April 15, 2005

Dr. Linda P. B. Katehi
John A. Edwardson Dean of Engineering
Schools of Engineering
Purdue University
Engineering Administration Building, 101
400 Centennial Mail Drive
West Lafayette, IN 47907-2016

Dear Dr. Katehi:

As Chair of the Committee of Visitors (COV) for the Electrical and Communications Systems (ECS) Division in the Directorate for Engineering, it my pleasure to submit the attached report based on the COV visit to ECS on March 16-18, 2005.

The COV members judged the ECS Division highly successful in achieving the desired outcomes of its investments in people, ideas, and tools. Overall, the ECS Division is very effectively and skillfully managed. The acting Division Director has done an excellent job and has put forward an excellent vision. The reorganization of the division in order to enhance the Integrative Systems area is well considered, defined, and directed. ECS program managers are committed to meeting all guidelines and requirements and work very well together. Guidance to review panels with respect to the use of the two NSF merit criteria has been improving, and panel execution is very efficient. The staff is excellent in keeping paperwork and administrative decisions moving in a timely manner.

The COV would like to take this opportunity to strongly encourage the Engineering Directorate to enhance support for the ECS Division. The COV has serious concerns over the decreasing discretionary absolute funding provided by the ECS Division budget, the low proposal success rate, and decreasing award size that cannot be overemphasized. These conditions are highly inconsistent with a division that funds research directly or indirectly responsible for eight of the National Academy of Engineering's "20 greatest engineering achievements of the twentieth century" (W. Wulf, "Great Achievements and Grand Challenges," *The Bridge*, vol. 30, no. 3&4, Fall/Winter, 2000).

These conditions jeopardize the productivity of the ECS research community, the ability to recruit graduate students into academic and research careers, and ultimately, the competitiveness of the U.S. engineering research enterprise. They must be addressed quickly and decisively.

We commend and thank acting Division Director, Dr. Usha Varshney, the Senior EngineeringAdvisor, Dr. Lawrence Goldberg, and the Program Directors: Drs. Kishan Baheti, Filbert Bartoli, Rajinder Khosla, James Mink, Vittal Rao, Kevin Tomsovic, and Paul Werbos. We would also like to thank Ms. Gwendolyn Owens and the rest of the ECS Division staff for their preparation and support during the process.

Please let me know if you require additional information or clarification from the Committee. It was a pleasure to be a part of this important process for the ECS Division and the National Science Foundation.

Sincerely,

Gary S. May
Chair, ECS COV

cc: Dr. Usha Varshney

Committee of Visitors Report

Directorate for Engineering

Division of Electrical and Communications Systems

March 16-18, 2005

OVERVIEW

The Committee of Visitors (COV) met on March 16-18, 2005 to review programs in the Electrical and Communications Systems Division (ECS) in the Directorate for Engineering. The Division is comprised of three programs: Electronics, Photonics, and Device Technology (EPDT), Controls, Networks, and Computational Intelligence (CNCI), and Integrative Systems (IS). All of the programs were reviewed for the three years from FY 2002-2004. The IS program is smaller than the EPDT and CNCI programs and was, therefore, reviewed as part of EPDT and CNCI.

During the review, the COV evaluated 178 jackets (proposal actions) that were randomly selected over this three-year time period. A pool of approximately 400 jackets (again, randomly selected) were provided by the ECS administrative staff.

Oral presentations of the programs and processes were provided by the acting Division Director and program directors. ECS statistical data and annual reports were also provided.

The COV's responses in the report follow the prescribed template for the FY 2005 COV Reviews. Section A covers the integrity and efficiency of the Division's processes and management. Section B covers the outputs and outcomes of NSF investments (B.1 covers the people goal, B.2 the ideas goal, B.3 the tools goal, and B.4 the organizational excellence goal). Section C provides a summary on areas of improvement, program performance, and feedback on the COV process.

The COV found that the ECS Division has been highly successful in meeting its program goals and objectives, and that the division processes are carried out with the highest integrity. The ECS program areas are increasingly important to the nation and the world - from generating fundamental knowledge to creating technological solutions for the benefit of individuals and society.

