NATIONAL SCIENCE FOUNDATION
Directorate for Engineering
4201 Wilson Boulevard, Room 505
Arlington, Virginia 22230

TO: John Brighton
AD/ENG

FROM: Bruce Hamilton
DD/BES

DATE: July 22, 2005

SUBJECT: Report on Diversity, Independence, Balance and Resolution of Conflicts for the BES COV

This is my report to you on the diversity, independence, balance and resolution of conflicts of the Committee of Visitors (COV) for the Division of Bioengineering and Environmental Systems (BES) held during February 28 – March 2, 2005.

The COV, which was assembled to review the BES Division, and whose report was presented to the Engineering Advisory Committee on May 11, 2005, consisted of nine persons, of whom five are male and four female. One of the members of the committee is African-American and one is Hispanic.

Five of the COV members are from academia, two from industry, one from a non-profit corporation, and one from the Federal Government. The Chair of the COV is a bioengineer, and the Vice Chair is an environmental engineer. The members represent all the relevant areas of chemical, environmental, and bioengineering. All invited COV members attended the meeting.

The chair of the COV is a member of the National Academy of Engineering. The committee members from academia are either full or associate professors. The industry members are senior in their companies. The non-profit corporation member is a vice president (RAND). The Federal Government member is a division director at NIBIB/NIH.

Three members (Kelley, Koller, Meerman) have neither been applicants to BES in the past five years nor served as ENG Advisory Committee members. Most COV members are familiar with BES, from having served on the ENG Advisory Committee or review

panels, or are former or current grantees. None had proposals pending with BES during the COV meeting. A conflict of interest briefing was held on the first day of the COV meeting. The absence of any conflict of interest was confirmed by asking all to complete the NSF Conflict of Interest form, none of which disclosed any conflicts. Assignments were made to ensure that there would be no conflicts of interest. No real or apparent conflicts arose during the course of the meeting.

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OVERVIEW/SUMMARY FOR BES COV REPORT

The COMMITTEE OF VSITORS (COV) met on February 28th, March 1st and 2nd, 2005 to review programs in the Bioengineering and Environmental Systems Division of the Engineering Directorate in the National Science Foundation. This Division consists of three clusters: Biochemical Engineering and Biotechnology; Biomedical Engineering and Research to Aid Persons with Disabilities; and Environmental Engineering and Technology. All three clusters were reviewed.

In the course of its review, the COV read and evaluated 92 jackets -- files containing proposal actions from 2002-2004. The selection was a stratified random sample as described in the report. The total pool of jackets during the last three years was 2584 and all were available upon request. Oral presentations were made by the head of the Engineering Directorate, the Division Director and the Program Directors. This information along with the files provided the principal information for the Committee to consider during its deliberations.

The COV's responses in this report follow the prescribed template for FY 2005 COV Reviews. Parts A.1,A.2,A.3,A.4, and A.5 deal with the Integrity and Efficiency of the Program's Processes and Management. Parts B.1,B.2,B.3, and B.4 deal with Outputs and Outcomes of NSF Investments. Part C covered Other Topics.

The COV commends the Division for its effective and efficient processing of proposal reviews, exceeding the 70% less than six month dwell-time target in each of the three years of study. This is particularly impressive in light of the greatly increased numbers of proposals processed compared to the 2000-2002 time frame of the last COV report.

Overall the COV found the programs in the Division were doing extremely well in meeting stated goals and objectives. The management of BES appears excellent. As noted in the last COV report, this is particularly noteworthy in view of the wide range of programs in the Division's portfolio, the very tight budget within NSF, and their emphasis on building young academic investigators through a large investment in CAREER Awards.

FY 2005 REPORT TEMPLATE FOR
NSF COMMITTEES OF VISITORS (COVs)

Date of COV: Feb. 28 -March 2, 2005
Program/Cluster: Entire BES division
Division: BES
Directorate: ENG
Number of actions reviewed by COV[1]: Awards: 43 Declinations: 47 Other: 2
Total number of actions within Program/Cluster/Division during period being reviewed by COV[2]: Awards: 353 Declinations: 2170 Other: 61
Manner in which reviewed actions were selected: **Stratified random sample. Stratified by year (2002, 2003, 2004), cluster (BEB, BME/RAPD, EET), proposal type (CAREER, unsolicited, metabolic engineering, CLEANER; solicitations for NSE and BE excluded because they have their own COVs plus panels often not run by BES), and proposal action (award, non-award). Within stratifications, each COV member randomly chose at least ten jackets for inspection (nominally, 5 awards, 5 declines). Any BES jacket for 2002-2004 was subject to inspection at the request of any COV member. A comprehensive electronic index of all BES proposals for 2002-2004 was provided to the COV.**

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

Briefly discuss and provide comments for *each* relevant aspect of the program's review process and management. Comments should be based on a review of proposal actions (awards, declinations, and withdrawals) that were *completed within the past three fiscal years*. Provide comments for *each* program being reviewed and for those questions that are relevant to the program under review. Quantitative information may be required for some questions. Constructive comments noting areas in need of improvement are encouraged.

A.1 Questions about the quality and effectiveness of the program's use of merit review procedures. Provide comments in the space below the question**.** Discuss areas of concern in the space provided.

QUALITY AND EFFECTIVENESS OF MERIT REVIEW PROCEDURES	YES, NO, DATA NOT AVAILABLE, or NOT APPLICABLE[3]
1. Is the review mechanism appropriate? (panels, ad hoc reviews, site visits) Comments: **While the use of panel and ad hoc reviews appears to be sufficient to identify quality proposals and provide feedback to those not funded, the COV observed there is occasional bias evident during panel review on the part of external reviewers. For example, investigators with a significant track record of success (or less established investigators with an excellent pedigree) are sometimes accorded more slack during evaluation and ranking.**	**YES**
2. Is the review process efficient and effective? Comments: **The COV felt the overall review process is effective and is working well. Despite receiving over 900 proposals in both 2003 and 2004, most proposals have been reviewed in a relatively timely manner (about 80% within 6 months of receipt, exceeding NSF goal of 70%).**	**YES**
3. Are reviews consistent with priorities and criteria stated in the program's solicitations, announcements, and guidelines? Comments: **While reviews are clearly focused on intellectual merit first and broader impact secondarily, awards and feedback are generally consistent with stated program criteria. However, the COV felt that continued improvement in attention to broader impact should be encouraged. In addition, the COV recommends that BES provide more guidance for panel members about the significance of the broader impact criterion.**	**YES/NO**

[1]To be provided by NSF staff.
[2] To be provided by NSF staff.
[3] If "Not Applicable" please explain why in the "Comments" section.

