enable discovery, learning and innovation."

Comments: There has been some interesting new tool development to date from the NSEC, NIRT, NER, and NUE programs. It should be noted that the projects under review fit well into the broader NNI and NCN programs and take advantage of them from a 'tools' point of view. However, the COV posits that there are many facilities, tools and infrastructures yet to be developed, and that these developments will be forthcoming in future years of the NS&E program. We must also look for connections with industry for near-term projects. Section D provides examples of new tool development.

It should be noted that with the short duration of funding, the NER has and will most likely continue to aid in the development of minor instruments or in the use of creatively combined instruments and/or techniques. Perhaps a NER with a higher funding level is necessary to explore the feasibility of larger or more complex instruments.

B.4 <u>OUTCOME GOAL for ORGANIZATIONAL EXCELLENCE</u>: Providing "an agile, innovative organization that fulfills its mission through leadership in state-of-the-art business practices."

Comments: NSF has made enormous progress in this area and should serve as a model for other organizations. Comments from the COV members during the meeting about NSFs NS&E program included quotes such as "off-scale program," "phenomenal impact," and "world-wide impact."

See Section A.5 for comments concerning the Management Plan.

PART C: OTHER TOPICS

C.1 Please comment on any program areas in need of improvement or gaps (if any) within program areas.

For additional gaps, see Sections C.3, D.1, and D.2.

C.2 Please provide comments as appropriate on the program's performance in meeting program-specific goals and objectives that are not covered by the above questions.

No additional comments here.

C.3 Please identify agency-wide issues that should be addressed by NSF to help improve the program's performance.

Organization: The Nanoscale Science and Engineering Program is organized in a way that may be unique within the Foundation. A working group chaired by Mike Roco and Lance Haworth coordinates the activities of all participants, reviews, and awards. The working group is charged with the responsibility of coordinating the process and assuring the uniformity and balance of the awards made. This process is defined in the annual NSF-wide Management Plan, which is developed and approved by the entire NS&E Group and by each Directorate. This relatively unusual process was deemed by the COV to be appropriate for NS&E although there was a general feeling that a more formal management structure might need to evolve at some point in the future.

Increased workload for NSF staff: The COV recognized the significant challenges represented in obtaining effective, multidisciplinary reviews of proposals in this field. Although review panels are organized along topical lines, many truly promising proposals involve participation of more than one scientific discipline (often disciplines that are highly divergent from one another). Putting together a panel that can effectively evaluate the promise of a proposal of this type is non-trivial. Engaging a large number of program managers greatly enhances the resources that can be used to obtain effective, multidisciplinary panels. However, virtually none of the program managers has NS&E as their first priority. The NS&E Program is an add-on to the workload for most participating program managers. This is part of a general trend of increased workloads of professionals within the Foundation. The high quality of staff throughout the Foundation provides the COV with some confidence that the reviews are being carried out in a thorough and considered manner. Nevertheless, increased workload will inevitably impact the quality of the review process in a negative way.

Award rate for nano/bio proposals: The high proposal pressure from the community and the small amount of funding available from the Bio Directorate conspire to create very low award rates for the theme area "Biosystems at the Nanoscale." This is particularly troublesome, as many COV members identified the nano-bio area as one in which breakthroughs will occur and major advances will be made. This situation places an unjustified burden on proposers.

	Award Rate of NS&E Proposals	Award Rate of Theme "Biosystems at the Nanoscale"
NIRT	13.8%	8.2%
NER	20.9	14.0

These figures are for FY 2001 - FY 2003 and include funding from both the budget allocated for the NSE solicitations and the additional funds committed from individual "core" programs. The award rate is calculated by dividing the number of awards by the total number of proposals. Note that (a) the number of proposals allowed from each academic institution was limited; and (b) the rates of funding (not award success) would be lower if calculated on the proportion of funds awarded/funds requested because of the reductions of the initially requested budgets.

C.4 Please provide comments on any other issues the COV feels are relevant.

Redundancy: A number of COV members found the COV questions unclear and/or redundant. For example, it was hard to discern the difference between sections A1 and A2.

Inconsistency among reviewers: Although beyond the scope of this COV, one member was struck by the widely varying ratings that proposals received. A single proposal could receive E, VG, G, P from different reviewers. Once the PI addresses the issues cited, is the revised proposal sent to the same set of reviewers?

C.5 NSF would appreciate your comments on how to improve the COV review process, format and report template.

Abstracts: It would have been nice to have the abstracts for the declined proposals.

Report generation software: The COV chair spent an inordinate amount of time copying and pasting documents. Shareware would be nice!

Additional: The COV would work more effectively if NSF compiled proposed answers to the broad questions and asked the COV to endorse or criticize this self-evaluation.

SECTION D: NS&E ISSUES

People, Ideas and Tools

D.1 What is the quality and relevance of the portfolio? Are there key gaps? What are important emerging needs and opportunities? (All modes and themes)

Overall: The quality and relevance of the NS&E portfolio is extremely high. Except as noted below, the portfolio covers important emerging needs and opportunities. The Section below defines gaps; Section D.2 provides examples of success stories.

Biosystems: The COV found a very low number of nano-bio proposals. Many COV members feel that the nano-bio area is where entirely new industries and products will be established. Examples include drug delivery, which includes entirely new pathways for targeted delivery. Other examples include diagnostics and new analytical capabilities. The COV recommends that there be a solicitation specific to nano-bio to fill the programmatic gap identified above. The COV also advises that this must be carefully written to avoid the response that "everything bio is nano."

Nanoscale structures, novel phenomena, quantum control: The portfolio is very good. Techniques to observe and better characterize nanoscale structures are long term investments, as are methods to analyze novel nanodevices. A nice example of an area currently under study includes new nanotube tips for Scanning Tunneling Microscopy STM (NER 0103476). A novel example of nanofabrication techniques was given by Lee (NER 0102639).

Nanodevices and architecture: Most of the jackets examined concerned projects characterized as device-focused, including exploration of materials and processes with some prospect of generating new devices. There is concern about the lack of projects that include a focus on architecture. Some of this has been funded by other agencies (i.e. DARPA Moletronics Program), and also it may be too early in the "post-CMOS" period to think very hard about "architectures." This is a difficult area and there is no certainty that there will be a successor to the silicon transistor. Still, some attention to the balance of this portion of the portfolio will be warranted in the next few years.

Environment: Other than the NSEC at Rice, there is not much work on environmental issues at NSECs. Environmental issues were considered in 16 NIRTs and NERs that have primary focus on environment. Because of current concerns about the toxicity of nanoparticles, there will be a strong push on NSF. The COV recommends that NSF work closely with NIH and EPA on these issues. An additional dimension is using nanoscale tools to learn more about the environment. Furthermore, the area of environmental fate and transport is important because it impinges on exposure, as does nanoparticle detection. NSF collaborates with ten other agencies including EPA, FDA, USDA, and NIH in an interagency "Nanotechnology Environment and Health Issues" working group under the NNI. This group currently meets once per month.

Theory: The NSECs do not directly address the issue of theory, modeling and simulation as a primary goal, but all centers have a component on this topic. However; there is a nano modeling center at Purdue (not part of the portfolio under review). Thirty-seven NIRTs and NERs awards have a primary focus the same topic. There was no direct NUE involvement for theory and modeling, although some is mixed in the projects. This is appropriate, however, because of the intent ("hands on," "laboratory") of the solicitation. It was very encouraging to see strong synergy between computational and experimental research proposed by the NIRTs.

It is very important that experimental, theoretical, and modeling approaches are considered in the NS&E initiative. Sixteen jackets were reviewed for this COV process related to the theme of multi-scale, multi-phenomena theory, modeling, and simulation. These sixteen proposals included eight submitted to NIRT and eight submitted to NER. No sample proposals submitted to NSEC or NUE were provided for that theme. Five proposals in the NIRT category were funded. In the category NER three proposals were funded within the reviewed sample of proposals. The funded NIRT proposals seem to be excellent and address well both technical and educational objectives. It was very encouraging to see a strong synergy between computational and experimental efforts of Co-PIs.

The NER proposals seem to be complementary to the overall process and they seem to play an important role in any exploratory research. It would be beneficial to have a better definition of what constitutes "high risk" related to both experimental and theoretical research.

In the final assessment it would be good for students to have NUEs and NSECs established in the area of theory, modeling, and simulation at the nanoscale. Until now, no NUE proposal has been funded for the Multi-scale, Multi-Phenomena Theory, Modeling, and Simulation theme.

Manufacturing: The addition of the Nanomanufacturing Centers addressed a major gap in the NSEC Program and has provided a valuable addition to the suite of Centers already in place. These Centers play an important role in that they advance science activities from promising fabrication technologies into production-viable processes. The NSECs provide the required stability for universities to establish state-of-the-art facilities that can define novel manufacturing processes. As NSECs become established and industry ties mature, a clearer understanding of actual production issues will serve to enhance the Centers' focus.

Many of the research efforts that have manufacturing components need to more clearly articulate the scalability of the fabrication processes and the required supporting infrastructure necessary to achieve production-level status. This would require the proposer to take a manufacturing engineer's perspective of defining a potential manufacturing process (controls, product packaging for downstream use [aerosols, fluids], process planning, in-process inspection, robust product design). The current nanomanufacturing NSECs are pioneers in this endeavor and have broken ground regarding the vision of large-scale nanomanufacturing.

From the jacket review, there appear to be no NUEs in nanomanufacturing. This is unfortunate as manufacturing education for undergraduates does serve as a key mechanism to excite students to continue graduate studies in this area. It was noted that nano-bio manufacturing was missing from the current NSEC portfolio except for RPI (Nanobiomaterials manufacturing is included only as a component in the NSEC portfolio), although the STC at Cornell provides some of this function.

