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Dr. Kevin C. Kahn
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Dear Dr. Kahn:

As Chair of the Committee of Visitors (COV) for the Electrical and Communications Systems (ECS) Division in the Directorate of Engineering, it my pleasure to submit to you the attached report, based on the COV visit to ECS on Sept 9-10, 2002.

The COV members judged the ECS Division highly successful in meeting and continually improving process requirements, and in the outcomes of its investments in people, tools, and ideas. We were particularly impressed with the strategic program development by the program directors and leadership within ECS. We encourage the Engineering Directorate to enhance support of the ECS Division. We commend and thank the Division Director, Dr. Vasundara Varadan, the Senior Engineering Advisor, Dr. Lawrence Goldberg, and the Program Directors: Drs. Kishan Baheti, Filbert Bartoli, Rajinder Khosla, James Mink, James Momoh, Paul Werbos, and Usha Varshney. We would also like to thank the ECS Division staff members for their preparation and support during the process.

Please let us 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 yours,

April S. Brown

OVERVIEW

The Committee of Visitors (COV) met on September 9 and 10, 2002 to review programs in the Electrical and Communications Systems Division (ECS) in the Engineering Directorate. 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 1999-2001. The IS program is much smaller than the EPDT and CNCI programs and was, therefore, reviewed as part of EPDT and CNCI.

During the review, the COV evaluated approximately 90 jackets (proposal actions) 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 Division Director and all of the 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 2002 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 and mirrors the Foundations strategic plan: B.1 covers the people goal, B.2 the ideas goal, and B.3 the tools goal. Sections B.4-6 provide a summary on areas of improvement, program performance and feedback on the COV process.

The COV would like to make the make the following general comments and recommendations.

The COV found that the ECS Division has been highly successful in meeting their 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. The ECS Division is well positioned to increase impact through its strategic program areas and initiatives.

The COV identified specific areas of improvement to enhance the Division's abilities to carry out its mission.

(1) *Enhance the impact of program outcomes.* The COV commends the Division and Directorate leadership for creating and supporting a broad range of relevant and "forward-thinking" ECS programs through the EPDT, CNCI, and IS program divisions. However, the COV expressed concern that the overall ECS budget was not large enough to enable high impact in all of the specific programs (including the special initiatives). The COV encourages the Directorate and Division leadership to continue to enhance the budget (and the average project duration/funding level). In addition, the ECS Division should create more opportunities for program leverage and partnership in appropriate areas with other Divisions and Directorates (such as CISE). The COV also observed that the GPRA-specified requirement of outcomes and outputs determination

is difficult without enhanced post-award tracking of projects. Improvements in post-award processing will enable improved assessment of impact and therefore justification for future program development.

(2) *Enhance the support of innovative projects.* The ECS Division primarily utilizes the SGER (Small Grants for Exploratory Research) program for the support of innovation projects. The mechanism is effective: the project is evaluated by a program director and does not require peer review. This mechanism therefore allows the support of projects that may not review well, since innovative projects tend to be intrinsically high risk. The SGER budget is too small, however, to create significant program impact. The COV encourages the Division and the Foundation to enhance mechanisms for the support of innovative projects.

(3) Develop and sustain a broad base of knowledgeable reviewers, and improve documentation and the understanding of NSF Review Criteria. The ECS Division has decreased the time to proposal action significantly over the past four years by moving away from mail reviews to, primarily, panel reviews. The COV encourages the Division to continue to increase the diversity (gender, ethnicity, racial, geographical, institutional) of the panels. It is recognized that institutional diversity is particularly important for judging applications-oriented projects. Finally, the Division is encouraged to continue process improvements in the records of panel discussions, and written reviews that lead to proposal action. Requiring panelists to submit written reviews prior to the panel is important to maintaining review integrity.

(4) Improve the understanding and use of NSF Review Criterion 2. (Broader Impacts) The COV observed inconsistent use and interpretation of Criterion 2 (Broader Impacts) by proposers, reviewers, and program directors. The COV encourages the NSF to continue improvements in the articulation and dissemination of specific guidelines that aid in meeting this funding criterion.