4. 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? Comments: **The COV feels that panelists must document more explicitly in the summary portion of their individual reviews how each arrives at their overall rating. While the majority of reviewers adequately comment on the intellectual merit of each proposal, the COV suggests that panel moderators ensure that each panelist revises (if necessary) their review comments to ensure the PIs receive constructive feedback on declined proposals. The written comments should be consistent with the overall rating.**	**YES/NO**
5. Do the panel summaries provide sufficient information for the principal investigator(s) to understand the basis for the panel recommendation? Comments: **While the summaries frequently reflect some aspects of the panel discussion, they do not always fully address the evaluation criteria. The COV recommends that panel moderators review the summaries and suggest improvements when the summaries are lacking. When reviewers' evaluations are widely divergent, the panel summary should reflect the resolution reached during the panel's discussion.**	**YES**
6. Is the documentation for recommendations complete, and does the program officer provide sufficient information and justification for her/his recommendation? Comments: **The COV found that some proposals withdrawn due to funding by other agencies did not contain a summary statement of the review process. The COV recommends that proposals withdrawn due to funding by other agencies must still contain a context statement summarizing the review process.** **If a program officer's funding deviates from a panel's recommendation, this should be clearly documented. The COV suggests adding a diary note when the rationale is based on information that is not intended for the PI.**	**YES**
7. Is the time to decision appropriate? Comments: **Although the COV is sure PIs would like to hear sooner, about 80% of proposals were reviewed with final recommendation made by BES within 6 months of receipt in 2003 and 2004.**	**YES**
8. Discuss any issues identified by the COV concerning the quality and effectiveness of the program's use of merit review procedures: **None other than those noted above.**	

A.2 Questions concerning the implementation of the NSF Merit Review Criteria (intellectual merit and broader impacts) by reviewers and program officers. Provide comments in the space below the question. Discuss issues or concerns in the space provided.

IMPLEMENTATION OF NSF MERIT REVIEW CRITERIA	YES, NO, DATA NOT AVAILABLE, or NOT APPLICABLE [4]
1. Have the individual reviews (either mail or panel) addressed both merit review criteria? Comments: **Utilizing NSF GRPA Performance Indicator Data for the period 2002 – 2004, the following percentages of reviews addressed both merit review criteria: for 2002 (85%), for 2003 (91%), and for 2004 (94%). This reflects a continual improvement over the sample period, and an overall high level of compliance.**	**YES**
2. Have the panel summaries addressed both merit review criteria? Comments: **92 jackets (45 awards, and 47 declines) were reviewed, and the *Panel Summaries* were checked to see if they addressed both merit review criteria. 82 (89%) summaries addressed both merit criteria, while 10 (11 %) did not. Most of the panels that did not consider both criteria were from 2002. In 2003 and 2004, both criteria were more likely to be considered.**	**YES**
3. Have the *review analyses* (Form 7s) addressed both merit review criteria? Comments: **92 jackets (45 awards, and 47 declines) were reviewed, and the *review analyses* were checked to see if they addressed both merit review criteria. 92 (100 %) analyses addressed both merit criteria, while 0 (0 %) did not.**	**YES**

[4] In "Not Applicable" please explain why in the "Comments" section.

4. Discuss any issues the COV has identified with respect to implementation of NSF's merit review criteria.

The COV discussed the relative weighting of the technical aspects versus the broader aspects. No weighting criteria were proposed. However, it was noted that the technical aspects were often used as a first cut to determine the rating of a proposal and then the broader aspects were considered to insure they were appropriately addressed. The broader aspects should include both the educational aspects and the benefits to society.

A.3 Questions concerning the selection of reviewers. Provide comments in the space below the question. Discuss areas of concern in the space provided.

SELECTION OF REVIEWERS	**YES , NO, DATA NOT AVAILABLE, or NOT APPLICABLE[5]**
1. Did the program make use of an adequate number of reviewers? Comments: **As a rule, a minimum of three reviewers was assigned to each proposal, and often four or more reviewers were assigned. For fiscal years 2002-2004, the average number of reviewers per proposal was 3.74.**	**Yes**
2. Did the program make use of reviewers having appropriate expertise and/or qualifications? Comments: **A highly qualified group of individuals representing a broad and appropriate range of expertise was recruited to serve as reviewers. Reviewers included a mix of senior and junior faculty and representatives from industry, though industrial representation could be improved. Increased efforts to recruit professionals from industry are encouraged, recipients of SBIRs may be a promising source. The inclusion of junior faculty as reviewers serves an important training role and should be continued.**	**Yes**

[5] If "Not Applicable" please explain why in the "Comments" section.

3. Did the program make appropriate use of reviewers to reflect balance among characteristics such as geography, type of institution, and underrepresented groups? Comments: **The geographical and institutional distribution among reviewers was strong with nearly every state and the District of Columbia represented as well as the full range of institutional types. While the representation from members of underrepresented groups and women was in line with distributions within the population and within academe, the Program is encouraged to continue and intensify its strong efforts to include underrepresented minorities and women as reviewers.**	**Yes**
4. Did the program recognize and resolve conflicts of interest when appropriate? Comments: **Conflicts of interest were appropriately addressed and fully documented. Reviewers and program officers were diligent in following established procedures.**	**Yes**

5. Discuss any issues the COV has identified relevant to selection of reviewers.

The COV recognizes the challenges associated with ensuring that a diverse panel of reviewers is recruited, particularly in the recruitment of members of underrepresented groups and women. Statistics (2001) available for women in BME, for example, reveal that 40% of BS degrees, 38% of MS degrees, and 30% of PhDs are awarded to women, yet 17.5%, 11.1%, and 4.4% of the assistant, associate, and full professors, respectively are women. It will take time for the pool of potential women reviewers to grow substantially such that their level of participation on panels is significantly increased. The COV suspects that comparable statistics for underrepresented minorities are even more dismal. Efforts to maximize panel participation from the existing pool of underrepresented minorities and women are highly encouraged. Drawing on databases for underrepresented minorities and women, that may be available from professional societies may be helpful.

A.4 Questions concerning the resulting portfolio of awards under review. Provide comments in the space below the question. Discuss areas of concern in the space provided.

RESULTING PORTFOLIO OF AWARDS	APPROPRIATE, NOT APPROPRIATE[6], OR DATA NOT AVAILABLE
1. Overall quality of the research and/or education projects supported by the program. Comments: **Proposals resulting in awards are generally rated excellent by several reviewers, and rate in the top 10-20% of submitted proposals. Prestigious awards won by supported PIs since 2002 attest to the quality of the projects supported by the program: (2002) Howard Hughes Medical Institute Million Dollar Undergraduate Education Award; two elected to NAE; Draper Prize to Bob Langer (2004); two BES PIs elected to IOM; and one PI won NSF Waterman Award.**	**APPROPRIATE**
2. Are awards appropriate in size and duration for the scope of the projects? Comments: **The average BES award size is essentially the same dollar amount, $120,998, as the average ENG award of $119,837, and is appropriate given the scope of the projects proposed. However, BES-supported research generally has a higher burden of laboratory/experimental costs that are not reflected in the typical BES award. In fact, BES awards are considerably smaller and shorter (e.g., 3 yrs vs. 4-5 yrs) than similar awards made by other organizations (e.g., NIH), resulting in relatively limited scope projects relative to those funded by other organizations.**	**APPROPRIATE**
3. Does the program portfolio have an appropriate balance of: • High risk projects? Comments: **SGER funds amount to 9% of the <u>unsolicited</u> funding, providing unique opportunities for high-risk projects. Reviewers' notes and panel summaries indicate a reasonable fraction of projects being "high risk - high reward." General proposals with divergent reviews might be another source of high-risk research that could be considered and encouraged for SGER award applications.**	**APPROPRIATE**

[6] If "Not Appropriate" please explain why in the "Comments" section.