However, the COV identified the following specific areas of improvement to enhance the Division's abilities to carry out its mission:

(1) *Impact of program outcomes.* The COV commends the Division leadership for creating and supporting a broad range of relevant and "forward-thinking" ECS programs through the EPDT, CNCI, and IS programs. However, the COV has major concerns that the ECS budget is not large enough to enable high impact. Discretionary award size is decreasing over time in both absolute and inflation-adjusted dollars. Awards now seem to be about as low as possible to support a GRA and any meaningful time for the PI. This situation is particularly troubling in the case of new PIs. The CAREER Award funding rate has declined from 29% in 2002 to only 16% in 2004 and is continuing to decline. NSF used to be thought of as the place where a small amount of funding could be obtained with some reliability, assuming a high quality proposal was submitted. This was perhaps the case when the success rate was 25-30%, but not at the present rate of ~15%. These conditions jeopardize the productivity of the ECS research community, the ability to recruit graduate students into academic and research careers, and ultimately, the competitiveness of the U.S. engineering research enterprise. This problem must be addressed, quickly and decisively. The COV, therefore, strongly encourages the ECS Division and Engineering Directorate leadership to continue to make the case to enhance the budget (and the average project duration/funding level) to reasonable levels.

(2) *Appropriate use and support of innovative projects.* The ECS Division primarily utilizes the SGER (Small Grants for Exploratory Research) program for the support of innovation projects. This mechanism is effective and allows the support of projects that may not review well, since innovative projects tend to be intrinsically high risk. One potential concern that was observed, however, is that some SGER proposals may be coded as SGER for unjustified reasons. That is, some SGER awards seemed to be "mainstream" awards for senior PIs. In those cases, it seemed hard to justify the use of an SGER, and in the jackets there was no serious or consistent justification. In addition, the SGER budget is too small, however, to create significant program impact. The COV encourages the Division, Engineering Directorate, and the Foundation to enhance mechanisms for the support of innovative projects.

(3) *Breadth of the research portfolio.* The present areas of ECS are a subset of the areas found in EE (and related) departments around the country. For instance, there is little emphasis on signal processing theory and algorithms and very little in system theory. On the other hand, some proposals submitted to ECS could very well be funded by CISE. Addressing the boundaries between NSF Divisions may help put more resources in the perceived gaps of ECS. ECS should also increase its emphasis on appropriate aspects of advanced communications to reflect emerging engineering opportunities. Examples include intra- and inter-chip networking and communications, terahertz communications, and ultra-wideband optical and wireless communications. Finally, ECS should also be proactive in defining and capturing ECS-specific activities in bioelectrical devices, subsystems, and systems biology.

(4) *Understanding and use of NSF Review Criterion 2.* The COV observed that individual reviews are increasingly responding to the guidance and addressing both intellectual merit and broader impacts. Compliance is now virtually 100%. However, the interpretation of the "broader impacts" criterion (Criterion 2) and relative weight given to the requirement is inconsistent across panels. In some cases, this criterion is given very brief ysis forms tend to address both criteria, they place much greater emphasisattention by the PI and reviewer. Furthermore, although review anal upon intellectual merit. In many cases, these analyses are duplication of panel summaries. The COV encourages ECS to continue to elaborate on the review criterion for broader impacts and provide appropriate guidance to PDs and reviewers.

(5) *Diversity among the reviewer base.* The COV encourages the Division to strive continue to increase the diversity (gender, ethnicity, racial, geographical, institutional) of the panels. Although panels seem to have adequate geographical distribution, female reviewers are still underrepresented. In addition, ethnicity data on reviewers was incomplete, thereby making it difficult to draw any conclusions regarding the participation of underrepresented groups.

CORE QUESTIONS and REPORT TEMPLATE
for
FY 2005 NSF COMMITTEE OF VISITOR (COV) REVIEWS

Guidance to NSF Staff: This document includes the FY 2005 set of Core Questions and the COV Report Template for use by NSF staff when preparing and conducting COVs during FY 2005. Specific guidance for NSF staff describing the COV review process is described in Subchapter 300-Committee of Visitors Reviews (NSF Manual 1, Section VIII) that can be obtained at http://www.inside.nsf.gov/od/gpra/.

NSF relies on the judgment of external experts 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. Committee of Visitor (COV) reviews provide NSF with external expert judgments in two areas: (1) assessments of the quality and integrity of program operations and program-level technical and managerial matters pertaining to proposal decisions; and (2) comments on how the outputs and outcomes generated by awardees have contributed to the attainment of NSF's mission and strategic outcome goals.

Many of the Core Questions are derived from NSF performance goals and apply to the portfolio of activities represented in the program(s) under review. The program(s) under review may include several subactivities as well as NSF-wide activities. The directorate or division may instruct the COV to provide answers addressing a cluster or group of programs – a portfolio of activities integrated as a whole – or to provide answers specific to the subactivities of the program, with the latter requiring more time but providing more detailed information.