ECS Committee of Visitors 2002
Electrical & Communications Systems Division
National Science Foundation
September 9 and 10, 2002

April Brown (Chair)
Chair, Department of Electrical and Computer Engineering
Duke University

Kwame Boakye
Vice President - Technology
Harris Corporation

Ralph K. Cavin
VP Research Operations
Semiconductor Research Corporation

Eugene Deloatch
Dean of Engineering
Morgan State University

Steven Director
Dean, College of Engineering
University of Michigan

Floyd Galvan
Sr. Project Manager
Entergy Transmission

Linda Katehi
John A. Edwardson Dean of Engineering
Purdue University

Robert F. Leheny
Director, Microsystems Technology Office
Defense Advanced Research Projects Agency

Richard C. Powell
Vice President for Research and Graduate Studies
University of Arizona

Yahya Rahmat-Samii
Chair- Department of Electrical Engineering
UCLA

Ron Reedy
CTO; VP, Space & Defense
Peregrine Semiconductors

Taher Saif
Assistant Professor - Mechanical and Industrial Engineering
Research Assistant Professor - Micro and Nanotechnology Laboratory
University of Illinois at Urbana-Champaign

Shankar Sastry (Co-Chair)
Chair, EECS and Professor of BioEngineering
University of California – Berkeley

Michael A. Stroscio
Professor of Bioengineering
University of Illinois at Chicago

Allen Tannenbaum
Julian Hightower Professor
Departments of Electrical & Computer and Biomedical Engineering
Georgia Institute of Technology

FY 2002 REPORT TEMPLATE FOR NSF COMMITTEES OF VISITORS (COVs)

Date of COV: September 9-10, 2002	
Program/Cluster:	EPDT, CNCI, IS
Division:	ECS
Directorate:	ENG
Number of actions reviewed by COV: 84 (in part A)	

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

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 below the table.

QUALITY AND EFFECTIVENESS OF MERIT REVIEW PROCEDURES	YES, NO, or DATA NOT AVAILABLE
Is the review mechanism appropriate? (panels, ad hoc reviews, site visits) Comments: ECS is in the process of significantly reducing time to decision for proposals. Increasingly, panel reviews are used for proposal evaluation. ECS program directors indicate that panel reviews preceded by submitted written reviews have improved the quality and fairness of the review process. The COV strongly supports the requirement for written review submission prior to the panel. Strong leadership by the program director during the panel review is encouraged to improve the review process.	YES
Is the review process efficient and effective? Comments: The reviewers are judged to be experts in the field. We urge ECS to continue all means of increasing panel diversity. To this end, the COV recommends consideration of alternative panel meeting approaches, such as teleconferences, etc.	YES
Is the time to decision appropriate? Comments: In 1999, 58% of the proposals were processed in six months or less; in 2000, 36%; and in 2001, 63%. From projections for 2002, we assume 2001 was an anomaly. We encourage ECS to continue to improve processes to reach their performance goals.	YES
Is the documentation for recommendations complete? Comments: The documentation is complete and thorough. The program directors should continue to improve the proposal action justification documentation for Criterion 2 (What are the Broader Impacts of the Proposed Activity?)	YES

Are reviews consistent with priorities and criteria stated in the program's solicitations, announcements, and guidelines? Comments: Generally, the reviews were found to be consistent with the program specifications. However, Criterion 2 was not adequately addressed throughout the proposals. It is noted that both reviewers and ECS program directors did not effectively address both Criterion 1 and 2 for the proposals.	YES

Discuss issues identified by the COV concerning the quality and effectiveness of the program's use of merit review procedures:

(1) The COV commends the ECS Division for improving the time to decision for proposal action. However, the panel expressed concerns about the ability of the program director to exercise leadership in enabling an appropriate proposal action outcome. It is believed that requiring written reviews one week prior to the panel meeting will improve the process, and will improve the documentation supporting the proposal action (see (2) below).

(2) The COV found that the evaluation of Criterion 2 (Broader Impacts) was not uniformly clear or consistent, and not necessarily relevant. In some cases, Criterion 1 (Intellectual Merit) evaluations were inconsistent. The program director should encourage more complete written summaries and reviews. This may be aided through FASTLANE.

(3) The expectations and requirements for addressing Criterion 2 (Broader Impacts) are not clear. The COV encourages NSF to enhance the understanding and use of Criterion 2 for all its' constituencies.

(4) It is noted that significant matching should not be a primary criterion for awards as has been observed.