NIRT: The NS&E Program supports an impressive portfolio of research themes and supporting modes. The NIRT Program solicitation defines the foundation and a supporting environment that promotes teaming and cross-disciplinary work. The four-year funding allows the team to establish credible relationships that will last. The ability for current NIRT Programs to compete in FY 2005 further validates NSF's commitment to deeply root successful programs at selected universities.

Societal: Societal components of the existing NSECs tend to be educational or tech transfer components and not true applications of social scientists doing research on the most important areas to get into. One NIRT at the University of South Carolina is dedicated to social aspects and interaction with the public. A NSEC solicitation specific to the societal ramifications of nanoscience and engineering would be beneficial. The COV notes that the recent workshop on societal issues was educational for the community.

Other: There were few proposals in the sample addressing Lab-on-a-Chip, nano valves, nano-actuators, and nanofluidics. These are enabling areas for medical diagnostics. The way diseases will be diagnosed in 20 years will be very different than the way that is done today. In a droplet of blood, urine, saliva, or in an exhaled breath, we will look for specific "biomarkers" of the disease state. These may be proteins or small molecules, and we may not understand their relationship to the disease. We may only know that the body expresses these biomarkers when the disease is progressing. The questions become: What are these biomarkers, and What technologies will we use to detect them? It is clear that bio/nanotechnology will play a role here. This will include the development of nano-fluidic systems to process the blood, urine, etc., sample and ultra-sensitive nanoscience based bio-sensing systems. For this reason, greater emphasis within NSF should be placed on nano-bio. This should be done in collaboration with NIH. NSF might focus on the device and diagnostic side and NIH could focus on the biomarkers themselves.

NSEC: From an NSEC perspective the overall portfolio is short on biosystems (RPI has some contribution here), architecture, environmental nanotechnology (although Rice does have a significant program here) and societal impact. A new societal impacts center solicitation which may happen in 2005 may help. Possibly NSF should create a nano-bio Center solicitation to assure that this part of the opportunity space is supported at the Center level.

NER: There do not appear to be major gaps, with the possible exception of support of the nano-bio area.

NUE: One potential gap is in faculty training. For example, if a faculty member desires to incorporate nanoscience and nanotechnology into their existing courses or develop new courses, is there a means by which they can get the necessary training (knowledge, skills)? A course for faculty on nanomechanics was supported in 2003 and 2004 at Northwestern University; other outreach/courses are organized by professional societies such as ASME, AIChE, ACS, and APS at times with complementary support from NSF. Other gaps are not obvious at this time, as the program is only beginning.

D.2 Have the investments produced significant outcomes? (All modes and themes)

The NS&E investment has produced substantial and significant outcomes. Exemplars of these outcomes, which involve people, tools, and ideas, are organized below according to the NS&E themes of support.

People: The emergence of a nanoscience and engineering community is an enormous cultural impact of the NSF investment. A decade ago people were doing nanoscience research in ones and twos. Now there are meetings and journals and communities for new assistant professors to become part of (and to be judged by). This is a very significant and long-lasting outcome.

Another important cultural impact of the NSF investment in NS&E is the encouragement of interdisciplinary research. The structures of the NSECs and NIRTS, particularly, require a team approach to research and innovation, training researchers to have scientific breadth as well as depth. This truly fosters and encourages interdisciplinary collaboration and will surely be a long-lasting change.

Education is another highly significant outcome of the NS&E portfolio. See Section B, above, for estimates of the numbers of graduate and undergraduate and high school students that have benefited from this portfolio. In addition, the NSECs have been active in developing courses and have had impact on children through Nanokids (Rice NSEC 0118007) and Nano*High (University of California at Los Angeles, NIRTs 0210690 and 0200742). Most universities now have courses in nanoscience and engineering, whereas a decade ago there were none.

The NUEs also address curriculum development, although it is too early to assess the impact. For example, the NUE at the University of Puerto Rico - Mayaguez (0304348) focuses on an active learning experience for undergraduates. In one set of experiments, the students synthesize nearly mono disperse silver nanowires based on wet chemical methods and then characterize the size distribution by scanning electron microscopy.

Tools: There are several examples of the development of tools for NS&E. For example, researchers at Northwestern (NSEC 0118025) have produced an *in situ* TEM nanomanipulator, allowing nanoparticles and nanomaterials to be characterized in three dimensions. A group at Harvard (NSEC 0117795) has developed methods to produce atomically sharp and reproducible AFM tips. A group at Texas A&M University (NIRT 0103455) has designed and fabricated microfluidic devices for the manipulation of micro/nano particles and droplets. These devices can apply controlled forces with attoNewton accuracy and manipulate droplets with volumes in the picoliter to femtoliter range. This is significant because the control of femtoliter size droplets means that one could deliver one molecule per droplet and control chemical reactions between single molecules.

Ideas: A plethora of novel ideas have emerged from NSF's investment in NS&E. The following list provides highlights in each of the theme areas.

Biosystems at the nanoscale: A number of very exciting ideas and tools have resulted from NS&E's investment in biosystems. For example, Kumta at Carnegie Mellon University, in collaboration with researchers at the University of Pittsburgh (NIRT 0210238), has prepared ceramic nanoparticles that carry non-viral DNA. Using ink-jet production, they can create unique three-dimensional shapes that correspond to desired bone reconstruction. When these materials are deposited in the body, they promote bone formation where there previously was no bone.

Another intriguing area of investigation is “vault nanocapsules.” Vaults are hollow structures that look like nanoscale (42 x 75 nm) mummy cases, and are found inside living cells of many organisms. Rome at the University of California at Los Angeles (NIRT 0210690) has developed methods to self-assemble vaults at will, and has discovered how to package large bioengineered proteins into the hollow cavities of the vaults. A wide variety of applications is envisioned, including drug delivery, biological sensors, enzyme delivery, controlled release, environmental and medical detoxification, and nano-electrical machine (NEMS) application.

Nanoscale structures, novel phenomena, quantum control: Awards are producing exciting developments in this area. For example, scientists from Columbia University, IBM, and the University of New Orleans (NSEC 0117752) announced in the June 26th issue of *Nature*, the first new “meta-materials” -- a three-dimensional assembly of magnetic and semiconductor particles only billionths of a meter across. This demonstration of modular assembly of nanomaterials promises to allow custom design of materials with tailored properties.

Interdisciplinary research performed at the University of Pennsylvania (NIRT 0102459), along with colleagues at the University of Sheffield, uses self assembly of conical dendrons into complex 8,500 atom spheres, which form a complex liquid crystalline material. This could be a model of what happens within a cell, to get large-scale supramolecular structures. Percec and colleagues' goal is to develop photonic crystals having predictable and reproducible interactions with light.

New molecular junctions (NER 0102960) show stable nanometer scale tunneling junctions between two Au films on a silicon chip, and future work may lead to reproducible molecular devices and molecular electronics. NSF awards have funded development of nanoscale channels (NER 0103140). Exploratory research awards spawned nanoscale wires (NER 0102467) and valves and Organic Light Emitting Doides (NER 0204978).

Nanoscale devices and system architecture: The NS&E investment has led to the production of a number of interesting devices. For example, a group at the University of California at Berkeley (NIRT 0210176) has synthesized molecular machines, which in turn, may some day form the sub units for molecular-mechanical assemblies. The machines are based on phorphyrins, functionalized carbon nanotubes, and azobenzene. Motion is induced by an external electromagnetic field.

Light, instead of an external electromagnetic field, is used to drive molecular motors being developed at the University of Nevada, Reno (NIRT 0210549). This motor is based on a linked trityl base supporting a dibenzofulvene rotor, and is activated by photon-induced isomerization about the exo double bond of the fulvene moiety. Theoretical models and simulations are being used to provide additional information about the expected mechanism for the rotor drive unit.

Although a number of significant and promising outcomes have emerged from the NS&E portfolio, no new device or new architecture has really generated excitement in the broader engineering and science community. However, this observation is not a strong criticism of the project portfolio. Many devices are invented; the market chooses very few.

Nanoscale processes in the environment: Nanometer sized particles in the atmosphere represent the precursors for the formation of larger particles, including natural forms of precipitation. Thus, the physiochemical properties of atmospheric nanoparticles are fundamental to our understanding of many aspects of the global climate. Additionally, atmospheric nanoparticles are being implicated as playing critical roles in human health effects associated with air quality. A group at Harvard University, in collaboration with the University of California at San Diego and Arizona State University (NIRT 0304213) is using a wide range of analytical tools to understand the interaction of nanoparticles with water and other vapors.

Multi-scale, multi-phenomena theory, modeling, and simulation: Close interaction among researchers from different fields, and especially those involved in theory and modeling with experimentalists is a very encouraging trend, which should lead to better understanding of phenomena on the nanoscale. An example is the work at Harvard (NSEC 0117795), which is investigating the coherent flow of electron waves. They have simulated the quantum flux density of electron flow in a two-dimensional electron gas from a quantum point contact. The pattern of flow in the simulated image agrees quite well with the flux density, and shows fringes produced by backscattering like those seen in the experiment.

Manufacturing processes at the nanoscale: Novel methods are being developed for potential use in nanoscale manufacturing. Several promising areas are noted below:

- At the University of Massachusetts, Amherst (NIRT 0103024), researchers are using as templates diblock copolymers, whose self-assembly on the nanoscale can be controlled. Exposure to light is used to selectively degrade regions to obtain a honey-comb like nanoporous array template. Electrodeposition can produce vertical nanowires.

- At the University of Minnesota (NIRT 0210844), an interdisciplinary team is investigating the use of DNA as programmable scaffolding upon which nanocomponents precisely self-assemble. This work will help address the basic scientific and engineering challenges in the development of DNA nanotechnology for the precise assembly of components for nanoelectronics.