4. Does the program portfolio have an appropriate balance of: • Multidisciplinary projects? Comments: **A very high percentage of projects are multidisciplinary, including engineering, biology, and/or medical components, buoyed by the large number of CAREER awards (126 of 520 awards). This aspect is a considerable strength of the program portfolio. BES is the only ENG division that has a formal unsolicited proposal competition for support of multi-disciplinary groups in its core programs.**	**APPROPRIATE**
5. Does the program portfolio have an appropriate balance of: • Innovative projects? Comments: **Reviewers appear to be keenly alert to the importance of innovative projects and rate proposals accordingly. It appears that BES has an appropriate balance of funded innovative projects.**	**APPROPRIATE**
6. Does the program portfolio have an appropriate balance of: • Funding for centers, groups and awards to individuals? Comments **While the majority of funding appears to go to individual awards, BES is planning for a large facility award (CLEANER). It was noted that centers are supported by the Engineering Education and Centers Division of ENG/NSF. Given the funding available to BES, it appears that BES has an appropriate balance of group and individual awards.**	**NOT APPLICABLE**
7. Does the program portfolio have an appropriate balance of: • Awards to new investigators? Comments: **Awards to new PIs were 30-40% of the total awards made by BES in 2004, exceeding the NSF goal of 30%. Overall, new investigators experienced a 9-12% success rate during FY2002-2004.**	**APPROPRIATE**
8. Does the program portfolio have an appropriate balance of: • Geographical distribution of Principal Investigators? Comments: **BES has active awards in 44 of the 50 states including 18 of the 24 EPSCOR states.**	**APPROPRIATE**

9. Does the program portfolio have an appropriate balance of: • Institutional types? Comments: **BES funds research in predominantly 4 yr colleges, State & Local institutions, Masters degree schools, Non-Research Intensive PhD Institutions, and Research Intensive PhD Institutions (the top 100). Given the focus on engineering training and education, the distribution seems appropriate.**	**APPROPRIATE**
10. Does the program portfolio have an appropriate balance of: • Projects that integrate research and education? Comments: **The majority of funded projects emphasize training and education aspects of the project, especially CAREER (126 of 520 active awards) awards.**	**APPROPRIATE**
11. Does the program portfolio have an appropriate balance: • Across disciplines and subdisciplines of the activity and of emerging opportunities? Comments: **The portfolio includes a wide range of disciplines and subdisciplines, including emerging opportunities, although the "emerging opportunities" (exploratory research) area may be increasingly threatened as ad hoc initiatives with mandatory allocations attain higher funding priorities.**	**APPROPRIATE**
12. Does the program portfolio have appropriate participation of underrepresented groups? Comments: **For FY2002-2004, proposal success rates of women and minorities appeared to be higher than for males. Without data on the percentage of underrepresented groups that would be present in the eligible PI population, the COV is unable to determine if the participation is appropriate or not.**	**DATA NOT AVAILABLE**

13. Is the program relevant to national priorities, agency mission, relevant fields and other customer needs? Include citations of relevant external reports. Comments: **Program staff support and participate in a variety of workshops and other meetings that cover the topic, viz: CLEANER; World Technology Evaluation Center (WTEC) Tissue Engineering Study; Operating Room 2020 Workshop; International Conference on Aging, Disability, and Independence (ICADI). The program is highly relevant to the mission of supporting engineering education, and within the constraint of available funding, to supporting the deployment of new innovations into service for society.** **EXAMPLE:** ***Washington Researchers Seek High-Tech Ways to Help Blind Students Associated Press (02/13/05)*** **With National Science Foundation support, researchers at the University of Washington are attempting to automate the translation of complex graphics used to teach technical subjects into material readable for the blind to give this disabled group a chance to pursue careers in science, computers, and engineering.**	**APPROPRIATE**
14. Discuss any concerns relevant to the quality of the projects or the balance of the portfolio. **The COV expressed concern regarding (i) the limited size of awards relative to the actual scope and cost of performing research in the supported BES-related fields (e.g., the already low budgets were often reduced by NSF staff when awarded); (ii) the low funding success rate, which discourages some in BES-supported fields from seeking NSF support; and (iii) requirement for significant research funds in addition to NSF funding, at least in some cases, in order for PIs to make significant progress towards the specific aims of the BES grant. These concerns are significant in light of the expanding diversity of BES-supported research as it impacts an even greater range of disciplines and societal issues.**	

A.5 Management of the program under review. Please comment on:

1. Management of the program.

Overall management of BES appears excellent. Some specific points supporting this include:

- **GPRA 6-month dwell-time target (at least 70% "DD concurred" within 6 months) consistently exceeded:**
  - **2002 72%**
  - **2003 80%**
  - **2004 78%**

- **Top-notch PIs as demonstrated by Academy elections and prizes:**

  2005 NAE: George Georgiou (1987 BES PYI)
  NAE: Harvey Blanch (steady BES support)

  2004 Institute of Medicine (IOM): Frances Arnold (1989 BES PYI)
  Institute of Medicine (IOM): Cato Laurencin (steady BES support)
  Waterman: Kristi Anseth (1997 BES CAREER Award)

  2002 NAE: Tom Graedel (steady BES support)
  Howard Hughes Meduical Institute (HHMI): Rebecca Richards-Kortum (1991 BES PYI)
  Draper: Bob Langer (steady BES support)

- **Balanced Program Officer staff: 6 from universities, 6 NSF Career**

- **Aggressive support staff development program: promotions, first Science Assistant in ENG, formal support staff reorganization**

- **Aggressive collaborations with other ENG divisions (Technology for a Sustainable Environment [TSE], New Technology for the Environment [TSE]), NSF directorates (Quantitative Systems Biotechnology [QSB], Materials Use: Science, Engineering, and Society [MUSES]), and other agencies (Metabolic Engineering [ME], Multi-Agency Tissue Engineering Science Working Group [MATES], Biophotonics, Multi-Scale Modeling [MSM], Image-Guided Interventions [IGI], Forum on the Interface of the Life Sciences and Physical Sciences), often in leadership roles (ME, MATES, Biophotonics, MSM, IGI, Interface)**

Aggressive pursuit of high risk ideas: CLEANER, MSM, QSB, MUSES, Nanotoxicology, SGERs.