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 below the table. (Provide fraction of total reviews for each question)

IMPLEMENTATION OF NSF MERIT REVIEW CRITERIA	% REVIEWS
What percentage of *reviews* address the intellectual merit criterion?	89% (107)
What percentage of *reviews* address the broader impacts criterion?	65% (81)
What percentage of *review analyses* (Form 7's) comment on aspects of the intellectual merit criterion?	92% (35)
What percentage of *review analyses* (Form 7's) comment on aspects of the broader impacts criterion?	66% (25)

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

The COV strongly supports the peer review process; however, proposals for highly innovative and disciplinary "boundary" projects often risk poor reviews. The COV supports enhancing and supporting stronger program director flexibility and authority to fund these projects.

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

SELECTION OF REVIEWERS	YES, NO Or DATA NOT AVAILABLE
Did the program make use of an adequate number of reviewers for a balanced review? Comments: At least three reviews were used, with four-five more typical.	YES
Did the program make use of reviewers having appropriate expertise and/or qualifications?	YES
Did the program make appropriate use of reviewers to reflect balance among characteristics such as geography, type of institution, and underrepresented groups? Comments: The spreadsheet of reviewers provided by ECS shows that a diverse pool of reviewers (in the senses specified above) is available. However, the COV could not identify reviewer relevant information from the jackets.	Not enough data
Did the program recognize and resolve conflicts of interest when appropriate? Comments: None of the reviewed jackets contained conflicts of interest.	Not enough data
Did the program provide adequate documentation to justify actions taken?	YES

Discuss any concerns identified that are relevant to selection of reviewers in the space below.

The COV urges ECS and NSF to continue to enhance reviewer diversity (broadly interpreted). There was general discussion on what actions can be taken. Suggestions included using teleconferences for panel reviews, and exploiting local government (such as Department of Defense) talent. The COV believes that a greater number of industrial reviewers will improve review quality.

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 below the table.

RESULTING PORTFOLIO OF AWARDS	APPROPRIATE, NOT APPROPRIATE, OR DATA NOT AVAILABLE
Overall quality of the research and/or education projects supported by the program. Comments: The overall award portfolio was judged to consist of the high quality research and education projects.	**APPROPRIATE**
Are awards appropriate in size and duration for the scope of the projects? Comments: ECS is commended for increasing the average award size and duration over recent years. The COV believes ECS is generally under funded for the research portfolio. Finally, we encourage program directors to insure that the budget matches the projects needs.	**YES**
Does the program portfolio have an appropriate balance of • High Risk Proposals Comments: The SGER program is an excellent vehicle for seeding high risk projects. Roughly 50% of the SGER awardees write a follow-on three-year ECS grant proposal. The SGER budget should be increased so that more innovation can be funded.	**YES**
• Multidisciplinary Proposals Comments: A number of the ECS initiative programs are multidisciplinary. The Integrative System awards are (by nature of the program) multidisciplinary. Multidisciplinary unsolicited proposals between major research areas may have a lower funding success rate.	**YES**
• Innovative Proposals Comments: program directors need more flexibility to fund innovative proposals.	**YES**
Of those awards reviewed by the committee, what percentage of projects address the integration of research and education?	**71 % (25)**

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

The ECS Division is commended for creating a program structure: EPDT, CNCI, and IS, that is agile and reflects the nature of research at the forefront of Electrical and Communications Systems. The ECS program directors have successfully identified and created initiative programs (Tether free/Wireless, Spintronics, XYZ on a Chip, for example). ECS has maintained a reasonable base funding and increased the size and duration of awards. The support of junior researchers is particularly effective. However, the COV is concerned that the ECS budget is not large enough to create significant impact across its portfolio. The COV encourages the Division, Engineering Directorate leadership, and the NSF to continue to develop additional funding and leverage in this critical technological area.