- At Penn State (NIRT 0210229), an interdisciplinary team is developing a new nanomanufacturing technology that utilizes carefully designed nanoreactor systems to align, bond, and assemble oriented nanomaterials as they are produced, rather than trying to manipulate them afterwards. The realization of this approach will lead to mass production of ordered polymeric nano-composite materials that cannot be made in any other way, and fast, reproducible fabrication of nano-electronics devices.

- At the University of North Carolina (NIRT 0210543), an interdisciplinary team is developing a motion control platform for accurate measurement and manufacturing of nanostructures. The instrument would enable nanometer resolution tools to focus on a nano-device placed anywhere over the instruments operating range for applications such as imprint lithography, lithographic self assembly, nanowire circuitry and complex multi-process and multi-scale assemblies.

Societal and educational implications: A group at UCLA (NIRT 0304727) is providing an interesting tool for nanoscience. It aims to use econometric methods to estimate the impact of nanoscale science and technology research directly on firms' entry and success and hence on U. S. economic growth, standard of living, and competitiveness. The project also performs scientometric and institutional analyses of the diffusion of knowledge on nanotechnology, and networks in nanoscale science and technology. It will examine the involvement of academic scientists in commercialization and investigate the effect of such involvement on their scientific productivity and teaching. Results of the research will be placed in an integrated database that will be made available as a public, web-deployed digital library called NanoBank.org. It is anticipated that the digital library will be useful for other researchers pursing different social science analyses, investors, firms interested in investing in nanotechnology, policy makers, and nano scientists and engineers.

A group at the University of South Carolina (NIRT 0304448) has mounted a program to produce an informed approach to nanoscale science and technology. This project establishes an integrated and participatory model for the facilitation of public understanding of nanoscale science and technology. Through workshops, colloquia, conferences, publications, and courses, this interdisciplinary research team will engage faculty and bench scientists, humanities and legal scholars, students, and citizens, giving this project broad social impact. A second component of the project addresses ways that information about nanoscience diffuses from the laboratory and ultimately to society. A third research area focuses on the issue of risks tied to cascading effects, exploring analogies with genetic engineering. The last research area concentrates on communicating about nanoscale science and technology as it engages the public—including the public at large, but also our legal and political systems.

Technology transfer and crosscutting: There have been a number of successful spin-off companies from NS&E funded projects. For example, the Northwestern NSEC (0118025) has two spin-off companies that are making and selling products. One is Nanosphere, Inc., a nanotechnology-based life sciences company. It is developing molecular testing systems that set a new standard in the accuracy, speed and simplicity of molecular detection for medical diagnostics.

NanoInk is commercializing the dip-pen DPN™ process and developing products to support process requirements. NanoInk currently provides its customers with a rapid prototyping platform for nanomaterials discovery by offering products that leverage the DPN process. One of their entry-level products allows researchers an affordable avenue for bottom-up nanofabrication.

Other spin-off companies include Carbon Nanotechnologies, Inc. from the Rice NSEC (0118007) and Applied NanoWorks from the NSEC at Rensselaer Polytechnic Institute (0117792).

D.3 Has there been successful development of a knowledge base for systematic control of matter at the nanoscale that will enable the next industrial revolution for the benefit of society?

The ability to systematically control matter at the nanoscale has been a great success story. The developments are on track for this longer term goal. Nanoparticle synthesis strategies that didn't exist five to ten years ago now allow us to control size and composition and shape with precision and infinite variability. For example:

- Semiconductor Quantum Dots - We can control size and optical properties of semiconductor nanoparticles at will. These particles are made by simple chemical synthesis methods. The applications of quantum dots in bio-sensing are rapidly developing. Example: UC Davis (NIRT 0210807)
- Carbon Nanotubes – These are now commercially available. Example: Smalley at Rice University (NSEC 0118007).
- Metal Nanoparticles – Colloidal metal nanoparticles have been studied since Faraday. However, these particles were almost always spherical. In recent years we have learned to control the shape of the metal nanoparticles, making nanorods and nanoprisms. These have many applications, for example in surface-enhanced Raman spectroscopy, that are progressing. Example: Penn State (NIRT 0210229).

- Organic Nanoparticles - There are many examples here, including *dendrimer chemistry,* which allows us to control size and chemistry of organic nanoparticles with amazing precision and great variability. Applications to drug delivery are being developed. Examples: Crommie at UC Berkeley (NIRT 0210176), Karen Wooley at Washington University (NIRT 0210247).

New fabrication techniques are being developed, including nanolithography and chemical vapor deposition techniques. For example, new chemical vapor deposition (CVD) growth techniques of carbon nanotubes hold great promise for the development of integrated nanoscale systems (NIRTs 0103585,0210580,0304246). NSF is supporting the developments of new nanoscale fabrication techniques, such as deposition by ultrafast laser-assisted scanning probe techniques (NED 0103390).

Furthermore, the area of molecular electronics is where a tremendous amount of work is beginning to produce some fundamental understanding for the phenomena and how these phenomena may be exploited for sensors, for ultra high density memory, etc. Areas include new magnetic phenomena, which can generate new memory concepts. We are learning a tremendous amount about the creation of nanoscale particulate materials, including needles, pyramids, and other novel shapes, and about the electrical, chemical, and mechanical properties of these materials and composites made from these materials.

The important question is: Will these developments enable the next industrial revolution? We now need to move into areas that will bridge the gap between fundamental understanding and industrial processes, and here the future is less certain. For example, the ability to assemble, measure, and model lags significantly behind the repertoire of experimental methods available to make nanoparticles. As an example, there are perhaps 50 ways to make a small amount of drug nanoparticles, perhaps three ways to make large (manufacturing scale) amounts, almost no knowledge regarding how to incorporate drug nanoparticles into practical products, and minimal knowledge in how to test for safety and comparative efficacy of products containing drug nanoparticles.

Despite the remarkable progress cited above, there is a long way to go. The need to "systematically" control matter and enable the next generation of industry may require a more focused and strategic investment than is appropriate for NSF. While this topic lies outside the purview of the COV, we urge NSF to couple with other mission agency investments in NNI to ensure that fundamental knowledge is transferred and appropriately developed to ensure broader societal impact.

Theory supporting a knowledge base for systematic control of matter at the nanoscale: The awards address many key issues related to properties, interactions, and processes at the nanoscale. Some of the characteristic awards addressing the key issues facing NS&E include:

- Computational Design of Nanostructured Complex Fluid Formulations: A Feasibility Study (NER 0304596)
- Computational Design and Optimization of Nanoscale Spintronics and Thermoelectric Devices (NIRT 0210717)
- Nanojets – Formation, Characterization, and Application (NIRT 0304009)
- Multi-scale Modeling and Simulation of Adhesion, Nanotribology and Nanofluidics (NIRT 0103408)

- Study of Self-organization in Strained Heteroepitaxial Nanostructures: Multi-scale Modeling, Simulation, and Experiment (NIRT 0210095) and
- Mechanism-based Modeling and Simulation in Nanomechanics NIRT (0103257).

The progress from these efforts has been significant; however, it seems that we are still far from having a full knowledge base for systematic control of matter at the nanoscale.

D.4 Has there been movement towards applications/transfer to the broader society? (All modes and themes)

One important measure of movement toward applications is the development of "spin-out" businesses. Some of these are enumerated in Section D.2, above. The COV recommends that NSF develop a systematic approach to track this outcome (additional management resources may be required). Here again, strategic alliances with other mission agency NNI investments could serve as another import tool for moving fundamental science toward application/transfer to broader society.

In the area of Nanoscale Devices/Architecture, another measure is the "uptake" by established companies in the semiconductor industry. The fact that Semiconductor Research Corporation (SRC) is in the process of partnering with NSF on a new initiative in this area suggests that the present program has generated interest within the industry. Partnership between SRC and NSF in the evaluation of future proposals will enhance industry interest and "uptake."

In 2002, NSF has added a new theme in the program solicitation called "Manufacturing at the Nanoscale" in order to accelerate support for manufacturing. Also, contacts with industry and industrial groups have been initiated.

In the short term, biological and medical applications are already being commercialized. In the realm of higher density electronic devices and manufacture thereof, great progress is being made and we can be assured that new generations of electronic device fabrication will employ concepts and processes developed as a direct outcome of the NS&E programs. New materials with dramatically improved physical and chemical properties are being developed that will impact a broad spectrum of applications.

NSEC: The NSECs partner with industry and have been instrumental in developing spin-off companies (see Section D.2, above). Nevertheless, partnerships between the NSECs and the existing companies could be stronger and the emphasis on technology transfer could be greater.

NER: It is difficult to evaluate the transfer of technology from the NER program because of its short-term exploratory nature. One way to facilitate tech transfer is by customizing the broader impact criterion to ensure that proposers and reviewers emphasize projects that test issues regarding feasibility, scalability, safety, etc. NSF needs to encourage these activities or otherwise new faculty avoid the topics, and at some point we lack the scientific infrastructure to address them (for example, pharmaceutical manufacturing research is an almost non-existent field and provides a great case study)

Societal implications: The scientists working in this area have become a community. The number of scientists working in this area, and the amazing web of interdisciplinary connections established are one of the best outcomes to date. This societal dimension is critical for maintaining U. S. leadership in this area.

Education: The web has become an important tool for the dissemination of information about nanoscience and engineering. For example, the University of Wisconsin (partially by NIRT 0210588) has developed a high school curriculum that will be nationally syndicated in nano-bio geochemistry and how it affects global climate and oceans and continental chemistry. It has already been field-tested and is being refined.

The question is: How do educators find out about this and other web-based educational tools? How do we bring educators into the mix? It is essential that high school teachers are deeply involved in developing new curricula from the outset.