The Division or Directorate may choose to add questions relevant to the activities under review. NSF staff should work with the COV members in advance of the meeting to provide them with the report template, organized background materials, and to identify questions/goals that apply to the program(s) under review.

Guidance to the COV: The COV report should provide a balanced assessment of NSF's performance in two primary areas: (A) the integrity and efficiency of the ***processes*** related to proposal review; and (B) the quality of the ***results*** of NSF's investments in the form of outputs and outcomes that appear over time. The COV also explores the relationships between award decisions and program/NSF-wide goals in order to determine the likelihood that the portfolio will lead to the desired results in the future. Discussions leading to answers for Part A of the Core Questions will require study of confidential material such as declined proposals and reviewer comments. *COV reports should not contain confidential material or specific information about declined proposals.* Discussions leading to answers for Part B of the Core Questions will involve study of non-confidential material such as results of NSF-funded projects. It is important to recognize that the reports generated by COVs are used in assessing agency progress in order to meet government-wide performance reporting requirements, and are made available to the public. Since material from COV reports is used in NSF performance reports, the COV report may be subject to an audit.

We encourage COV members to provide comments to NSF on how to improve in all areas, as well as suggestions for the COV process, format, and questions.

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

Date of COV: March 16-18, 2005
Program/Cluster: EPDT/CNCI/IS
Division: ECS
Directorate: ENG
Number of actions reviewed by COV[1]: Awards: 98 Declinations: 80 Other: 0
Total number of actions within Program/Cluster/Division during period being reviewed by COV[2]: Awards: Declinations: Other:
Manner in which reviewed actions were selected: Randomly

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

1. Is the review mechanism appropriate? (panels, ad hoc reviews, site visits) Comments: The COV commends the ECS Division for implementing a requirement that proposal reviews be completed and submitted prior to the beginning of the panel. This should help, but not alleviate some of the group dynamics during the panel discussions. Most reviews seem to be panel reviews. The process appears to work well. Site visits are extremely well done. One potential concern observed is that some SGER proposals may be coded as SGER for unjustified reasons. That is, the SGER is for high-risk concepts that may not review well. However, several SGER awards seemed to be "mainstream" awards for senior PIs. In those cases, it seemed hard to justify the use of an SGER, and in the jackets there was no serious or consistent justification.	YES
2. Is the review process efficient and effective? Comments: The panel review process is very effective and well managed. The 14% success rate is a concern, but is more a function of the number of proposals and budget limitations than the review process.	YES
3. Are reviews consistent with priorities and criteria stated in the program's solicitations, announcements, and guidelines? Comments:	YES
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: PIs receive the panel summaries and the individual reviews, which accurately represent panel deliberations. Comments related to the broad impacts criterion are sometimes sparse. This could be due in part to limited details supplied by the PI. The problem is most evident for unsolicited proposals. Some broad impacts appeared to be extrapolated by the reviewers rather than written as a goal of the PI.	YES
5. Do the panel summaries provide sufficient information for the principal investigator(s) to understand the basis for the panel recommendation? Comments: Usually. Comments are sparse on broad impacts on many reviews. One suggestion for improvement would be to have ECS provide a more structured template clarifying the priorities and review criteria for each solicitation,	YES

particularly for broader impacts. Also, it useful for summaries to provide feedback to the PI on how to improve declined proposal. This was done in some cases, but not always.	
6. Is the documentation for recommendations complete, and does the program officer provide sufficient information and justification for her/his recommendation? Comments: Generally, program directors do a very good job in fleshing out and clarifying panel recommendations. In a few cases, however, more justification for a recommend/decline decision could be added. This is particularly true if the reviews are not uniformly excellent or very good. Statistics concerning the number of proposals submitted and number accepted could be provided to the PIs. There also seems to have been a period of time for which some panel 'matrices' were absent from the jacket. It appears that the present practice is to include these matrices – and this is recommended to fully document each proposal in its jacket.	YES
7. Is the time to decision appropriate? Comments: In nearly all cases, the time to decision was six months or less.	YES
8. Discuss any issues identified by the COV concerning the quality and effectiveness of the program's use of merit review procedures: The analog of "grade inflation" is not apparent in these peer reviews. There were few poor grades, but many of all the other categories, from fair to excellent. Thus, a good range of the assessment scale is still being used.	