B.1.a COV Questions for PEOPLE Goal

PEOPLE GOAL INDICATORS	PROGRAM ACHIEVEMENT SIGNIFICANT, OR NOT SIGNIFICANT, OR DOES NOT APPLY, OR DATA NOT AVAILABLE (select one)
Development of well-prepared scientists, engineers or educators whose participation in NSF activities provides them with the capability to explore frontiers and challenges of the future (PI) A number of NSF programs support engineers, scientists and educators at different career stages, including the CAREER program. The COV chose examples of eminent researchers supported by the ECS Division. In ECS-9729405, Professor George M. Whitesides, of Harvard University is developing soft lithography and microcontact printing processes that have had a major role in extending the use of MEMS to areas of biology, chemistry, and medicine. In 1999, Professor Whitesides was awarded the National Medal of Engineering in recognition of his extraordinary research accomplishments. In ECS 99-06247, Professor Daniel C. Tsui, a Nobel Laureate at Princeton University, is developing patterned quantum dot (PQD) structures and investigating the infrared detection of PQDs. The success of this proposal will certainly advance the field of quantum engineering and its applications towards new devices. Professor Petar Kokotovic, (ECS- 0042194) at UC Santa Barbara is a member of the NAE and winner of 2002 IEEE James H. Mulligan, Jr. Education Medal. He is best recognized for his pioneering contributions to control theory and engineering and for his inspiring leadership as mentor, advisor, and lecturer over a period spanning four decades. The ECS Division has supported his research from 1979 until today. His other recent awards are ECS- 9528370 and 9812346. While at the University of Illinois, he pioneered singular perturbation techniques, used today in power systems and adaptive controllers. At UC Santa Barbara, his group has developed constructive nonlinear control methods and applied them in automotive and jet engine applications.	SIGNIFICANT

Improved science and mathematics performance for U.S. K-12 students involved in NSF activities; Comments: ECS supports improved science and mathematics for U.S. K-12 students directly in specific programs, and throughout individual grants. The RET (Research Experience for Teachers) program has been lead by the ECS Division. An example is ECS–0093716, plus RET: Professor Alexander Mamishev at the University of Washington is a recent CAREER awardee. He has been extremely active in a novel outreach program, in which undergraduate students take a class on engineering creativity, and then act as mentors to high school students in a national competition. The regional competition which this PI helped organize attracted 1,000 participants from 10 states and an audience of 5,000. In ECS-9810081, Professor Vijay Vital, (RET supplement in 2001 to ECS-9810081), at Iowa State University has been very active in Research Experience for High School Teachers. This project dealt with the development of MATLAB-based simulation experiments for high school physics students. The teachers were also exposed to the powerful engineering ideas related to modeling and simulation. Based on this initial effort the teachers then developed a series of experiments for the high school physics courses, which involved both experimentation and simulation. The students now use MATLAB as a part of the regular course in the Ames High School in Iowa. In ECS-9906062, Professor James Momoh at Howard University created a summer outreach program for high school students and teachers at Howard University. This program exposes high school and junior college students to research activities in electrical engineering. During the four-week course, students learned about the basics of electrical engineering and worked in teams to develop research projects.	SIGNIFICANT

Professional development of the SMET instructional workforce involved in NSF activities ECS has supported numerous SMET instructional workforce projects via RUI, RET, ADVANCE and CAREER awards. ECE funds most requested supplements for REUs and RETs. The ECS Program directors have been active in developing and implementing the Research Experiences for Teachers (RET). To help identify, link, and foster collaborations between local K-12 teachers and NSF funded researchers, a regional workshop was held. 41 NSF funded researchers and 180 teachers from DC, Virginia, Maryland, and Delaware attended this workshop. As a result, the teachers had a unique opportunity to look at various NSF-funded projects and 67 teachers participated in the RET program during the summer of 2002.	**SIGNIFICANT**

Contributions in developing diverse workforce through participation of underrepresented groups (women, underrepresented minorities, persons with disabilities) in NSF activities; ECS program directors have helped to initiate and sustain NSF programs supporting underrepresented groups and, in addition, have supported PIs (underrepresented groups) in research and education awards. For example, ECS program director, Dr. Usha Varshney, has actively participated in managing and supporting the ADVANCE program. Specific support is described in the following examples. In ECS–0114835, RET, Professor Arlene Cole-Rhodes of Morgan State University is a POWRE awardee involved in pattern recognition for remote sensing, and has participated in the ECS-wide RET supplement program. Her activities have served to enhance teacher appreciation of sensor data in relation to the impact of space related research on our lives. In ECS/CAREER 0134228, Professor J. Hudgings is developing a physics/engineering laboratory at Mount Holyoke College, for the first time on that campus. The project includes collaboration with industry and other academic institutions. The PI is also developing a web-based project to promote interest on science and engineering among women. In ECS-9908578, Professor Chuanyi Ji at Rensselaer Polytechnic Institute is developing tools related to the control of large-scale networks and grids. Such systems occur commonly in information networks, transport networks, and other distributed systems. Her work has demonstrated that local computation may be used to effectively control and configure global states in the distributed system.	**SIGNIFICANT**