D.5 Do the awards reflect synergistic research collaborations and partnerships with industry or government laboratories? Is there international collaboration? (NIRTs and NSECs)

Due to the complexity of developing nanomanufacturing processes, Centers must look to establishing ties with industry and government laboratories. The global marketplace pressure is also motivating U.S. Centers to collaborate with international partners to accelerate new work to the forefront and possibly first to market.

Industry: Collaboration with industry was a requirement of the NSEC solicitations. It is important to note that some of the industrial interactions are relatively short term whereas others are long term in nature. The COV saw evidence of broad partnerships with industry but was unable to assess the strength of the collaborations. The interaction with industry (electronic industry) will be explicitly included in the FY 2004 program solicitation.

National Laboratories: Government laboratories are nominally a part of numerous NSEC programs. However changes in the government laboratories themselves have been necessary to reprioritize programmatic activity to make these interactions real.

International: Several NIRT awards listed collaborators from Europe, Asia, and Israel. About $300,000 in supplements (to about 15 NIRTs per year) are provided by the International office each year to support either NIRT or NSEC international interactions. All NSECs have international collaborations, as do approximately one-fourth of the NIRTs. Periodical workshops have been organized with Japan, Korea, EU, Switzerland, Latin America (PASI), and other countries in order to encourage new collaborations.

D.6 Has NS&E been responsible for developing a broad-based and capable interdisciplinary research community that advances fundamental nanoscience and engineering knowledge, with impact on other disciplinary fields? (All modes and themes)

The developments are on track for this longer term goal. One of the most significant outcomes of the NS&E investment has been the development of a broad-based and capable interdisciplinary research community. COV members termed this contribution "off scale" and used words like "outstanding performance." The program structure that NSF has instituted truly fosters and encourages interdisciplinary participation and is very effective in developing an interdisciplinary research community.

NSF has done an exceptional job in building nanoscience, a nanoscience community, and the tradition of interdisciplinary collaboration. The NS&E program should be praised for setting the standard in this regard. There is no question that the strong interdisciplinary research community that has been fostered by the NS&E will be contributing to the next generation of work force who will be extremely well equipped for our nation's next generation of industrial needs.

The existence of this community is evidence by the large number of meetings that service the community and the journals that are emerging to capture the advances. Examples of new journals include the American Chemical Society's *Nano Letters* and *Small*.

D.7 Have the awards promoted the successful development of a skilled workforce and a public that is informed about nanoscience and nanoengineering? (NIRTs and NSECs)

The developments are on track for this longer term goal. The NS&E program has been pivotal in developing a skilled workforce and a public that is informed about nanoscience and engineering. The number of scientists working in this area and the amazing web of interdisciplinary connections established are some of the best outcomes to-date. The skilled workforce and the web of interactions are critical for maintaining U.S. leadership in this area. The outcomes are on track for development of a skilled nanotechnology workforce and an informed public on nanoscale science and engineering.

The entire NUE program is designed to promote the successful development of a skilled workforce and a public that is informed about nanoscience and nanotechnology. A particularly good example of workforce development is the Pennsylvania State University, University Park program (NUE 0302163) whose goal is to develop a well-educated, technician-level nanotechnology workforce. This is accomplished by offering Penn State and area community college students a six-module capstone semester at the Penn State Nanofabrication Facility. In addition, this same Penn State NUE project offers summer "nano camps" for middle school and high school students from across Pennsylvania, contributing to a more scientifically informed public.

In some cases, industry has partnered with educators to train students. An excellent example of such a partnership was between Siena College and Evident Technologies, Inc. (NUE 0303992). Evident Technologies, a nanotechnology manufacturing and application firm, provided internships for undergraduates. Evident Technologies also provided expert staff members to team-teach a nanotechnology course at Siena College.

Many NSECs have partnerships with museums as a way of informing the public and enthusing children about nanotechnology. NSF has issued numerous press releases in the area of NS&E. These have been well-coordinated with the PIs and the PI institutions and were written in a compelling and interesting fashion.

D.8 Do the awards increase opportunities for underrepresented individuals and institutions to conduct high quality, competitive research and education activities? (All modes and themes)

The awards have increased opportunities for underrepresented individuals and institutions to be involved in NS&E research and education. It is clear in evaluating the review process and inspecting the jackets that minorities are strongly encouraged to become involved, including their participation as principal investigators and as panelists. The NS&E Group has raised these objectives in its periodical meetings. However, the question remains about why the success rate for underrepresented minorities is so low (see table in Section A.4). The desired outcome is to <u>build minority research leaders</u> and not just participants.

An example of increased opportunities for underrepresented groups and institutions to conduct educational activities includes the Columbia University (NUE 0304101) partnership with Norfolk State University, an HBCU. Faculty from Norfolk State will incorporate the nanoscience modules developed at Columbia into their chemistry and materials science courses.

The NSECs also involve significant placement of underrepresented groups, both scientific and educational. An example includes Columbia University (NSEC 0118025), where Barnard College and City College of New York are both major participants in the educational and research program. More importantly, however, these programs are providing research and educational opportunities to young and capable underrepresented students and teachers who will become the new leaders in research and scholarship.

D.9 Have the awards promoted the development of new instrumentation for next-generation research and education? (All modes and themes)

The NS&E portfolio provides several examples of the development of new instrumentation. Many of these have been mentioned elsewhere in this report and include new tips for AFMs (Harvard NSEC 117795) and the nanoscale dip pen (Northwestern NSEC 0118025). Furthermore, our understanding of how to employ nanoscale instrumentation and interpret the results has improved significantly through the NS&E programs.

There has also has been significant development of instrumentation for educational purposes. RPI (NSEC 0117770), for example, is developing new video techniques for utilizing planetarium environments to demonstrate nanoscale events. Cornell is developing new instrumentation to help demonstrate the fundamentals of scanning probe microscopy. Educational spin-out companies are now beginning to appear (at Cornell University and University of Wisconsin).

It takes decades to develop instrumentation, and the programs we are looking at, especially the NERs, are simply too new. It should also be noted that NSF has a separate program devoted entirely to instrumentation. Although this is geared toward purchasing existing commercially available equipment, it would be interesting to learn how the Major Research Instrumentation program feeds into the nano program.

D.10 Is the NS&E-supported research infrastructure appropriate to enable major future discoveries? (Modes of support and themes)

The developments are on track for this longer term goal. The availability of multiple funding modes within NS&E is very appropriate for producing enabling technologies. However, before we fully answer this question, it is important to set the stage for generally how things will go in nanoscience and technology in the future. At least in terms of nanotechnology and the end products that come from it, we are still clearly in the first generation of what is often called passive nanostructures (nano-coatings, nano-particles, etc.). These products and uses are novel and important, but just the very beginning. The current developments are on track for establishing a proper infrastructure in the long term. Over the next twenty years or so, experts are anticipating that second, third, and fourth generation developments will occur in the areas of active nanostructures, nanosystems, and heterogeneous molecular nanosystems, respectively (Roco, M.C., 2004, *AIChE Jounal*, 50, 890-897). Therefore, further development of research infrastructure appropriate to enable major discoveries in the future is absolutely critical so that we can reap the benefits from this revolution as soon as possible.

At this time, the answer to this question is generally yes, at all levels. The four to five year funding periods for NIRTs and NSECs are conducive to enabling future discoveries when one remembers that nanoscience and engineering technology is still in its infancy, and tremendous strides in research are still occurring with each passing year. But all NSF initiatives, including NS&E, are created with a limited lifetime. NS&E was originally set up to distribute its last solicitation during 2004, for FY 2005. Apparently, former NSF Director Rita Colwell extended this to 2007, but the future beyond that is unclear.

This COV suggests that the NSF management start now to address the questions and uncertainties of the future of NS&E beyond 2007. Many suggest that nanoscience and engineering is important to our future and some compare it to the impact of the genomics revolution. It seems that NS&E funding should not simply "dissolve" into core programs within the Foundation at the time of the "sunset" of this initiative. Instead, this funding should morph into some sort of entity that keeps this field clearly visible and somehow separately functional within NSF. Ultimately, this will help ensure a research infrastructure within the U.S. that is appropriate for the continued enablement of major discoveries well into the future.

One can also ask whether the research themes, as put forward in NS&E solicitations, are appropriate in enabling future discoveries. This COV was very impressed with the wording of the research themes in these solicitations. The themes (at least in 2001) were divided into six topics that covered scientific, engineering, and societal aspects of nanoscience and technology. Although many examples of research areas are given under each topic, they are clearly not meant to be exhaustive, allowing for the PI's to use their imagination as much as they wish. Apparently, as long as they can convince the panel and program managers that what they are doing in truly nanoscience or nanotechnology, it will certainly be considered for funding.

Finally, the NSF staff who designed the program should be commended for recognizing the importance of encouraging exploratory research through the NER program, and investigating partnerships through the NIRT program, by explicitly creating proposal solicitations for these purposes. These modes are relatively novel, and the committee finds these to be powerfully useful tools in accomplishing the aims of the program.

D.11 Do the NS&E-supported facilities increase access to state-of-the art facilities, tools and databases for U.S. researchers, educators, and students? (Modes of support-facilities and themes)

Even though the NSECs, NERs, and NIRTs were not designed as open access centers, they still increase access to state-of-the-art facilities. These facilities are used in a wide variety of educational programs from undergraduate research to visiting high school students to visiting or resident high school teachers. They are available to education professionals as well. It is important to note that the PIs of the NERS and NIRTs are encouraged to use the NNIN.

The NER grants, by virtue of their short-term nature, are not the best suited to provide shared infrastructure. Perhaps support for central testing facilities would help in the development of dynamic, high-quality short-term experimental science.