2. Responsiveness of the program to emerging research and education opportunities.
Comments:

- **Aggressive pursuit of emerging research opportunities: QSB, Biophotonics, MUSES, Tissue Engineering/Regenerative Medicine (TE/RM), Multi Scale Modeling (MSM), CLEANER, SGERs, etc.**
- **High emphasis on CAREER awards (integrated research and education); made the largest number of CAREER awards in 2005 for any ENG division, even though BES has the smallest budget by far of any ENG division.**
- **Only non-EEC ENG division that invests in ERC and Bioengineering and Bioinformatics Summer Institutes (BBSI) programs**
- **Strong co-funding of Departmental Level Reform with EEC**
- **Heavy participation in Integrative Graduate Education and Research Traineeships (IGERT) by BES staff**

3. Program planning and prioritization process (internal and external) that guided the development of the portfolio.
Comments:

- **Numerous workshops interacting with the academic, industrial, and government communities (CLEANER, Biochemical Engineering (BCE), Metabolic Engineering (ME), Image Guided Interventions (IGI), Interface on the Life Sciences and Physical Sciences)**
- **Explicit draft strategic plan**

4. Additional concerns relevant to the management of the program.

- **BES success rate for 2004 was 13% average ENG average was 15%. These success rates are too low --management should seek ways to improve this. One possibility might be to explore mergers and consolidations both within ENG and with units of other directorates.**

PART B. RESULTS: OUTPUTS AND OUTCOMES OF NSF INVESTMENTS

NSF investments produce results that appear over time. The answers to the first three (People, Ideas and Tools) questions in this section are to be based on the COV's study of award results, which are direct and indirect accomplishments of projects supported by the program. These projects may be currently active or closed out during the previous three fiscal years. The COV review may also include consideration of significant impacts and advances that have developed since the previous COV review and are demonstrably linked to NSF investments, regardless of when the investments were made. Incremental progress made on results reported in prior fiscal years may also be considered.

The following questions are developed using the NSF outcome goals in the NSF Strategic Plan. The COV should look carefully at and comment on (1) noteworthy achievements of the year based on NSF awards; (2) the ways in which funded projects have collectively affected progress toward NSF's mission and strategic outcomes; and (3) expectations for future performance based on the current set of awards. NSF asks the COV to provide comments on the degree to which past investments in research and education have contributed to NSF's progress towards its annual strategic outcome goals and to its mission:

- To promote the progress of science.
- To advance national health, prosperity, and welfare.
- To secure the national defense.
- And for other purposes.

Excellence in managing NSF underpins all of the agency's activities. For the response to the Outcome Goal for Organizational Excellence, the COV should comment, where appropriate, on NSF providing an agile, innovative organization. Critical indicators in this area include (1) operation of a credible, efficient merit review system; (2) utilizing and sustaining broad access to new and emerging technologies for business application; (3) developing a diverse, capable, motivated staff that operates with efficiency and integrity; and (4) developing and using performance assessment tools and measures to provide an environment of continuous improvement in NSF's intellectual investments as well as its management effectiveness.

B. 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."

The COV believes that BES has achieved its goal for people through its early and sustained support of promising investigators, entrepreneurial engineers and scientists, and commitment to diversity.

I. Comment: BES has contributed to the creation of knowledge through its identification and support of distinguished individuals who have subsequently been recognized by their peers and others for their excellence. Examples include:

- Frances Arnold, Professor at California Institute of Technology has been honored as a newly elected member (2004) of the Institute of Medicine of the National Academies. She was also the recipient of the 2004 American Institute of Chemical Engineers award from the Food, Pharmaceutical, and Bioengineering Division, and the current (2005) recipient of an American Chemical Society National Award, the Francis P. Garvan-John M. Olin Medal. She is a member of the NAE and has received a number of awards from the BES Division (BES-8957118, 9416915, 9901495, 9981770, 0118565 and 0313567).

- Rebecca Richards-Kortum, Professor at University of Texas has received a 2002 HHMI (Howard Hughes Medical Institute) Professor Award. She has received a number of awards from the BES division (9872829, 0119450, 0201351) for support of her research and from the IGERT program of the DGE (9870653) for interdisciplinary graduate training.

- Kristi Anseth, Professor at the University of Colorado in Chemical and Biological Engineering and a CAREER awardee (BES-9734236) has received the 2004 Waterman Award. This is NSF's highest honor for a young scientist or engineer. Anseth was chosen for her individual achievements and her groundbreaking work in new biomaterials that are engineered to help the body heal itself. Unlike synthetic body parts, such new materials may lead to new treatments for damaged knees, hips and even heart structures that will contribute to faster healing and a quicker return to a better quality of life.

- Thomas Graedel, Professor at Yale University in the School of Forestry and Environmental Studies has recently been elected to the National Academy of Engineering. The BES division has supported Dr. Graedel's research in sustainability through several awards (9727295, 9818788, 0223985, and 0329470). His innovative work on materials balances and complete elucidation of the use and cycling of industrial minerals such as iron has contributed significantly to the science of resource management.

- Cato Laurencin, Professor at the University of Virginia has recently been named to the Institute of Medicine of the National Academies. Dr. Laurencin's research has been supported over the years through many awards from the BES division (9553162, 9707865, 9741694, 9817872, 9896282, 9940586, 9940587, 9980298, 0115404, 0201923, 0216343, 0225995, 0336736, 0343620).

II. Comment: BES has a well-established record of supporting individuals engaged in innovative research.

- Thomas Wood and William Bentley from the University of Connecticut and the University of Maryland, respectively, with support from NSF Grant BES 0124401, have used engineered enzymes for synthesizing a class of compounds that show promise for treating Parkinson's disease. Using directed evolution and saturated mutagenesis, they have developed bacteria that harbor an improved monooxygenase for the production of 4-nitrocatechol from nitrobenzene. The catechol has been challenging to produce with high purity and high yield by traditional chemical oxidation. This work has resulted in a significant technological breakthrough for the pharmaceutical industry. It has also provided for the cross-disciplinary training between chemical engineers and molecular biologists that is necessary for further advances in the development of pharmaceuticals for the treatment of chronic disease.

- Jens Karlsson, a CAREER grant (0314343) recipient at Georgia Institute of Technology has contributed to the science of cryobiology in his devitrification modeling for the freeze-thaw of cryopreserved cells and tissues. With his colleagues, Dr. Karlsson has shown that the size of intracellular ice crystals can decrease with slower warming rates, greatly increasing the survivability of cryopreserved cells and tissues, which is of enormous benefit to medical practice.

III. Comment: BES support has contributed to numerous new patents and contributed to economic development through its support for researchers who have established companies based on their research outcomes.