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: The jackets indicate that the individual reviews are increasingly responding to the guidance and addressing both intellectual merit and broader impacts. Compliance is now virtually 100%. However, the interpretation of the "broader impacts" criterion and relative weight given to the requirement is inconsistent across the panels. In several cases, this criterion is given very brief attention by the PI and reviewer (see A.1.4).	YES
2. Have the panel summaries addressed both merit review criteria? Comments: See A.1.5.	YES
3. Have the *review analyses* (Form 7s) addressed both merit review criteria? Comments: See A.1.6. These forms address both criteria, but have much greater emphasis upon intellectual merit. In many cases, these analyses are duplication of panel summaries. It might be useful for the PD to explicitly address these in terms of his/her own vision for the program.	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.

ECS should elaborate on the review criteria for broader impact and provide more guidance to the panels. If NSF feels that the two criteria be addressed separately, then there should be two formal components of the project description (rather than just the proposal summary). In other words, a PI would submit to *FastLane* the "broader impacts" description as a separate section. Also, a policy of returning to the program manager any panel review summary that does not address broad impact should be implemented.

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:	YES
2. Did the program make use of reviewers having appropriate expertise and/or qualifications? Comments:	YES
3. Did the program make appropriate use of reviewers to reflect balance among characteristics such as geography, type of institution, and underrepresented groups? Comments: Panels had adequate geographical distribution. Most reviewers tend to be male. Female reviewers are underrepresented. In addition, ethnicity data on reviewers is incomplete, thereby making it difficult to draw any conclusions regarding the participation of underrepresented groups.	YES
4. Did the program recognize and resolve conflicts of interest when appropriate? Comments: No conflicts were found.	N/A
5. Discuss any issues the COV has identified relevant to selection of reviewers. None.	

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

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: An excellent cross-section of technical research is evident. The projects provide superb training experiences for graduate students.	APPROPRIATE
2. Are awards appropriate in size and duration for the scope of the projects? Comments: Award size is decreasing over time in absolute dollars and more so in adjusted dollars. Awards now seem to be about as low as possible to support a GRA and any meaningful time for the PI.	NOT APPROPRIATE
3. Does the program portfolio have an appropriate balance of: • High risk projects? Comments: The SGER program, in particular, emphasizes high-risk projects and is increasing in size. The COV applauds this. However, due to budget pressures, not enough high-risk projects are currently funded.	APPROPRIATE
4. Does the program portfolio have an appropriate balance of: • Multidisciplinary projects? Comments: Strategic initiatives strengthen this component enormously. There is strong evidence of multidisciplinary work, leading to unique innovation. This is especially true in the EPNES program, where all projects examined appeared to be multidisciplinary.	APPROPRIATE

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

5. Does the program portfolio have an appropriate balance of: • Innovative projects? Comments:	APPROPRIATE
6. Does the program portfolio have an appropriate balance of: • Funding for centers, groups and awards to individuals? Comments: Nearly all centers are funded by the EEC Division, as opposed to ECS. Funding for collaborative projects is appropriate, but is occupying an increasing fraction of the budget. Funding for single PIs is decreasing and should be increased.	APPROPRIATE
7. Does the program portfolio have an appropriate balance of: • Awards to new investigators? Comments: New PIs have proposals fairly evaluated and are well represented within the funding portfolio. However, the CAREER Award funding rate has declined from 29% in 2002 to only 16% in 2004 and is continuing to decline. Funding for more awards is needed here.	APPROPRIATE
8. Does the program portfolio have an appropriate balance of: • Geographical distribution of Principal Investigators? Comments:	APPROPRIATE
9. Does the program portfolio have an appropriate balance of: • Institutional types? Comments:	APPROPRIATE
10. Does the program portfolio have an appropriate balance of: • Projects that integrate research and education? Comments: It would be useful to require an educational plan for all proposals. In the case of regular proposals, this could be only a paragraph.	APPROPRIATE
11. Does the program portfolio have an appropriate balance: • Across disciplines and subdisciplines of the activity and of emerging opportunities? Comments:	APPROPRIATE

12. Does the program portfolio have appropriate participation of underrepresented groups? Comments: The portfolio includes awards to institutions such as HBCUs/MIs and institutions with high populations from underrepresented groups. The funding rate for women PIs is good. However, the number of applications from Hispanic PIs is low, and the percentage of those funded is worse than all ECS proposals.	APPROPRIATE
13. Is the program relevant to national priorities, agency mission, relevant fields and other customer needs? Include citations of relevant external reports. Comments: The ECS division funds a great deal of innovative research as defined by the *National Innovation Initiative* report by the Council on Competitiveness. However, it is not always clear that industrial applicability is well represented. There are several GOALI awards in the portfolio, and these have excellent industrial interaction. However, because there is a low level of follow-up once an award is made, there is no guarantee that the industrial interaction proposed is carried through.	APPROPRIATE
14. Discuss any concerns relevant to the quality of the projects or the balance of the portfolio. ECS is covering an enormous area with very few resources. Budget constraints and fenced funds limit the number of unsolicited and high-risk proposals. The SGER mechanism is not sufficiently used.	