In almost all of the NUE supported programs, students gained access to state-of-the-art instrumentation such as SEM, TEM, STM and AFM for hands-on experiments and research. The exposure to and use of sophisticated modeling software (molecular dynamics, Monte Carlo) would be beneficial to prepare new generations of graduate students focussing on theory at the nanoscale.

D.12 Do the NSECs include effective programs to address the societal ramifications of advances in nanoscale science and engineering?

The inclusion of programs addressing the societal ramifications of nanoscale science and engineering has been an evolution in the NSEC solicitations. It has also been an evolution in the way the NSECs have operated. Currently, five of the NSECs have societal and ethical implications research components.

One example is Northwestern's (NSEC 0118025) collaboration with management school faculty and students to develop business plans for scientists who propose ideas for starting businesses based on NSEC work. This has educational benefits for the business students involved as well as promoting technology transfer from the NSEC.

Rice's center (NSEC 0117874) includes a similar collaboration with the Rice Alliance for Technology and Entrepreneurship, as well as courses (weekend workshops and a graduate course in entrepreneurship for scientists and engineers).

Columbia (NSEC 0117752) has developed a series of short courses on ethical conduct of research and on societal impacts and public policy.

RPI (NSEC 0117792) has a team of researchers considering strategies for managing the radical nanotechnology inventions. This research involves interviews with scientists and firm managers.

Cornell (NSEC 0117770) has a research team investigating long term societal implications of nanotechnology and electronics.

However, a strong relationship between centers and industrial partners is still lacking. Migration of technology is a social ramification. Many NSECs are now actively generating business spin-offs, which will demonstrate technology migration through business activity and with business benchmarks, and which will contribute to our societal condition. Furthermore, several supplements to existing NSECs were awarded to explicitly add a societal component to the program that was not part of the initial proposed program.

Appendix A: Explanation of Sampling Strategy

Proposal Sampling Methods for Nanoscale Science and Engineering Committee of Visitors

(Sampling Designed and Performed by Susan Russell, SRI International)

Goal: Select a total of 120 to 150 proposals, with equal numbers of awards and declines

<u>METHODS:</u>

1. Sorted by mode (NER, NIRT, NSEC, NUE)

2. Within each mode, sorted by PI. If PI had multiple proposals, selected awarded proposal and deleted declined proposal(s). If no awards, then selected most recent declined. If more than one award, selected most recent and deleted other(s).

NSEC: no duplicate PIs. Selected all awards. For declines, sorted by solicitation year and division. Then selected every 10th declinee after random start

NUE: no duplicate PIs. Sorted awards and declines (separately) by division and year of solicitation. Used random starting point to select systematic random samples of 5 awards and 5 declines.

NIRT: deleted 238 duplicate-PI proposals. Sorted awards and declines (separately) by division, year of solicitation, and state. Used random starting point to select systematic random samples of 30 awards and 30 declines. Next, to obtain sufficient numbers of awards in each theme, all other awards in the "societal" theme (n=1) were selected, 3 additional awards in "multi-scale modeling" were randomly sampled, and 2 additional awards in "environmental" were randomly sampled. Finally, to include some proposals that were recommended but not funded ("rec proposal"), one such proposal in each theme was randomly sampled. For each rec proposal added to the sample, one randomly selected decline that matched by NSF division was deleted. Exception: Only one "societal" proposal was recommended but not funded; this proposal was funded under NER. These are noted in the sample as "-rec" in the theme column. NSF was unable to locate the jackets for 1 NIRT award and 8 declines, the latter including 4 that had been recommended but subsequently declined. The award was replaced with a randomly selected award in the same theme. Information about which declines had been recommended was not immediately available, so we were unable to replace these with other recommended declines. All declines were replaced with other that were randomly selected from among all NIRT declines.

NER: deleted 146 duplicate-PI proposals. Sorted awards and declines (separately) by division, year of solicitation, and state. Used random starting point to select systematic random samples of 30 awards and 30 declines. Next, to obtain sufficient numbers of awards in each theme, all awards (n=2) in the "societal" theme were selected, 3 additional awards in "multi-scale modeling" were randomly sampled, and 3 additional awards in "environmental" were randomly sampled. NSF was unable to locate the jackets for 4 NER awards. These awards were randomly replaced by awards in the same theme, with one exception: there were no other societal theme awards to replace the one that could not be found. This award was replaced by an award in the manufacturing processes theme, which was underrepresented in the sample.

Summary of Nanoscale Proposal Population and Sample

	POPULATION					SAMPLE				
	NER	NIRT	NSEC	NUE	TOTAL	NER	NIRT	NSEC	NUE	TOTAL
Awards	221	160	7	32	420	38	36	7	5	86
Declines	844	972	73	43	1932	30	30	7	5	72
Total	1065	1132	80	75	2352	68	66	14	10	158
PIs who submitted more than one proposal	146	238	0	0						

	NER Awards				NIRT Awards			
	Population		Sample		Population		Sample	
THEMES	No.	%	No.	%	No.	%	No.	%
biosystems (B)	23	10%	7	18%	14	9%	2	6%
device/system arch (D)	70	32%	11	29%	33	21%	7	19%
societal/educ'l (E)	2	1%	1	3%	2	1%	2	6%
manufac processes (F)	28	13%	4	11%	28	18%	6	17%
multi-scale modeling (M)	24	11%	5	13%	13	8%	5	14%
environmental (P)	10	5%	5	13%	7	4%	5	14%
structures (S)	64	29%	5	13%	63	39%	9	25%
TOTAL	221	100%	38	100%	160	100%	36	100%

Appendix B: Agenda

National Science Foundation

Committee of Visitors
Nanoscale Science and Engineering 2001-2003
Room 530, Main NSF Building

Agenda

Tuesday, May 11, 2004

8:30 a.m.	Welcome
8:45 a.m.	Introductions and Charge to Committee (Jelinski)
9:00 a.m.	Conflicts of Interest (Wellek)
9:15 a.m.	Overview of NS&E and Opportunity for Questions (Roco)
10:00 a.m.	Break
10:15 a.m.	Overview and description of available material and data, core questions (McCullough)
11:00 a.m.	How to Read a Jacket (Owens)
11:15 a.m.	Jacket review, split into groups
12:15 p.m.	Working Lunch - Jacket Review, group discussions, until 4:15 p.m.
4:15 p.m.	Convene Committee to discuss progress/identify questions for COV staff, Program Managers, etc.
5:15 p.m.	Adjourn
6:15 p.m.	COV dinner @ Nouveau East (Ballston Mall)

Wednesday May 12, 2004

8:30 a.m.	Committee meets with COV staff to address questions and comments
9:00 a.m.	Committee meets with NS&E group and leaders of NIRT, NER, NSEC, NUE
10:15 a.m.	Break
10:30 a.m.	Continue review of jackets and prepare input for COV Report
12:00 p.m.	Lunch
1:00 p.m.	COV Drafts Report - Template Questions
5:00 p.m.	Convene Committee to discuss progress and distribute sections of draft report
5:30 p.m.	Adjourn; dinner on own

Thursday, May 13, 2004

8:30 a.m.	Committee convenes to discuss sections of draft report and to reach agreement on report language
11:30 a.m.	Committee provides overview of key findings to NSF
12:00 p.m.	Adjourn

APPENDIX C: CHARGE TO THE COMMITTEE OF VISITORS

NSF Nanoscale Science and Engineering (NS&E)

Review of Activities Conducted Under the NS&E Proposal Solicitations For Fiscal Years 2001, 2002, and 2003

I. General Information about Committees of Visitors

NSF relies on the expert judgment of COVs to maintain high standards of program management, to provide advice for continuous improvement of NSF performance, and to ensure openness to the research and education community served by the Foundation. COVs also provide expert judgments necessary for NSF to comply with the Government Performance and Results Act of 1993 (GPRA).

COVs assess NSF's performance in two primary areas: (A) the effectiveness of the processes that involve proposal review; and (B) the quality of the results of NSF's investments in the form of outputs and outcomes that appear over time. COVs also explore the relationships between award decisions, programmatic goals, and NSF-wide goals, to determine the likelihood that the award portfolio will lead to desired results in the future.

The review of results is partially driven by the need to respond to the GPRA, which requires all federal agencies to establish a five-year strategic plan, produce annual performance plans, and submit annual performance reports to the President and the Congress. COV reports are an important source of information for NSF's annual performance reports.

II. Guidance and Format

Each COV is asked to use a COV report template common to all programs or activities (see Attachment A, Core Questions and Report Template FY 2004 Committee of Visitor Reviews), as well as questions specific to the program or activity being reviewed. The COV report should provide specific examples of significant impacts and achievements, identify weaknesses, and document findings. A large sampling of proposal files and of final project reports will be available to the committee for this purpose. The COV report format calls for assessment of the past three years' operations and results from completed awards.

III. Topics Common to all COVs

The following is a general overview of process and programmatic topics that the Committee is asked to address. Particulars may be found in Appendices A and B.

Proposal Processing:

With respect to the NS&E solicitation(s), the COV is asked to evaluate, among other things:

- The effectiveness of the overall selection process and the various processes used to solicit, review, recommend, and document proposal actions.

- Implementation of the NSF merit review criteria, particularly the degree to which reviewers and program officers apply the criterion regarding the broader impacts of the proposed activity.

- Whether program officers have selected adequate numbers of high-quality reviewers with technical competence and freedom from bias.

- Whether the activity as a whole demonstrates an appropriate mix of support for women, minorities, types of institutions, and geographic regions.

- The appropriateness of the activity's portfolio with regard to quality of work, award size and duration, and relative "riskiness" of the proposed research and education plans supported.