- Robert Langer, Professor at Massachusetts Institute of Technology has been awarded over 400 patents dealing with drug delivery systems and tissue engineering. This work has resulted in the formation of more than 25 companies. Prof. Langer's world-recognized work has been supported by several BES grants over the years (9202311, 9525913, 9904368).

- Work by Chaitan Khosla, Professor at Stanford University, on novel antimicrobial and anticancer drugs has led to the formation of Kosan Biosciences. This start-up firm is working with major pharmaceutical companies to bring the most promising drugs to market. Prof. Khosla's work has been supported by several BES grants over the years (9209901, 9457259, 9806774, 9910949).

- Professor Michael Shuler at Cornell University has received several patents for novel cell culture systems. His work with plant cell culture systems led to the formation of Phyton Catalytics. This firm has been working with Bristol-Meyers Squibb on the production of Taxol, which is used in the treatment of several forms of cancer. Prof. Shuler's work has been supported by several BES grants over the years (9412249, 9632961, 9909133, 0109936, 0342985).

- Professor Friedrich Srienc at University of Minnesota-Twin Cities has developed novel instrumentation that promises to significantly facilitate the study of cell-to-cell variability in cell populations. This instrumentation may be useful in medical research, since detection of cell variability is one of the first diagnostic steps in cancer research. Several National as well as Minnesota companies have expressed significant interest in this technology, and it is likely that in the near future this device will be available on the biotechnology instrumentation market. Professor Srienc received support from BES 9986029.

IV. Comment: BES has contributed to the development of a diverse workforce through CAREER Awards to diverse faculty and support for outreach programs to diverse students.

- In 2002, one of the BES PECASE Awardees was a woman. In 2003, both BES PECASE Awardees were women, one of whom was African American.

- A CAREER Award to Prof. Yadong Li (0238765) at Jackson State University, a Historically Black University, provides an opportunity for a large number of African American students to become involved in research dealing with environmental hazards associated with disposal of electronic waste.

- A grant to Norma Cantu (0339201) **"**Adelante!" focuses on Latinas in Math, Science and Engineering. Latinas, and specifically Chicanas, are significantly underrepresented in math, science and engineering disciplines. One goal of Adelante! was to bring together Chicana graduate students and professors in science, math, and engineering at the annual meeting of the Mujeres Activas en Letras y Cambio Social (MALCS) held in San Antonio. The conference was held in August 2003 and it was very successful with 27 Chicana students and 10 professors participating in the conference attended by over 300 Chicanas.

V. Comment: BES has supported the efforts of investigators in the promulgation of science and engineering through outreach activities in grade schools, high schools and the community at large.

- All CAREER Awardees are expected to participate in activities that are inclusive of training and education of others. BES invests heavily in CAREER awards.

- In a continuing grant (BES-0094010), Gary Huber at the University of California – San Diego is developing teaching module software for high school students to enable the understanding of the interactions of complex biological molecules.

- See third bullet under previous comment.

- CAREER Award BES-0093916 to Dr. Steven Warren, Kansas State University, supports design component-based patient monitoring technologies for the home. As part of this award, the PI is promoting the interest of young girls in science and education through an arrangement with the NSF-supported “Girls Researching Our World (GROW)” project at KSU. The PI has organized several workshops in which girls in grades 6-8 are introduced to biomedical research instrumentation.

VI. Comment: BES support has facilitated the establishment of international collaborations.

- Garrick Louis at the University of Virginia (CAREER/PECASE BES-9984318) reported that as part of his supported work, he has conducted case studies in Nelson County (Virginia), Tobago (W. Indies), and Metropolitan Manila (Philippines) on municipal sanitation system capacity deficiencies.

- Professor Gill G. Geesey at Montana State University (BES 0116013) has developed a research collaboration with an investigator in Mexico that is fostered, in part, by funding from the NSF CONACyT Program. In this work, the properties and strengths of microbial adhesives are being characterized using atomic force microscopy and other methods.

- Professor Kara Nelson at the University of California-Berkeley (BES 0239144) engages young engineers and scientists in international research and education, especially in developing countries. Features include development of continuing collaborations with public and private organizations that employ engineers to work in developing countries.

- Professor Ned Hwang (BES 9812752) at the University of Miami and Professor Y. K. Lin (BES 0049040) at Florida Atlantic University are involved in a collaborative project on mechanical heart valve (MHV) testing. The testing protocol is being developed jointly at the U.S. institutions and the National Health Research Institutes, Taiwan.

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

The COV believes that BES has been highly successful in meeting its goal for ideas.

BES appears to be a leader within ENG in developing "Big Ideas" and picking project winners among its large pool of unsolicited proposals. On a program scale, BES staff gave the COV six examples of such big ideas that are at various stages of implementation: Collaborative Large-scale Engineering Analysis Network for Environmental Research (CLEANER); Quantitative Systems Biotechnology; Biophotonics and Image-Guided Interventions; Materials Use -- Science, Engineering, and Society (MUSES); Multi-scale Modeling; and Tissue Engineering. Perhaps the most ambitious among these is CLEANER, whose purpose is to fundamentally "transform and radically advance the scientific and engineering knowledge base for addressing the challenges of large-scale human-dominated complex environmental systems." Within NSF, ENG led the conceptualization and solicitation for Quantitative Systems Biotechnology and then recruited other directorates to participate. (BES, *Draft Strategic* Plan, February 18, 2005).

At the individual project level, a selected sampling of nuggets garnered from FY2004 GPRA material suggests the range of BES-funded work and the exemplary work that emerged from formative ideas. Each of these examples illustrates the multiple ways in which scientific discovery and engineering innovation are connected to learning and service to society.

- **An ultra-miniature confocal laser scanning microscope (Nugget ID: 8448).** A Major Research Instrumentation award (MRI) was made to enable the development of a miniature confocal laser scanning microscope for in situ imaging of bacterial biofilms in their natural environments. The research team, which includes investigators from Montanta State University's Center for Biofilm Engineering and Department of Electrical and Computer Engineering and Microvision, Inc., has exploited recent advances in Silicon micromachining and microlens technologies to produce a confocal microscope smaller than 2 mm in diameter and only 10 mm long. The successful development of this high resolution miniature probe will enable in vivo and in situ research in areas that were not available with existing techniques. Of particular importance to society is the potential of the device for diagnosing epithelial or endothelial disease, e.g., endocarditis, at an early stage. (PI: David Dickensheets)

- **Biodetoxification of Organophosphorus Nerve Agents by Immobilized Escherichia coli with Surface Expressed Organophosphorus Hydrolase and CBD Protein in a Fixed-film Bioreactor (Nugget 8246).** The investigators have succeeded in developing two technologies for the neutralization of an important class of chemicals known as organophosphates (OP), which are widely used as pesticides and insecticides in agriculture but also can be used as nerve agents against humans.