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

1. Management of the program. Comments: Overall, the ECS Division is very effectively and skillfully managed. The acting Division Director has done an excellent job and has put forward an excellent vision. Her reorganization plans and the establishment of the IS area is well considered, defined, and directed. Her management is viewed as very strong and has brought stability to a program that was suffering from a certain lack of direction. ECS program managers are committed to meeting all guidelines and requirements and appear to be working very well together. Guidance to review panels has been improving and panel execution is becoming more efficient. The staff is excellent in keeping paperwork and administrative decisions moving in a timely and smooth manner. The acting director deserves credit.

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

The program opportunities are selected to address areas of emerging research and are focused upon state-of-the-art research. Education opportunities are well-integrated into many research programs. The program is excellent in its ability to adapt to, define, and incorporate emerging research trends (to the degree that budget constraints allow).

The EPDT/IS/CNCI structure captures the complete panorama of ECS research. Increased IS emphasis is especially valuable, worthy and timely. Increased efforts at getting the word out to potential PIs should pay big dividends—especially at this time when there is an increasing need and desire to integrate a number of technologies to realize new application specific devices.

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

The research portfolio includes a well-balanced selection of programs and topics. PIs contribute significantly to ECS portfolio development through workshops, conferences, websites, and constantly evolving research. However, it sometimes appears that the prioritization process for the portfolio may be too heavily influenced by top-down initiatives and fenced funds.

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

The uncertainty in the Division Director position is a concern to the CoV. Stable management is fundamental to efficient and effective operation of the division. A quality candidate that has a fair and balanced vision to the program is required. The CoV notes that the current acting director has done an excellent job and has performed with high competence.

In addition, management should undertake a series of studies to determine:

- Why is the number of proposals growing so quickly?
- What short and long term affects will a 14% success rate have on the research community?
- How can intra and interagency collaboration be more effectively utilized? For example, it would seem that more CISE connections could be mutually beneficial.
- How can greater incentives be provided for cross-disciplinary work?
- What are the best long term outcome metrics to evaluate proposal success?

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."

Comments:

ECS has an impressive portfolio of topics, research results, and training methods for the next generation of scientists. These results will promote the competitive technology edge of the US for the next generation. A number of ECS programs support engineers, scientists and educators at different career stages, including the CAREER program. For example, a University of Maryland research team led by Professor Elisabeth Smela (ECS-0225489) is developing a biolab-on-a-chip that will allow long-term studies of large arrays of single cells, including monitoring each cell's electrical activity, temperature, and movement. The chip combines sensors and circuitry fabricated using modern microchip technology. It will contain chambers to hold fluids, which can be opened or closed by electronic command, fabricated using microelectromechanical systems (MEMS) technology The group has fabricated a bioamplifier chip, a chip that can sense the weak electrical signals from single heart muscle cells and send out a strong, amplified version of these signals to the user. They have also fabricated tiny chambers, or vials, with lids for holding the cells. In 2005, Prof. Smela received the Presidential Early Career Award for Science and Engineering (PECASE).

In addition, Professor John Papapolymerou of Georgia Tech received CAREER award (ECS-0218732) to develop low loss and low cost impedance tuners for future multi-band communication systems. His solution is based on low-loss, low power, compact RF Micro-Electro-Mechanical-System (MEMS) impedance tuners that will be able to accommodate the changes in the RF transistors resulting from operation in different bands or under different conditions. The proposed solution could revolutionize the hardware of next generation wireless communication systems and enable system flexibility.

The ECS Division also supports a number of innovative educational activities that address the development of a global and well-prepared workforce. For example, in ECS-0329743, Professor Raffaello D'Andrea of Cornell University has made pioneering contributions to the integration of research and education in control systems engineering. Every year 30 students (15 undergraduates and 15 graduates) construct a team of fully autonomous robots and participate in the international RoboCup (Robotic Soccer) competition. Cornell has won the competition 4 times since 1999.