Outcomes:

The outcomes review will examine the extent to which NS&E awards contribute to the accomplishment of NSF-wide outcome goals as set forth in the Foundation's Strategic Plan, goals defined in the NS&E solicitation and in the NS&E Performance Assessment and Rating Tool (PART).

The NSF-wide strategic outcomes are:

- People: A diverse, competitive and globally-engaged U.S. workforce of scientists, engineers, technologiests and well-prepared citizens.
- Ideas: Discovery across the frontier of science and engineering, connected to learning, innovation, and service to society.
- Tools: Broadly-accessible, state-of-the-art S&E facilities, tools and other infrastructure that enable discovery, learning and innovation.
- Organizational Excellence: An agile, innovative organization that fulfills its mission through leadership in state-of-the-art business practices.

IV. Specific Goals of the NS&E Solicitation

The COV is also asked to examine the extent to which specific awards have contributed to the attainment of the goals of the NS&E solicitation itself. The overall goal of NS&E is to support fundamental research and catalyze synergistic science and engineering research and education in emerging areas of nanoscale science and technology. More detailed indicators for assessing progress towards the NS&E goals are included in Appendix B.

V. Access to Documents

Prior to the meeting, the COV will receive summary information reflecting the review process and award results. At the meeting, subject to the conditions concerning conflicts of interests and confidentiality described below, the COV will be provided a sample of files representing proposals submitted for the FY 2001-2003 NS&E solicitations (including awards, declines, and those “on the funding margin,” i.e., strongly considered for award, but declined). The COV will also receive lists of *all* proposals submitted for FY 2001-2003 NS&E solicitation, noting their disposition, and is free to request the files for any of them. The COV may also request additional statistics from NSF databases and explanations from NSF program officers on any points needing elaboration or clarification.

VI. Conflicts of Interests

We ask that you not examine any document or file from your home institution or any document or file with which you are or were associated as a collaborator of any type. This restriction applies to each COV member individually and does not preclude other members of the Committee from reviewing or making judgments about projects based on these documents. If you have any affiliation that may be construed as creating a conflict of interests in these terms, we ask that you excuse yourself from that particular discussion.

VII. Confidentiality

Most of the material you will review is confidential and is protected by the Privacy Act. It is important that you honor this confidence. You should not discuss the content of the files, statistics, or policy documents with anyone outside the Foundation. You should not disclose the identity of the proposal reviewers, the contents of the reviews, or any of the contents of the documents in the files.

VIII. COV Report

The COV will be asked to develop and transmit a final report of its findings to the chair of the Advisory Committee for the Directorate for Engineering within two weeks of the COV meeting. The Chair of the COV has the final responsibility for preparing the report.

Before completion, and for accuracy only, the COV report will be reviewed by the head of the NS&E COV Working Group (Ms. Jo Culbertson).

The final report and the Foundation’s response will be sent to appropriate NSF advisory groups for information, after which they will be forwarded to the NSF Inspector General and distributed to the management and staff of NSF. The report will then be made available to the public upon request.

Appendix D: Brief Backgrounds of Committee Members

Valerie Ashby is an Associate Professor, Department of Chemistry, University of North Carolina (UNC) at Chapel Hill. She received the B.S (1988) and Ph.D. (1994) from UNC. She was a Visiting Scientist at the IBM Almaden Research Center in 1992 and at Eastman Chemical Company in 1993. In 1994 and 1995 Dr. Ashby was an NSF Postdoctoral Fellow and a NATO Postdoctoral Fellow at the Johannes Gutenberg University of Mainz Institute for Organic Chemistry. From 1996 through 2003 she was with the Department of Chemistry at Iowa State University, where she won several university awards for teaching and research. In 2002 she was honored by the American Chemical Society as one of the top 12 young female chemists in the country. Dr. Ashby has published more than 35 papers and holds four patents.

Stuart Farquharson is President of Real-Time Analyzers, Inc., a spinoff company of Advanced Fuel Research (AFR) that focuses on Raman products. He received the Ph.D. in Physical Chemistry from the University of Texas in 1981 and joined AFR in 1992. He has been the PI on numerous Small Business Innovation Research (SBIR) and Small Business Technology Transfer (STTR) projects employing infrared and Raman spectroscopy. Dr. Farquharson performed the initial epitaxial silicon layer thickness measurements on silicon wafers, which is now the most sensitive determination of epi thickness in the industry. He also designed the first known three detector FT-IR system. This system, installed at Texas Instruments, won a 1995 R&D 100 award. Along with Carl Brouillette and Wayne Smith, he has also designed a state-of-the-art fiber optic FT-Raman system for industrial process monitoring and control. He has also designed a miniature electrolytic surface-enhanced Raman sample cell and developed simple SERS sample vials that enable researchers to extend their Raman measurements to trace chemicals at part per billion concentrations. Dr. Farquharson has published over 35 papers and holds 5 patents in the field. He has been a Chair or Co-chair at 10 SPIE (International Society for Optical Engineering) Conferences.

Michael Hochella is Professor of nanogeoscience and biogeochemistry at Virginia Tech, concentrating in the area of environmental chemistry. He received his B.S. and M.S. from Virginia Tech in 1975 and 1977, respectively, and his Ph.D. from Stanford University in 1981. After two years at the main research labs of Corning, Inc. (Corning, NY), he returned to Stanford for nine more years as a research professor. In 1992, he returned to the Department of Geosciences at Virginia Tech. He was a Fulbright Scholar to Germany in 1998, served as President of the Geochemical Society during 2000 and 2001, received the Alexander von Humboldt Research Award and Fellowship in 2001, and was awarded the Dana Medal by the Mineralogical Society of America in 2002. At NSF, he served on the Advisory Committee for Geosciences from 2000 through 2002.

Lynn W. Jelinski, COV Chair, is president of Sunshine Consultants, International, specializing in research competitiveness. She received her B.S. in chemistry from Duke University and her Ph.D., also in chemistry, from the University of Hawaii. After postdoctoral and staff fellow positions at the Johns Hopkins University and at the National Institutes of Health, Jelinski held research and research administration positions at AT&T Bell Laboratories (now Lucent Technologies), and professorial and administration positions at Cornell University and at Louisiana State University, where she was Vice Chancellor for Research and Dean of the

Graduate School. Jelinski's research specialty is biophysics with a focus on the biomolecular mechanisms for the strength of spider silk fibers. Her activities include serving as co-chair of the NSF-sponsored US/EC Workshop on Nanobiotechnology, participating in the World Technology Evaluation Center's Panel on Nanotechnology, serving on the advisory board for Cornell University's Science and Technology Center (STC) on Nanobiotechnology, and serving on the National Research Council Panel on Nanotechnology.

Kevin W. Lyons is a Program Manager with the Manufacturing Engineering Laboratory at the National Institute of Standards and Technology (NIST), Gaithersburg, MD. Since 2000, he has manages the Integrated Nano-to-Millimeter Manufacturing Technologies Program. The Program's research is structured to be responsive to the anticipated needs of the emerging U.S. nanotechnology industry through the development of models, architectures, and methods for process measurement and control systems that enable manufacturing across nanometer to millimeter scales. The current research areas are atomic scale manufacturing, molecular scale manipulation and assembly, and micro/millimeter scale positioning, machining, and assembly. He also serves as technical lead for research in Assembly, Virtual Assembly, and Rapid Prototyping. From 1996 through 2000 he served as Program Manager with the Defense Advanced Research Projects Agency (DARPA), where he was responsible for major programs in design and manufacturing along with a variety of Small Business Innovation Research (SBIR) and Small Business Technology Transfer (STTR) contracts. Prior to his government positions, he worked in industry for 15 years with assignments in engineering marketing, product design and analysis, factory automation, and quality engineering.

Lee Makowski is Director, Biosciences Division, Argonne National Laboratory. He received the B.S. in Physics from Brown University and the M.S. (1973) and Ph.D. (1976) in Electrical Engineering from MIT, following which he served as an NIH Postdoctoral Fellow and then as a Senior Research Associate at the Structural Biology Laboratory at Brandeis University. From 1980 to 1987 he was an Assistant Professor in the Department of Biochemistry and Molecular Physics at Columbia, and from 1987-1993 he was Assistant Professor, then Professor, in the Department of Physics at Boston University. From 1993-1997 he held professorships at the Florida State University, in the Institute of Molecular Biology, the Department of Biological Sciences, and the Department of Chemistry. From 1997-2000, he held two program officer positions at NSF, first for Instrumentation and Instrumentation Development in the Division of Biological Infrastructure, and then for Science and Engineering Centers in the Division of Materials Research. He has also been a member and organizer of various conference committees and review panels.

Charles R. Martin is a Professor of Chemistry and Director of the Center for Research at the Bio/Nano Interface at the University of Florida. His research interests lie at the interfaces between analytical chemistry, electrochemistry and materials science. Areas of special interest include nanomaterials and nanoporous membranes for chemical and bioseparations and analyses, molecular-recognition membranes, electrochemistry of nanoscopic electrodes and materials, and electrochemical energy storage and production. He received his B.S. degree at the Centre College of Kentucky, and did graduate work at the University of Arizona with Henry Freiser and postdoctoral work at the University of Texas with Allen Bard. He started his academic career at

Texas A&M University in 1981, moved to Colorado State University in 1990, and then to the University of Florida in 1999.

Terry Michalske currently serves as the Director for the Department of Energy/Center for Integrated Nanotechnologies which is jointly operated by Sandia National Laboratories and Los Alamos National Laboratory. He also heads the Integrated Nanotechnologies Department at Sandia National Laboratories. He has made numerous technical accomplishments in the areas of surface and interfacial phenomena, nanoscale properties of materials, and integrated microsystems. His work on the stress corrosion fracture of silica has been recognized by several international awards including the Ross Coffin Purdy Award (1985) and the Weyl International Glass Science Award (1989) and he is co-recipient of an R&D 100 Award (1994) for development of the Interfacial Force Microscope. Dr. Michalske has managed several technical organizations at Sandia including Surface Science, Biomolecular Materials, and Nanotechnologies. He is a Fellow of the American Vacuum Society and the American Ceramic Society, and he currently participates in a number of external advisory boards of university and government nanotechnology programs and initiatives.