Participation of NSF scientists and engineers in international studies, collaborations, or partnerships; Comments: International activities are supported in a number of special programs. One example, the Joint Optoelectronics Project, JOP, was a very successful international effort. It enabled researchers in both Japan and the US to gain access to advanced (pre-production) optoelectronic devices. Such devices are critical to exploring new applications of optics to advanced systems. In addition to the obvious result that advanced devices were made available across national boundaries, regular meetings were held to foster cooperative engagements between Japanese and US optics R&D organizations. A second example is the World Technology Evaluation Center, WTEC. This effort evaluates US competitiveness. The effort increased awareness of the global nature of advanced technology development.	SIGNIFICANT
Enhancement of undergraduate curricular, laboratory, or instructional infrastructure; Comments: ECS has supported a number of innovative undergraduate initiatives as indicated by several key examples which we explicate below. In ECS–9900394, Professor Principe at the University of Florida is developing educational materials. Principe's new text, published by Wiley, is the first neural and adaptive systems interactive electronic book targeted to undergraduate students in science and engineering. It contains many real-life examples. The author has also made much of his instructional material and application-oriented software available over the web. He maintains substantial collaborations both with Brazil and with Portugal. While teaching and editing a major IEEE journal in the bioengineering area, he manages a company to help disseminate software embodying his results. In ECS 9983954 Professor Rafello Andrea and his students at Cornell University won the 2002 **RoboCup** championship held on June 23, 2002 in Fukuoka, Japan. The Cornell team defeated their German rivals by a score of 7-3 in the finals. Professor D'Andrea is CAREER awardee in ECS and the project provides a perfect example in integration of research and education in engineering. The event brings together about 190 universities and technical schools with teams of small, but smart, robots. Competitors must design robots that will operate cooperatively, as well as build a vision system to enable the robots to detect the, ball and distinguish between their own players and their opponents.	SIGNIFICANT

Awardee communication with the public in order to provide information about the process and benefits of NSF supported science and engineering activities.

Comments: A number of research breakthroughs have been highlighted in the highest quality scientific (broad dissemination) journals and the "popular" press. Examples are given below.

The work of Professors J. Fraser Stoddart and James Heath at UCLA on the fabrication of molecular-scale electrical circuits was cited by *Science* magazine as the Technology Breakthrough of the Year 2001. Computer chips containing the molecular-scale components being developed by these researchers are expected to accommodate billions of transistors and revolutionize future computers and computer architectures. The *Science* article highlighted the widely perceived expectation that this work will launch many future scientific breakthroughs. This work is supported via ECS-0103559.

Professors David Braun and Kevin Kingsbury at California Polytechnic and State University have had their research on the application of semiconducting polymer materials to Light Emitting Diodes (LED) applications highlighted by their local TV media when their work was featured on the NBC affiliate KSBY in a news segment. Their research is focused on developing new co-polymer layers that ease electron injection and confinement of carriers to enhance the efficiency of light emission and is of interest to a lay audience primarily because of its anticipated impact on low cost, large area displays. This work is supported by ECS-9820781.

Professors Margeret Murnane and Henry Kapteyn at University of Colorado have reported their work on advanced solid-state lasers in which they have demonstrated the production of sub-10 femtosecond laser pulses in *Science* 280, 1412 (1998) and *Nature* 406, 164 (2000). Their work has also been commented on in general audience journals including *Physics Today* "Search and Discovery", August 2000; *APS News*, March 1999; and, *Inside R&D Alert*, Wiley. Their results are of wide interest because their laser system operates at close to the fundamental limit for pulse generation. Professor Murnane was recently awarded a John D. and Catherine T. MacArthur Foundation "Genius" Award for 2000. ECS-9024033 (SGER) and ECS-9616079 support this research.

SIGNIFICANT

B.1.b COV Questions related to PEOPLE Areas of Emphasis

For each relevant area shown below, determine whether the program's investments and available results demonstrate the likelihood of strong performance in the future? Justify your argument by providing NSF-supported examples of investment results (with grant numbers) that relate to or demonstrate outcomes for the PEOPLE goal and relevant indicators. If the area of emphasis is not relevant to the activity, do not discuss.