Furthermore, in ECS-0335088, Prof. Bozenna Pasik-Duncan of Kansas State University designed a workshop to increase the awareness of multi-disciplinary research in engineering for 250 students from Maui School District in Hawaii. The students learned from several exciting presentations specifically developed for secondary school level. The topics include: (1) the joys and perils of automation and soccer-playing autonomous robots working together in both defensive and offensive plays against the opposing team; (2) Design of autonomous four-wheel drive vehicle that must race across the desert from Barstow to Las Vegas. The vehicle is not allowed to have driver or any kind of remote control; (3) Learning about role of mathematics and engineering tools for animation and lighting of movies produced by Pixar for Walt Disney Company; (4) Embedded systems in cell phones and mechatronics for cruise control in cars. The goal of the workshop was to develop innovative educational material and encourage participation of students in on-going NSF supported research activities. *IEEE Control Systems Magazine* (July 2004) published workshop articles.

The Pennsylvania NMT (Nanofabrication Manufacturing Technology) Partnership's NSF Regional Advanced Technology Education Center for Nanofabrication Manufacturing Education involves more than 30 institutions of higher education, secondary schools, private industry, and others in joint efforts to meet the expanding needs of Pennsylvania industry for skilled nanofabrication workers, focusing on associate degree level technicians. The key feature of the Center is the extensive hands-on laboratory experience that students receive in the Penn State Nanofabrication Facility, which is part of the National Nanofabrication Infrastructure Network (NNIN) led by Professor Sandip Tiwari of Cornell University (ECS-0335765).

In ECS-0321449, Professor Janice Hudgings established the first engineering and physics research lab at Mount Holyoke College, a small liberal arts undergraduate college for women. Nineteen undergraduate women have conducted independent research in Hudging's lab to date, of which nine are minority women. The award, which focuses on the thermal measurement of optoelectronic devices on the nanoscale, has enabled the establishment of long-term collaborations between Mount Holyoke College and the Massachusetts Institute of Technology.

Finally, Professor Victor Dzidzienyo of Howard University (ECS-0335476) hosted an International Workshop on Power System Operation and Planning in Sub-Saharan Africa to bring together the best minds in Africa and the United States for exchange of ideas, dissemination of research results, and is leading to the development of a diverse work force to address future energy, educational and environmental issues.

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

Comments:

ECS has significantly advanced the frontiers of science, engineering and education in core programs and initiatives. Specific examples are provided below.

In ECS-0219466, Professor Tatsuo Itoh of UCLA developed and experimentally tested the spatial multiplexing of local antenna elements in large multi-dimensional arrays to reduce the size and cost of digital beamforming in smart antenna arrays. These efforts provide an effective means to drastically reduce the amount of costly RF front-end hardware in smart antenna receivers without sacrificing performance.

An excellent example of high-risk exploratory research is seen in ECS-0331515 "SGER: Flexible Thin Film Transistors Using Low Temperature Chemical Bath Deposition," which is the work of Professor Chih-hung Chang of Oregon State University, in which he addresses flexible (polymeric) substrates and high-performance inorganic materials for active devices applications. This research is helping to develop low cost and flexible integrated circuits that will enable many new applications.

In ECS-0322395, a research team led by Professor Jessy Grizzle at the University of Michigan is constructing a novel theory of bipedal locomotion control. Using the new theory, a planar bipedal robot achieved stable walking in a matter of days, instead of the six months to over a year of development time required by all previous methods. Moreover, the robot's motion is graceful and eerily human-like, though it results from pure mathematics, with no bio-mimetics involved. Grizzle and his team have just recently extended their theory to address running. The first experimental results are remarkable. This work has resulted in plenary talks to the control community and the biomechanics community. The results of this research have been broadly published in the archival literature and disseminated on the web.

In ECS-0329743, Professor Raffaello D'Andrea of Cornell University is developing new tools for controlling systems with large numbers of interacting components. With the advent of cheap sensors and pervasive communication and computing, there is a pressing need for feedback control of systems consisting of extremely large numbers of interconnected subsystems. Examples include automated highway systems, vehicle formations, cross-directional control in paper processing application, micro-cantilever array control for massively parallel data storage, and the national power-grid. These feedback control strategies must scale gracefully with the number of subsystems, which in practice can each have local sensing, actuating, and computing elements. Prof. D'Andrea has developed new tools for controlling this large, and growing, class of systems. The key innovation involves the use of sophisticated optimization tools, known as "semi-definite programming." The key property of this new strategy for controlling interacting subsystems is that the underlying strategy mimics the natural dynamics of the system. These new tools will allow researchers and practitioners to safely deploy intelligent, autonomous systems comprised of hundreds, and even thousands, of interacting components.