Fernando J. Muzzio is a Professor in the Department of Chemical and Biochemical Engineering, Rutgers University. He has been the Director of the Rutgers Pharmaceutical Engineering Program since its inception in 1995, and also the director of the New Jersey Particle Processing Research Center. Professor Muzzio obtained his B.S. (1985) in Chemical Engineering from University of Mar del Plata in Argentina, and his Ph.D. (1991) in Chemical Engineering from University of Massachusetts at Amherst. His main areas of research are liquid flow and mixing and powder processing. He is the author of over 150 peer-reviewed scientific articles, book chapters, and patents, and several hundred lectures and conference proceedings in areas relevant to the pharmaceutical industry. He is a consultant to most major pharmaceutical companies, as well as a number of petroleum, chemical, food, equipment, and instrumentation companies.

Karen J. Nordell joined the Department of Chemistry at Lawrence University in Appleton, Wisconsin as an Assistant Professor in 2000. She received the B.A. in chemistry (1992) from Northwestern University, and the Ph.D. in chemistry (1997) from Iowa State University. After spending a year as a Visiting Assistant Professor at Bucknell University, she spent two years in a postdoctoral position with Arthur Ellis, sponsored by the NSF-MRSEC at the University of Wisconsin Madison. As an inorganic materials chemist her research interests include the synthesis and characterization of new metal-organic coordination polymers as well as various new nanoscience projects. She is committed to engaging teachers and students of all ages in the excitement of nanoscience and nanotechnology through innovative curricular materials for the classroom and laboratory. In 2003, Nordell (PI) and two colleagues were awarded an NSF-Nanotechnology Undergraduate Experience (NUE) grant and created Lawrence's Nanoscience and Nanotechnology Program.

Jan A. Puszynski is a R.L. Sandvig Professor of Chemical Engineering, has been Dean of the College of Materials Science and Engineering at the South Dakota School of Mines and Technology (SDSM&T) since 2000. He received his M.S. degree in Chemical Engineering from the Technical University in Wroclaw, Poland (1973), and his Ph.D. in Chemical Engineering from the Institute of Chemical Technology in Prague, Czech Republic (1980). From 1982 through 1991, Dr. Puszynski was a lecturer and later a research professor at the State University of New York at Buffalo. In 1991 he accepted the faculty position in the Chemistry and Chemical Engineering Department at the SDSM&T. Dr. Puszynski continues to be very actively involved in materials research. Currently, his research program is funded by NSF, the Army Research Laboratory, the Army Research Office (Defense University Research Initiative on Nanotechnology Program), the NAVSEA Naval Surface Warfare Center, and the Civilian Research and Development Foundation. His research is focused on synthesis and processing of nanopowders, in-situ formation and densification of refractory nanocomposites, and investigation of reaction kinetics of ultrafast condensed phase reactions.

Dr. Linda Shimizu is currently a research assistant professor at the University of South Carolina, Columbia. She received a B. A. (1990) from Wellesley College, Wellesley, MA, and a Ph.D. (1997) from the Massachusetts Institute of Technology. After a year as an NIH Post-doctoral Fellow with Prof. John Essigmann in the Toxicology department at M. I. T. she moved to the University of South Carolina (USC) to start her own research in the area of supramolecular chemistry. She was appointed to the graduate faculty in 2003 and is a member of the USC Nanocenter. Her group focuses on the self-assembly of bis-urea macrocycles into columnar nanotubes. Dr. Shimizu is also a part-time consultant for Abt Associates, Inc. in Bethesda, MD.

Dr. Thomas Theis has been Director, Physical Sciences, at the IBM Watson Research Center, since 1998. In 1982 he became manager of a group studying growth and properties of III-V semiconductors. In 1989 he was named Senior Manager, Semiconductor Physics and Devices. In 1993, he was named Senior Manager, Silicon Science and Technology, where he was responsible for exploratory materials and process integration work bridging between Research and the IBM Microelectronics Division. While in this position, he was the principal author of IBM's $15 million three year DARPA Low Power Electronics Program, an industry-university-SEMATECH joint program that significantly advanced silicon-on-insulator materials, devices, and design techniques for low-power, high-performance microelectronics. Dr. Theis is a member of the IEEE and a Fellow of the American Physical Society (APS), and currently serves on advisory boards for the American Institute of Physics Corporate Associates, the APS Physics Policy Committee, the National Nanofabrication Users network, and the National Research Council’s Board on Physics and Astronomy. He served as a Member of the Committee for the Review of the National Nanotechnology Initiative, sponsored by the National Research Council. He has authored or co-authored over 60 scientific and technical publications.

Marie C. Thursby is a Professor of Strategic Management and the Hal and John Smith Chair in Entrepreneurship at the Georgia Institute of Technology. She received the A.B. (cum laude) from Mount Holyoke College and the Ph.D. from the University of North Carolina at Chapel Hill. Before joining Georgia Tech in 2002, she was a member of the economics faculty at Purdue University, where she held the Burton D. Morgan Chair of International Policy and Management. Dr. Thursby has developed and directed three major multidisciplinary programs for research and curriculum development including Purdue's Center for International Business Education and Research; the Technology Transfer Initiative; and the Innovation Realization Lab, which teams PhD students in science and engineering with MBA students to focus on the interface of technical, management, and economic issues involved in moving fundamental research into the marketplace. A research associate of the National Bureau of Economic Research since 1987, Dr. Thursby also serves on several editorial boards, including Management Science, the Journal of Technology Transfer, the Journal of International Economics, and the Review of International Economics. She has held faculty appointments with the University of Michigan, Ohio State University, Syracuse University, and North Carolina State University. Her areas of specialization include Economics of Innovation, International R&D competition, optimal license strategies, and international economics and industrial organization.

James T. Yardley is currently a Professor of Chemical Engineering at Columbia University where he serves as Director of the Center for Integrated Science and Engineering (formerly the Columbia Radiation Laboratory). Prof. Yardley is also managing director of the Columbia Center for Electron Transport in Molecular Nanostructures, one of the NSF-sponsored Nanoscale Science and Engineering Centers. He received a BS in Chemistry from Rice University (magna cum laude) in 1964 and PhD in Physical Chemistry from University of California at Berkeley in 1967. He served as Assistant Professor and Associate Professor of Chemistry at University of Illinois, Champaign-Urbana from 1967 to 1977 where he received the Alfred P. Sloan fellowship and a Dreyfus Teacher-Scholar Award. He has published over 110 research papers and is co-inventor on more than 25 issued US patents. Dr. Yardley previously served as Vice President for Technology with AlliedSignal's Electronic Materials business. At AlliedSignal (now Honeywell International), Dr. Yardley created a research program to develop new optical materials and devices resulting in several business ventures in polymeric optics. His organization also developed new polymeric substrate materials for advanced electronic circuitry.

Directorate for Engineering
MEMORANDUM

Date: September 01, 2004

To: J. Brighton, Office of the Assistant Director, ENG

From: M.C. Roco, Senior Advisor for Nanotechnology

Re: Demographics of the COV for NS&E solicitations

The COV to review actions taken under the first three Nanoscale Science and Engineering solicitations was held at NSF May 11-13-2004. Here is information about the composition of the COV and procedures to resolve conflicts.

Demographic Characteristics:

Gender:	6 Female, 10 Male
Geographic Distribution:	3 Northeast, 4 Mid-Atlantic, 4 South, 3 Midwest, 2 West
Minority Representation:	1 African-American, 1 Asian-American
Academic Institutions:	8 public, 2 private (one of which is primarily undergraduate)
Federal Laboratories:	3
Businesses:	1 large, 2 small
Recent NSF Awardees:	11
No Award Past Five Years:	5

Directorate staff made extensive efforts to recruit additional minority participants but their numbers in the relevant fields are small and the schedules of those contacted did not permit their participation.

Conflicts of Interest:

The introductory session included a conflicts briefing and review of confidentiality requirements. None of the members had proposals pending in the areas being reviewed during the period of time they were appointed and completed their COV assignments. The procedure for random selection of declinations and awards to be reviewed set aside all proposals on which COV members were principal investigators. The selection did include some proposals – awards and declinations - for which COV members had been reviewers. These did not pose disqualifying COIs. One COV member who had served on a recent review panel focused on topics that did not involve evaluating the work of that panel. The selection also included some proposals that posed institutional conflicts of interest for COV members, but they did not review those proposals.

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March 4, 2004

Dr. Linda Shimizu
Research Assistant Professor
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Dear Dr. Shimizu,

Thank you for agreeing to participate as a member of NSF's Committee of Visitors (COV) that was established to review NSF's Nanoscale Science and Engineering (NS&E) solicitation activities for Fiscal Years 2001, 2002, and 2003. The Committee will assess NSF's performance with regard to both the effectiveness of the proposal solicitation, review, and award processes that were used; and the quality of investment results as reflected in award outputs and outcomes.

This is the first of three mailings that you will receive in advance of the meeting from SRI International, a nonprofit contract research firm that is assisting NSF in preparing for the review. It contains information about the COV review process, the NS&E activity, and arrangements for the meeting. Please note that the second mailing, a c.d. and a letter, are also enclosed in a separate envelope.

The Committee is scheduled to meet from 8:30 a.m. on Tuesday, May 11, 2004, through 12:00 p.m. on Thursday, May 13, 2004, at the National Science Foundation in Arlington, VA. The agenda, directions, and other information will be included in a later mailing.