PEOPLE AREAS OF EMPHASIS	Demonstrates likelihood of strong performance in future? (Yes, No, Does Not Apply or Data Not Available)
K-12 Education -President's Math and Science Partnership Comments:	DOES NOT APPLY
Learning for the 21st Century: • Centers for Learning and Teaching (CLT) • NSF Graduate Teaching Fellows in K-12 Education (GK-12) Comments:	DOES NOT APPLY
Broadening Participation • Minority-Serving Institutions (MSI) programs **Graduate Student Stipends** • Increasing stipends for GRF, IGERT, and GK-12 Comments:	DOES NOT APPLY

Comment on steps that the program should take to improve performance in areas of the PEOPLE goal.

The COV commends the ECS Division for supporting investigators and students throughout careers and at critical periods. The ECS Division, and NSF, is particularly successful at supporting young investigators beginning their academic careers. The COV urges the ECS Division to continue to increase the numbers of PIs in underrepresented groups supported in various programs.

B.2.a COV Questions for IDEAS Goal

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

Consider each of the six indicators for the IDEAS goal in the table below. Has the activity supported projects that demonstrate significant achievement for the IDEAS outcome goal indicators? Complete the table below for each program reviewed. To support your results in the table, provide NSF-supported examples for each of the relevant indicators that apply to the activity and explain why they are important for the IDEAS outcome. If projects do not demonstrate significant achievement, comment on steps that the program should take to improve. Do not discuss if indicator is not relevant to the activity.

IDEAS INDICATORS	PROGRAM ACHIEVEMENT Select one SIGNIFICANT, NOT SIGNIFICANT, DOES NOT APPLY or DATA NOT AVAILABLE
Discoveries that expand the frontiers of science, engineering, or technology; Comments: ECS has significantly advanced the frontiers of science, engineering and education in core programs and initiatives. Through partnership with other programs in engineering, ECS has strengthened its' efforts towards this goal. Such efforts include the initiatives: Exploratory Research on Biosystems at the Nanoscale (NSF 99-109), Exploratory Research on Engineering the Transport Industries (NSF 00-42), and XYZ on a Chip (NSF 00-15). A specific example is given in the Wireless Technology and Information Networks Initiative (NSF 99-68). To encourage fundamental research in the wireless technology area, the Directorates for Engineering (ENG) and Computer and Information Science and Engineering (CISE), in cooperation with the Division of International Programs (INT), jointly sponsored this initiative that began in 1999. In Engineering the following specific areas were funded: antennas; propagation models; transceiver designs including the integration of RF MEMs; quasi-optics techniques for low-cost, high-power wireless devices; and educational software for the design and characterization of wireless systems. Specific individual program examples are given below: In ECS- 9980814, Professors Austin and Chou (Princeton University) are applying nanofabrication techniques to enable DNA sequencing. DNA molecules are guided into channels so that they can be imaged and characterized along their length. Such techniques may well lead to bio-analysis chip-scale systems. In ECS-0085695, Professor Juraj Medanic at the University of Ilinois at Urbana Champaign is investigating semi- or fully- automated driving in multi-lane highways systems that requires coordination of individual control units, and simulation models that characterize the effects of control on efficiency. In ECS-0085676 and ECS-0085669, Professor Arun Phadke at Virginia Polytechnic Institute and Professor Vijay Vittal, Iowa State University are investigating new concepts on damage assessment, control and restoration of electric power systems after catastrophic disturbances due to natural or man-made disasters.	SIGNIFICANT

Discoveries that contribute to the fundamental knowledge base; Comments: A number of examples are given below.	**If Significant, provide award #s**
A new type of laser was reported in *Science*, "Two-Dimensional Photonic Band-Gap Defect Mode Laser", Vol. 284, pp. 1819-1821, June 11, 1999. This work was led by Professor A. Scherer at the California Institute of Technology, and is funded under ECS-963293. Using nanofabrication methods the team has built the world's smallest laser structures at the same dimension as the wavelength of light. In related research on nanoscale devices, "quantum dot" devices are fabricated by Professor Dennis Deppe at the University of Texas at Austin (ECS-973482). Such a device will have applications in high-speed optical interconnections for massively parallel computer systems and for Gbit/s Ethernet. Professor Deppe won the 1999 Nick Holonyak, Jr. Award of the Optical Society of America for this development. A number of related awards were made in FY99 (ECS-9820129, U. Michigan, and ECS-877113, Northwestern University) to encourage the pursuit of quantum dot related research. In ECS-9700588 and LIS-9720305, Professor A. Tannenbaum and his students at the University of Minnesota have developed novel techniques for visual tracking, which may be employed for a number of problems in robotics, manufacturing, as well as automatic target recognition. The approach is based on their work in robust control as well as a new paradigm for image processing and computer vision utilizing the theory of geometric invariant evolution. The results are having a major impact on industrial, military, and medical imaging problems. In ECS-9624152, Prof. Bassam contributed to the development of feedback control engineering and theory for the treatment of uncertainty and robustness. Professor Bassam has applied these mathematical control theory concepts to study the long-standing problems of shear flow turbulence. Their research has shown that many observed phenomena of transition and turbulence can be shown to arise from a careful uncertainty analysis of the fluid dynamical equations.	