In the project "GOALI: Ocean Electric Energy Extraction" (ECS-0300386), Professor Annette von Jouanne of Oregon State University is developing ocean energy extraction research, which is fostering excitement and publicity. Her research has demonstrated that significant energy potentials exist in ocean waves. The PI has led graduate and undergraduate student teams through the development of novel renewable generator designs to extract electric energy from ocean waves. The PI's team of undergraduate students developed a novel permanent magnet linear generator buoy that was designed, constructed and tested in the PI's lab. The PI has developed a suite of direct drive buoy designs, converting the linear motion of the wave to electrical energy. This represents a radical departure in design for wave energy extraction systems. Several novel concepts are arising from this research focused on a simplification of processes (e.g. to replace hydraulics with direct drives; to allow generators to respond directly to the movement of the ocean and hence to process the energy extracted by power electronics and employing coupling by magnetic fields for contactless mechanical energy transmission). Understanding the processes requires advanced modeling techniques, including advanced fluid structure interaction modeling using a Commercial Computational Fluid Dynamics Program (Comet). Note that GOALI awards bring university research together with industry -- and this is represented in this project.

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:

The ECS Division has been successful in funding research infrastructure. The set of tools that are being developed are excellent and can have a huge impact in the development of future research and technology. Examples are given below.

The NNIN (ECS-0335765) is a **major** addition in the support of advanced and novel device research with applications across the boundaries of science and technology e.g. biotech, physics, chemistry, geology, sensing, etc.

Funding of a dual-beam e-beam writing system with SEM and FIB capabilities at RPI (ECS-0420946) is providing facility access to 11 projects involving 36 faculty, 48 graduate and 22 undergraduate students. The student population includes 26 women and underrepresented minorities. The group of scientists involved spanned 7 departments and 5 major research centers.

Professor Joseph Paradiso at the Massachusetts Institute of Technology (ECS-0225492) has developed a flexible physical test bed for study of large wireless sensor networks. Engineers and users in many fields have become excited by the potential of large-scale wireless sensor networks – networks which couple together huge numbers of sensors and small computers, for use in applications ranging from battlefields, to smart buildings, etc. Prof. Paradiso has constructed a simple physical testbed system for testing different theories of distributed sensing and computing, and different physical sensor placements. The testbed is basically a two-meter-by-two-meter bulletin board, into which he can insert specially designed "pushpins" which, though small, contain extensive sensing and computing and communication capabilities. The testbed makes it easy to experiment with changing number of sensors and changing patterns of sensor placement. It makes it possible to evaluate how large-scale alternative designs actually work in the physical world. So far, the PI has used it to demonstrate a number of design concepts previously discussed only in computer simulation, such as biologically inspired designs for detecting patterns of light.

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."

Comments:

The CoV would like to commend the ECS Division for its demonstrated commitment to organizational excellence in the development and management of research and education programs in support of the ECS research community. Panel management and execution has continuously improved. The time required for most panel reviews has decreased over the past 2-3 years from 2 full days to about 1.5 days. The requirement that written reviews be submitted before the panel meets is very positive and has greatly enhanced the effectiveness and quality of the panel review system. Guidelines, priorities, and conflict of interest issues are clearly stated to the panelists.

The CoV is impressed with the ECS division's ability to provide a credible, efficient merit review system with the increasing number of proposals received annually. The ECS continues to support a balanced diverse mix of new and emerging technologies for business application. The CoV observed a diverse, capable, motivated staff that operates with efficiency and integrity. The ECS develops and uses performance assessment tools and measures to provide an environment of continuous improvement in NSF's intellectual investments as well as its management effectiveness

The division holds regular internal meetings and retreats for continuous upgrading of strategy and identification of emerging areas for future investments. ECS Division program directors regularly participate in national and international meetings, symposia, workshops and conferences to monitor current status and future trends in areas of technical interest to the Division. The Division interacts and works very closely with other Divisions and Directorates within NSF and other government agencies to develop, manage, and fund collaborative programs and initiatives. Examples of the useful outcomes of these collaborative activities include solicitations such as the NASA-NSF-EPRI Joint Investigation of Enabling Technologies for Space Solar Power (SSP), the National Nanotechnology Infrastructure Network (NNIN), and the Electric Power Networks Efficiency and Security (EPNES).

The Division Director, Senior Engineering Advisor, Program Directors and the members of the Program Staff of the ECS Division work together as a team to offer the best possible service to the research community in order to support NSF vision, mission and goals.