To begin preparing for the meeting we have three requests:

1) Please read the attachments on the Charge to the Committee and the COV Report Template.

2) Please read the accompanying information about potential conflicts-of-interest. If you have **no conflicts**, sign and fax the enclosed form to: Ms. Robin Skulrak at SRI (fax: 703-247-8410). If you have a question or wish to discuss a possible conflict, please contact Jim McCullough, the SRI team leader, at 703-247-8570 or at james.mccullough@sri.com.

3) Please send a brief resume (100-150 words) to Mr. McCullough either by e-mail or fax, to the address and number stated above. An example of the brief resume is enclosed.

Also, please note that NSF has reserved a block of rooms for the **NSF/NS&E COV** at the Holiday Inn at 4610 Fairfax Dr., 10 minutes from the Foundation. We ask that you please make your own hotel reservations. The government single room rate for these rooms is $164.63 including taxes. To reserve one of these rooms, please contact the hotel at (800) 465-4329 or (703) 243-9800 and provide a credit card before April 10, 2004. Other nearby hotel accommodations include:

Comfort Inn-Ballston (10 minute walk to NSF)
Glebe Road and Rt. 66
Arlington, VA 22203
Telephone No.: (703) 247-3399
Toll Free: (800) 228-5150

The Arlington Hilton Hotel (Next to NSF)
North Stafford St.
Arlington, VA 22203
Telephone No.: (703) 528-6000
Toll Free: (800) 445-8667

As for other travel arrangements, please work with the NS&E travel coordinators Ms. Gwen Owens and Ms. Tyffani Smith. They will be contacting each member directly and will assist him or her with all other travel arrangements. Please see the following brief description of NSF travel regulations:

NSF provides an airline ticket to each COV member and $480 per day for each meeting day and $280 for an additional travel day. COV members who reside in the Washington metropolitan area will receive $280 per day. NSF deposits this money directly into individuals' bank accounts and the travel coordinators will provide instructions on direct deposit. There is no need to provide the Foundation with information on members' actual expenses.

NSF issues an electronic airline ticket directly to each COV member based on the government economy fare rates to the airport closest to their residents. **NSF cannot reimburse COV members for tickets that they purchase personally.** The $480 per day rate covers individuals' hotel, meals, taxis, parking and other travel expenses.

The second mailing (in two to three weeks) will include a list of about 3,000 proposals that were received in response to the NS&E solicitations, of which the Committee will review a sample. The mailing will also present demographic information about applicants and reviewers, describe a sampling strategy, show the list of sampled proposals, and ask whether you wish to add proposals to the sample from the complete list.

The final mailing in mid-April will be a CD containing the templates for the questions to be addressed by the COV and a considerable amount of detailed data about the proposals in the sample, such as information about investigator and reviewer demographics, time to decision, how review criteria were addressed, program relevance to national and Foundation priorities, etc. Information about awards will include investigators' reports about the progress of their work. NSF will also establish a password-protected web site that can be accessed through the Internet that will contain this information.

Information on the NSF Nanoscience and Engineering priority area is available on the web site http://www.nsf.gov/home/crssprgm/nano/previews.htm.

NSF appreciates your service on the Committee.

For the National Science Foundation,

Dr. John A Brighton
Assistant Director for Engineering

Enclosures

Please see the following enclosures:

- Example of Brief Resume
- Charge to the Committee
  Appendix A: FY2004 COV Report Template Parts A & B
  Appendix B: NS&E Issues
- Conflict of Interest Forms
- NS&E Solicitation
- NS&E Solicitation Management Plan
- Reports of the NS&E FY 2001 and 2002 Grantees Workshop
- NRC Report “Small Wonders”

CHARGE TO THE COMMITTEE OF VISITORS

NSF Nanoscale Science and Engineering (NS&E)

Review of Activities Conducted Under the NS&E Proposal Solicitations For Fiscal Years 2001, 2002, and 2003

I. General Information about Committees of Visitors

NSF relies on the expert judgment of COVs to maintain high standards of program management, to provide advice for continuous improvement of NSF performance, and to ensure openness to the research and education community served by the Foundation. COVs also provide expert judgments necessary for NSF to comply with the Government Performance and Results Act of 1993 (GPRA).

COVs assess NSF's performance in two primary areas: (A) the effectiveness of the processes that involve proposal review; and (B) the quality of the results of NSF's investments in the form of outputs and outcomes that appear over time. COVs also explore the relationships between award decisions, programmatic goals, and NSF-wide goals, to determine the likelihood that the award portfolio will lead to desired results in the future.

The review of results is partially driven by the need to respond to the GPRA, which requires all federal agencies to establish a five-year strategic plan, produce annual performance plans, and submit annual performance reports to the President and the Congress. COV reports are an important source of information for NSF's annual performance reports.

II. Guidance and Format

Each COV is asked to use a COV report template common to all programs or activities (see Attachment A, Core Questions and Report Template FY 2004 Committee of Visitor Reviews), as well as questions specific to the program or activity being reviewed. The COV report should provide specific examples of significant impacts and achievements, identify weaknesses, and document findings. A large sampling of proposal files and of final project reports will be available to the committee for this purpose. The COV report format calls for assessment of the past three years' operations and results from completed awards.

III. Topics Common to all COVs

The following is a general overview of process and programmatic topics that the Committee is asked to address. Particulars may be found in Appendices A and B.

Proposal Processing:

With respect to the NS&E solicitation(s), the COV is asked to evaluate, among other things:

- The effectiveness of the overall selection process and the various processes used to solicit, review, recommend, and document proposal actions.

- Implementation of the NSF merit review criteria, particularly the degree to which reviewers and program officers apply the criterion regarding the broader impacts of the proposed activity.

- Whether program officers have selected adequate numbers of high-quality reviewers with technical competence and freedom from bias.

- Whether the activity as a whole demonstrates an appropriate mix of support for women, minorities, types of institutions, and geographic regions.

- The appropriateness of the activity's portfolio with regard to quality of work, award size and duration, and relative "riskiness" of the proposed research and education plans supported.

Outcomes:

The outcomes review will examine the extent to which NS&E awards contribute to the accomplishment of NSF-wide outcome goals as set forth in the Foundation's Strategic Plan, goals defined in the NS&E solicitation and in the NS&E Performance Assessment and Rating Tool (PART).

The NSF-wide strategic outcomes are:

- People: A diverse, competitive and globally-engaged U.S. workforce of scientists, engineers, technologiests and well-prepared citizens.
- Ideas: Discovery across the frontier of science and engineering, connected to learning, innovation, and service to society.
- Tools: Broadly-accessible, state-of-the-art S&E facilities, tools and other infrastructure that enable discovery, learning and innovation.
- Organizational Excellence: An agile, innovative organization that fulfills its mission through leadership in state-of-the-art business practices.

IV. Specific Goals of the NS&E Solicitation

The COV is also asked to examine the extent to which specific awards have contributed to the attainment of the goals of the NS&E solicitation itself. The overall goal of NS&E is to support fundamental research and catalyze synergistic science and engineering research and education in emerging areas of nanoscale science and technology   More detailed indicators for assessing progress towards the NS&E goals are included in Appendix B.

VI. Access to Documents

Prior to the meeting, the COV will receive summary information reflecting the review process and award results. At the meeting, subject to the conditions concerning conflicts of interests and confidentiality described below, the COV will be provided a sample of files representing proposals submitted for the FY 2001-2003 NS&E solicitations (including awards, declines, and those "on the funding margin," i.e., strongly considered for award, but declined). The COV will also receive lists of *all* proposals submitted for FY 2001-2003 NS&E solicitation, noting their disposition, and is free to request the files for any of them. The COV may also request additional statistics from NSF databases and explanations from NSF program officers on any points needing elaboration or clarification.

VII. Conflicts of Interests

We ask that you not examine any document or file from your home institution or any document or file with which you are or were associated as a collaborator of any type. This restriction applies to each COV member individually and does not preclude other members of the Committee from reviewing or making judgments about projects based on these documents. If you have any affiliation that may be construed as creating a conflict of interests in these terms, we ask that you excuse yourself from that particular discussion.

VIII. Confidentiality

Most of the material you will review is confidential and is protected by the Privacy Act. It is important that you honor this confidence. You should not discuss the content of the files, statistics, or policy documents with anyone outside the Foundation. You should not disclose the identity of the proposal reviewers, the contents of the reviews, or any of the contents of the documents in the files.

IX. COV Report

The COV will be asked to develop and transmit a final report of its findings to the chair of the Advisory Committee for the Directorate for Engineering within two weeks of the COV meeting. The Chair of the COV has the final responsibility for preparing the report.

Before completion, and for accuracy only, the COV report will be reviewed by the head of the NS&E COV Working Group (Ms. Jo Culbertson).

The final report and the Foundation's response will be sent to appropriate NSF advisory groups for information, after which they will be forwarded to the NSF Inspector General and distributed to the management and staff of NSF. The report will then be made available to the public upon request.

-----Original Message-----
From: Katehi, Linda [mailto:katehi@purdue.edu]
Sent: Wednesday, January 12, 2005 9:17 AM
To: Brighton, John A.
Cc: Queen, Cassandra M.; Culbertson, Joanne D.; Whitlock, Sharon K.
Subject: COV Report on Nanoscience and Engineering

Dear John

With this email, I would like to acknowledge acceptance of the COV report on Nanoscience and Engineering by the Engineering Directorate Advisory Committee. The committee of visitors did an exceptional job in assessing the performance of a very successful program within NSF. The ADCOM has found this program to be of exceptional quality and we strongly recommend supporting it as it helps the directorate accomplish its strategic goals.

Best

Linda Katehi
Chair of NSF Engineering Directorate Adcom
and
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