These technologies serve not only to protect the public from chemical attack, but also as a valuable new tool for cleaning up OP contamination found in pesticide residues, agricultural runoff, and chemical weapons stockpiles. Parallel approaches have been explored to develop sensitive, selective, rapid, portable and low cost biosensors for detection of these nerve agents with funding from the U.S. EPA, the USDA and from the Memorial Institute for Prevention of Terrorism and the Office for Domestic Preparedness, U.S. Department of Homeland Security. (PI: Ashok Mulchandani)

- **Biomimetic Interfaces for Implantable BioMEMS (Nugget ID: 8403).** Dr. Desai and her colleagues have developed a versatile technique, combining surface engineering with layer-by-layer microfluidics technology, to create a 3-D microscale hierarchical tissue-like structure that models the vascular system. Though the vascular system was used as the model, the approach can be used for fabricating numerous tissue-like structures with controlled microarchitectures and 3-D configurations of multiple cell types that could be implanted in humans. As a PhD student at Berkeley, Dr. Desai developed a microscopic device that, when implanted in diabetic rats, delivered ongoing, regular doses of insulin. This device is now being developed for humans. She has developed a speck-size layered plastic device that, when swallowed, attaches to the intestinal lining, releasing medicine. As indicated above, she is now working on building better artificial blood vessels. As a result of her accomplishments in developing implantable devices, Dr. Desai was named one of the 10 most brilliant scientists in the US for 2003 by *Popular Science* magazine. Dr. Desai is a woman engineer in a still male dominated field. Her selection as one of the nation's most brilliant scientists attests to the importance of her research. Besides identifying principles for engineering surfaces that were biofunctional, the research fostered advances in developing therapeutic bioMEMS, lab on a chip platforms, and drug delivery systems that can more effectively interface with the biological world. Though the concept of tissue engineering has been around for some time, major breakthroughs have yet to be achieved. The device designed by Dr. Desai for delivering insulin has the potential to provide the first "cure" for diabetes. Her plan for creating artificial blood vessels with the potential for acting like normal vessels, e.g., with the ability to expand and grow, is extremely innovative.

Retrospectively, BES has been successful in identifying CAREER awardees who have gone on to develop big ideas of their own. For example,

- **Kristi Anseth.** Winner in 2004 of NSF's Alan T. Waterman Award, the foundation's most prestigious award for a young researcher (award 0444771), after being selected in 1997 by BES for a CAREER Award (9734236), "Photocrosslinkable Polymers for Fracture Fixation" and, in 1996, for SGER 9619331, "Development of Photocurable Degradable Polymers for Orthopedic Applications." Dr. Anseth is an outstanding example of a young PI deeply involved in discovery, learning, innovation, and service to society. Her Waterman Award (which includes a $500,000 grant over a three-year period to carry out research or advanced study in the field and institution of her choosing) is based on groundbreaking work in new biomaterials that are engineered to help the body heal itself (i.e., the subject of her BES CAREER and SGER grants). Since the inception at NSF of the annual Waterman Awards in the 1970s, a total of 29 Waterman Awards have been made. Of these, only 4 have gone to engineers. Of these 4, BES PIs have won 2, both in the last 5 years (one to Dr. Anseth, and one to Dr. Khosla, see next entry below). Dr. Anseth is the only woman engineer to date to have won a Waterman Award.

- **Chaitan Khosla.** Senior author of the 2002 publication in Science (291: 2275-2279) "Structural Basis for Gluten Intolerance in Celiac Sprue." This publication explicitly acknowledges support by the Alan T. Waterman Award, which Dr. Khosla received in 1999, based on his work, supported by BES, on microbial synthesis of novel polyketides. BES support of Dr. Khosla included his selection in 1994 as an NSF Young Investigator (forerunner of CAREER awards). Celiac Sprue, a widely prevalent autoimmune disease of the small intestine, is induced in genetically susceptible individuals by exposure to dietary gluten. Dr. Khosla is seeking a treatment for this disease, and has started a non-profit Foundation to facilitate this research. Additionally, based on his polyketide research, Dr. Khosla is co-founder of a start-up company, Kosan Biosciences (Haywood, CA).

- **Rebecca Richards-Kortum.** Winner of the 2002 Howard Hughes Medical Institute (HHMI) Million Dollar Undergraduate Educator Award. Selected by BES in 1991 as a Presidential Young Investigator (PYI; 9157202) for work to improve the basic understanding and the application of optical spectroscopy to biomedical problems. PI for IGERT 9870653, "A New Pathway for Multi-Disciplinary Graduate Education in Optical Molecular Bio-engineering". PI for BES Biophotonics grant 0119450, "Biospecific Contrast Agents for Pre-Cancer Detection" and 9872829, "Integration of Optical Spectroscopy and Optical Coherence Tomography: Increased Contrast to Recognize Early Ovarian Cancers." The work of Dr. Richards-Kortum clearly reflects a strong and recognized emphasis on learning (HHMI award and IGERT PI) coupled to discovery and service to society

- **Robert Langer.** Winner of the NAE 2002 Draper Prize, which has been called by Science, "the Nobel Prize of engineering." As quoted from the ENG AdCom brochure (page 1): "The investigators we support are not just academic researchers: they are real-world innovators and entrepreneurs. A case in point is Robert Langer—professor of chemical engineering at MIT, holder of 400 patents, founder of more than 25 companies, and one of "America's Best in Science and Medicine," according to Time magazine. NSF-ENG provided Langer with early-career support to study various materials as scaffolds for growing living human tissues. The resulting technology is now being used for applications such as cultivating human skin to treat skin ulcers in diabetics." Robert S. Langer is the Kenneth J. Germeshausen Professor of Chemical and Biomedical Engineering at the Massachusetts Institute of Technology. He is the also the only engineer to receive the Gairdner Foundation International Award; 64 recipients of this award have subsequently received a Nobel Prize. In 1989 Dr. Langer was elected to the Institute of Medicine of the National Academy of Sciences and in 1992 he was elected to both the National Academy of Engineering and to the National Academy of Sciences. He is one of very few people ever elected to all three United States National Academies and the youngest in history (at age 43) to ever receive this distinction. BES grants to Dr. Langer include 9112320, 9202311, 9525913, and 9904368. This is a clear case for discovery, innovation, service to society, and through his many students, learning.

- **Mary Jane Cunningham**, Houston Advanced Research Center. Nanomaterials are being developed and manufactured for uses in medicine, communications and energy. However, recent reports have shown that toxicity may occur when these materials come in contact with species in the environment as well as humans. Toxicogenomics is a new field of toxicology, that uses this new genetic information to better predict toxicity. Expression profiling of genes allows the investigator to look at all human gene patterns. SGER proposal 0436366, "Reverse Engineering Cellular Pathways from Human Cells Exposed to Nanomaterials-Development of Novel Risk Assessment Methods," is a merger between biotechnology (toxicogenomics) and nanotechnology. The foundation built from this work may enable toxicity to be predicted and allow new pathways and mechanisms for toxic effects to be determined based solely on this new data. This approach is a leading-edge approach involving "reverse engineering" and "systems biology".