PART C. OTHER TOPICS

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

The present areas of ECS are a subset of the areas found in EE (and related) departments around the country. For instance, there is little emphasis on signal processing theory and algorithms and very little in system theory. On the other hand, some proposals submitted to ECS could very well be funded by CISE. Therefore, addressing the boundaries between NSF Divisions may help put more resources in the perceived gaps of ECS.

ECS should increase its emphasis on appropriate aspects of advanced communications to reflect emerging engineering opportunities. Examples include intra- and inter-chip networking and communications, terahertz communications, and ultra-wideband optical and wireless communications.

ECS should also be proactive in defining and capturing ECS-specific activities in bioelectrical devices, subsystems, and systems biology.

Internally, to deal with the growing needs of the ECS community, the ECS division has proposed the reorganization of the Integrative Systems (IS) program within the division. The creation of a staffed and funded IS program within the ECS division will: (1) lessen the load on the EDPT and CNCI program officers with regards to submission of proposals falling into the area of integrated systems; (2) give more visibility and importance to the IS area; and (3) provide help in running panels for multidisciplinary strategic initiatives.

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.

Although alluded to in many of the above questions, the CoV believes that its serious concerns over the decreasing absolute funding provided by the ECS Division budget, the low proposal success rate, and decreasing award size cannot be overemphasized. NSF used to be thought of as the place where a small amount of money could be obtained with some reliability, assuming a high quality proposal is submitted. This was perhaps the case when the success rate is 25-30%, but not at 14%. At this low rate, success involves a good bit of luck. Once the reality of the 14% success rates is widely disseminated, researchers will think of NSF very differently.

These conditions jeopardize the productivity of the ECS research community, the ability to recruit graduate students into academic and research careers, and ultimately, the competitiveness of the U.S. engineering research enterprise. They must be addressed quickly and decisively.

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

The CoV recommends that the Foundation undertake a high-level study to analyze the impact of NSF awards. There are two major issues: (1) how is impact measured; and (2) how is the specific influence of NSF support on this impact extracted. Traditional measures used for performance analysis at all universities (i.e., papers, degrees produced, citations, awards, etc.). The criteria used to evaluate NSF will necessarily be different. The more interesting measures are those relating to

impact on society (i.e. companies started, patents issued, etc.). However, much of this impact is indirect, such as when an NSF-supported PI teaches a large class in his/her specialty, and a few students use these ideas later in way that has high impact. It is not entirely clear how to measure these things, but there are experts who do know how to do this well. It would be very interesting to develop a quantitative metric that gives the return on a $1 investment in ECS (or any other NSF division).

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

The increasing number of proposal submissions may require consideration of a policy of increased scrutiny of proposals for engineering content and eliminating those that don't address engineering issues as non-responsive to the solicitation. An example is physics or chemistry-oriented proposals in nanotechnology that might be more appropriately funded by the MPS Directorate. All ECS submissions should clearly indicate the engineering content.

In addition, further actions to relieve pressure engendered by the large and growing number of proposal submission should be considered. For example, consideration should be given to greater use of a pre-proposal process to filter non-competitive proposals at an early stage. NSF might also study ways to limit the number of proposals from individual PIs within a given time period.

Finally, the ECS website should be updated regularly to reflect priority areas as well as disseminate program information in a timely manner to the community.

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

A form should be developed that summarizes all actions relative to a proposal including reviewer data and recommendations, panel recommendations, Program Director recommendations with justifications (emphasizing the reasons for any variance with reviewer and/or panel recommendations), budget modifications (with an explanation of the rationale), relevant dates, and final disposition. All of this material is available in the jackets (in varying levels of detail) but bringing it all together in one place has merit and hopefully gives the data needed consistency.

The CoV also found it difficult to properly evaluate the organizational excellence of NSF management. The material presented indicates that management does indeed have a vision of organizational excellence and makes a sincere and effective effort to implement that view. However, insufficient material exists to ensure that the external (i.e., CoV) view of NSF is consistent with the internal view. The CoV questions the appropriateness of being asked to undertake such an evaluation.

The CoV requests that NSF provide further specific guidance as to the desired output from Section B of this report. If a sampling of outstanding program nuggets is all that is required, then perhaps the NSF program officers are in a better position than the CoV members to make these selections and complete this section.

Some thought should also be given as to how to recruit CoV members. Given the difficulty of convincing such busy people to participate in this important process, perhaps some thought should be given to implementing "virtual" CoV-like activities via electronic means (such as web conferences).

SIGNATURE BLOCK:

For the ECS CoV
Gary S. May
Chair