In summary, the COV believes that BES has done an excellent job in supporting quality investigators who have proceeded to produce new discoveries and technologies. The highly selective nature of BES funding -- many investigators seeking few dollars -- has had the effect of funding the top of the highly competitive pool of proposals and may account for an apparently high "hit" rate in terms of successful outcomes and technological pay-offs. The COV believes that BES may be missing even more opportunities due to insufficient resources.

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."

Resource information: facilities, databases, other infrastructure; partnerships with other agencies; use of the Internet.

The COV believes that BES has been successful in meeting its outcome goal for tools. For the period reviewed, BES has supported the development of many research tools, engineering devices, and cyber-infrastructure that enable innovation and learning. Below are examples of facilities, infrastructure, and research and application tools that have being developed from 2002 to 2004 with BES's support and an indication of their accessibility to the scientific community and to the public.

I. Facilities and Cyber-Infrastructure

National Nanotechnology Infrastructure Network (NNIN): BES invested $1.65 million in the in FY 2004 in developing a network for nanotechnology. This five-year, $70 million dollar investment across NSF has established a 13-university nationwide network led by Cornell University to support research and education in nanoscale science, engineering and technology. The network also includes Georgia Tech, Harvard, Howard, North Carolina State, Pennsylvania State, Stanford, UC Santa Barbara, Michigan, Minnesota, New Mexico, Texas-Austin, and Washington. By assembling and sharing specialized resources with all qualified users, NNIN has created the world's largest, most comprehensive and accessible nanotechnology laboratory. Accessibility to NNIN's technical resources and network service, when the project is completed, will be facilitated via a web-based application process (http://www.nnin.org). As of March 2, 2005 most of the links to NNIN services were under construction.

Major Instrumentation for Research and Education – BES is an active participant in the NSF-wide MRI program and has numerous active MRI grants. One example is radiochemical mass balance equipment that was purchased under MRI award BES-0216066 that is enabling undergraduate and graduate students and faculty at Seattle University to measure the radioisotope carbon-14, and which is used in a wide variety of research on the fate of organic chemicals in environmental systems. The specific applications for which the instrument was acquired include studies on phytoremediation. This piece of equipment is institution-based and is accessible primarily to students and faculty of Seattle University.

II. Research and Application Tools

Portable Video Board for Artificial Retina Research-BES supported grant 9808040 to W. Liu (North Carolina State University) that developed a programmable video board for artificial retina research. This portable device integrates a camera and retinal prosthesis chip and is suitable for chronic animal and human testing. The availability of this specialized instrument provides a tool that enhances potential of NSF-supported research to restore eyesight to millions of blind persons. Accessibility to Dr. Liu's findings in the form of technical articles, multimedia presentations, and contact with the Retina Prosthesis Group is possible via the Internet at http://www.ece.ncsu.edu/retina.

A fully autonomous underwater robot, ODIN (omni-directional intelligent navigator) - This was developed under NSF award 97016614 by J. Yuh (University of Hawaii). The robot uses intelligent control strategies based on fuzzy neural network and fuzzy clustering strategies, and it is capable of highly accurate positioning and tracking. Accessibility to ODIN's design features and publications of J. Yuh is possible via the Internet at http://www.eng.hawaii.edu/ME/faculty/yuh.htm, http://www.eng.hawaii.edu/~asl/research/odin.htm.

Technique to Prevent Membrane Fouling - Kimberly Jones, Howard University, developed an ion implanting technique to impart a permanent charge to membrane surfaces, which acts to prevent membrane fouling, a serious problem in the use of membranes for a wide variety of applications in water purification, food processing, and pharmaceutical manufacturing. This work was conducted as part of a CAREER award (97344299) and is notable in that the investigator is an African-American woman at an HBCU.

Patented Instruments for Separation of Immunologically Labeled Cells - Three new, patented instruments were developed by J. Chalmers and M. Zborowski (Ohio State University) for separation and analysis of immunologically labeled cells under BES project 9731059. These devices have potential use in a wide variety of fields, including medical, biochemical engineering, basic biology, and environmental engineering. Some applications include human stem cell separation for bone marrow transplants and separation of genetically engineered cells with specific phenotypes. Accessibility to technical articles and patent numbers related to this research can be found at http://www.che.eng.ohio-state.edu/~chalmers/publist.htm, and http://www.magneticmicrosphere.com

Technique for Building Protein Switches - Under BES-0239088, M. Ostermeier (Johns Hopkins University) has developed a general methodology for building protein switches. The technique, called random domain insertion, exploits the principles of evolution, and the development is significant in that methods to produce protein switches would enable the development of advances in a wide variety of biotechnology-related fields, including biosensors, biomaterials, gene therapy, drug delivery, and metabolic engineering.

Molecular Imaging for Brain Cancer Cells - An SGER award (BES-0201278) to D. Bornhop (Texas Tech U) developed a molecular imaging agent for brain cancer cells that specifically labels glioma cells and can provide both MRI and fluorescence signatures. This *in vitro* work has moved into the animal study stage.

An ultra-miniature confocal laser-scanning microscope was developed under an MRI award (BES-0079789) to D. Dickensheets (Montana State University). The device, called a confocal microprobe, is only 10 mm long and < 2 mm in diameter and supports brightfield and fluorescence imaging. Applications include in vivo imaging of human tissues using an endoscope or catheter platform for early and minimally invasive diagnoses of epithelial and endothelial disease. In addition, innovative imaging devices with cellular level resolution using micro-electromechanical systems for (MEMS) and optical coherence imaging technologies are being developed by M. Wu (UCLA) under BES-0119494) to create new technologies for minimally invasive internal body imaging, including screening cancer. Accessibility to information on this research can be found at http://www.montana.edu/news/1042143917.html, http://www.coe.montana.edu/ee/dickensheets/index.htm

A fluorescence imaging system for massively parallel DNA sequencing was developed under BES-0097793 by J. Yu and N. Turro (Columbia University). This sequencing system includes a chip with immobilized single stranded DNA templates that can self prime for the generation of the complementary DNA strand in the polymerase reaction. Research efforts related to this project were highlighted on the cover of the January 21, 2003, *Proceedings of the National Academy of Sciences*. The device is considered a novel approach to achieving a high throughput chip system for massively parallel DNA sequencing and has high impact because genetic mapping is becoming of far-reaching importance. Technical articles on this research can be found at http://www.columbia.edu/cu/chemistry/fac-bios/turro/faculty.html.

A partnership with FDA was developed to evaluate structural failures in clinically implanted heart valve prostheses. The project was conducted by, Y.K. Lin at Florida Atlantic University through an NSF/FDA letter of agreement and NSF award BES-0049040.

III. Educational Tools

A database of senior design projects for persons with disabilities was developed under the direction of PI J. Enderle (University of Connecticut) on NSF/BES project 9813338. The Web-based database is a good example of using the Internet to make information available to the community. Access to the database can be obtained through http://nsf-pad.bme.uconn.edu.

In-situ Instrumentation Symposium - A national symposium featuring technological developments in *in situ* instrumentation and sensors for environmental conditions, fate-and-transport modeling, and informatics was held at the University of Minnesota with funding support by NSF/BES and sponsorship by the Association of Environmental Engineering and Science Professors. Solicitation was developed for a project office to develop detailed plans and a community consortium to operate the planned facilities, and the two-year project-office award is expected to begin in mid-2005.

In summary, the COV's assessment is that a significant number of application, research and education tools has been developed with funding from BES. Some of these tools have now moved to the animal study stage, have generated patents, or have triggered start-up of small companies. Accessibility to the results of most research projects by the scientific community and the public is possible via the Internet. In addition, BES is in the process of establishing infrastructure (e.g., NNIN) for large-scale instrumentation and network facilities. The COV believes that partnership is central to BES's success. The COV commends BES staff for seeking partnerships and being open to collaboration.

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

The COV believes that BES meets its outcome goal for organizational excellence.

The Bioengineering and Environmental Systems (BES) Division supports research and education in the rapidly evolving fields of bioengineering and environmental engineering. BES has two principal goals. The first goal is to enable and facilitate the deployment of new technologies in BES's fields in service to society in the health, biotechnology, and environmental arenas**.** The second goal is to advance bioengineering and environmental engineering education, particularly through the development of innovative programs by new and diverse faculty. These are critical areas for the US economy since the number of biomedical engineering jobs will increase by 31.4 percent through 2010---double the rate for all other jobs combined, according to the U.S. Department of Labor.

Response to previous COV review:
The previous COV identified several areas for improvement for the Division; one related to the NSF review criteria. It was noted that the Program Directors, in their review analyses, commented on "broader impacts" in 52 of 100 files examined and on "intellectual merit" in 73 of the 100 files. The committee recommended that the two criteria be given equal importance. In response to this recommendation, the BES Division has reminded review panels and mail reviewers to make and document specific comments on the broader impacts of the proposals that they review. This has resulted in much greater compliance with both elements of the NSF merit review criteria. However, it appears that for the majority of the reviews, the "intellectual merit" criterion still receives more consideration than the "broader impact" criterion. The COV recommends that the reviewers be reminded again of the importance of commenting on the intellectual merit and the broader impact for both the educational and research aims of the proposal and that the Program Directors also pay close attention to this when completing Form 7.

The previous COV recommended that BES strive to increase its partnering with other Directorates across the agency to leverage Division funds. Since that review, successful ongoing and new partnerships include the areas of Quantitative Systems Biotechnology, New Technologies for the Environment, Metabolic Engineering, Technology, for a Sustainable Environment, Multiscale Modeling, Sensors and Sensor Networks, Organic Electronics, and Computational Neuroscience. In addition to partnering with other NSF Divisions and Directorates, BES has done an excellent job at partnering or closely interacting with the following government agencies in the above areas: NIH, NSF, DOE, NASA, USDA, DOD, EPA, NIST, FDA, NOAA, AFOSR, NRL, and ONR.

Frequent Cross-Division and Cross-Directorate meetings have helped facilitate BES partnerships. This is how the CL*EAN*ER-CUAHSI Partnership was formed with GEO. It is also how CMS, CTS and CISE became major supporters of the new interagency solicitation led by BES on multi-scale modeling, and how other ENG divisions and BIO, MPS, and CISE became involved in the QSB solicitation led by BES. The same is true for the interagency Metabolic Engineering solicitation, and the Multi-Agency Tissue Engineering and Science (MATES) Working Group, both led by BES.

Additional areas for improvement;
This COV committee recommends additional practices that would lead to a more agile, innovative organization that fulfills it's mission through leadership in state-of-the-art business practices include:

- The BES Division has recently hired five Program Officers. Of these, three were women. BES has a highly diverse and capable staff that is highly motivated and is commended for that. To further strengthen the Division, the COV strongly recommends that BES hire a permanent Division Director for sustained management and leadership.

- The success rate for proposals in BES is low and the budget is not projected to increase. Given the current budget climate, it is recommended that BES set focused priority research and educational areas. The current draft strategic plan lays out goals and strategies for the Division in a very broad sense and lists activities that have already been implemented to reach the goals. The COV recommends that a strategic implementation plan be developed with future goals that are focused and specific and a map with out-year budget projections for the various programs.

- A program evaluation process should be put into place that feeds into the strategic implementation plan.

- There should be a clear relationship between the numerous WTEC study outcomes and the program priorities and program announcements in the Division.

- If possible, the BES should be more pro-active with the nanotechnology announcement so the funded proposals have high relevance to the Division.

- The projected future costs of CLEANER are very large. The Division should seek partnerships with other federal agencies such as NIH (NIEHS), EPA, and/or Dept. of Homeland Security to help leverage NSF funds.

PART C. OTHER TOPICS

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

None identified

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 question

None

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

C.4 Please provide comments on any other issues the COV feels are relevant.
The COV discussed extensively the relative weighting of the technical merit and broader impact criteria without coming to a definite conclusion. However there was concern that the metrics for progress in technical merit are utilized extensively (e.g. peer reviewed publications), methods for evaluation of progress in broader impact were less clear.

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

SIGNATURE BLOCK:

_____

For the [Replace with Name of COV]
[Name of Chair of COV]
Chair

BES COV REPORT ACRONYMS

BBSI – Bioengineering and Bioinformatics Summer Institutes

BCE – Biochemical Engineering

BE – Biocomplexity in the Environment

BEB – Biochemical Engineering and Biotechnology

BME – Biomedical Engineering

BME/RAPD – Biomedical Engineering Program and Research to Aid Persons with Disabilities Program

CAREER – Faculty Early Career Development Program

CLEANER – Collaborative Large-scale Engineering Analysis Network for Environmental Research

EET – Environmental Engineering and Technology

EPSCOR – Experimental Program to Stimulate Competitive Research

GRPA – Government Performance and Results Act of 1993

IGERT – Integrative Graduate Education and Research Traineeships

IGI – Image Guided Interventions

IOM – Institute of Medicine

MATES – Multi-Agency Tissue Engineering Science Working Group

ME – Metabolic Engineering

MSM – Multi-Scale Modeling

MUSES – Materials Use Science Engineering and Society

NAE – National Academy of Engineering

NSE – Nanoscale Science and Engineering

NTE – New Technologies for the Environment

ODIN – Omni-Directional Intelligent Navigator

PECASE – Presidential Early Career Award for Scientists and Engineers Program

BES COV REPORT ACRONYMS cont.

QSB – Quantitative Systems Biotechnology

SBIR – Small Business Innovation Research

SGER – Small Grant for Exploratory Research

TSE – Technology for a Sustainable Environment