Leadership in fostering newly developing or emerging areas;
Comments:

ECS has been active in promoting new and developing areas of research (examples are given throughout the report). Workshops also foster interest in new areas. One example along these lines was the workshop on Hybrid Systems: Computation and Control that was held in March of 2000 in Pittsburgh, PA. The goal of the workshop was to stimulate collaborative research between engineering and computer science focusing on hybrid systems. Another workshop was held to identify major research challenges as the electric power industry undergoes changes from a fully regulated monopoly to a competitive industry.

Examples of specific research projects that aim at developing new areas are ECS– 9941462 at the University of Washington. Under this grant, Professor C. Diorio, who has pioneered the extension of neuromorphic engineering into biologically inspired *learning* on a chip, is working on chip designs of practical interest to industry.

IECS-0010100 is a project headed by Prof John Volakis at the University of Michigan. He is integrating MEMS switches into microwave antenna apertures. This adaptive aperture technique enables the reuse of frequency spectrum through spatial diversity. This can be used in applications such as measuring drug delivery flows as well as in DNA research and forensic medicine.

Initiatives are developed in partnership with other agencies and from technology evaluation. For example, NSF 01-23 is a joint initiative of ECS and SRC to develop mixed signal technologies. The goal is to integrate analog and digital components on a single chip. Also, ECS sponsored studies conducted by the World Technology Evaluation Center at Loyola College in Baltimore to evaluate the competitive status of U.S. efforts, current collaborative activities, and opportunities for new approaches in U.S. research programs. The results of these studies are helpful in planning future investment strategies for ECS. The two studies that have been supported were in the areas of Spin Electronics and Quantum Information Science.

SIGNIFICANT

Connections between discoveries and their use in service to society; Comments: In ECS–0075691, a workshop emerged from a sustained effort by ECS to explore ways in which computational intelligence might be used to enable a deep reduction in the cost of options for solar power, terrestrial or in space. Important new opportunities did emerge, in discussions with many researchers, with NASA, and with the United Nations Millennium Project, all of which had some role in the development of a new joint initiative (NSF-NASA-EPRI, document number NSF 02-098 on www.nsf.gov) to follow through on these opportunities. There are many risks and uncertainties requiring further study, but there appears to be serious hope of developing an affordable alternative to nuclear power as a nonpolluting source of large scale baseline electricity, particularly in the developing world. In ECS– 0085676, Professor Arun Phadke at the Virginia Polytechnic University is using simulations to understand the large scale dynamics of electric power grids at a fine time scale (i.e. phase relations). After the 9/11 incident, he immediately began to apply this understanding and that of the colleagues he had worked with to the larger issues of infrastructure vulnerability. As President of the new International Institute for Critical Infrastructure, he has actively promoted deeper study of these vulnerabilities. Professor Robert Bitmead, ECS-0070146 at UC San Diego has developed nonlinear modeling and multivariable control to predict combustion instabilities in jet engines. In combustion processes, as the fuel to air ratio is reduced, the flame front becomes unstable and oscillates in position and temperature, leading to the loss of benefits accrued from operating with lean mixtures.	SIGNIFICANT

Connections between discovery and learning or innovation; Comments: Professor Annette von Jouanne, Ph.D., P.E., Oregon State University, (CAREER award: ECS #9733184) is studying power quality and translating simulation to education. This research has resulted in the development of a strong power quality and system compatibility program at Oregon State University. It has been a beneficial collaborative research resulting in educational partnerships and intellectual involvement with industries and utilities. The award has been leveraged to create multiple partnering and funding opportunities to enable the upgrade of the PI's laboratory to include a Power Quality Test Platform (PQTP) based on a 120kVA programmable source. A series of workshops has been developed to target high school students from Oregon. In addition local 3rd graders had a first hand demo of boost converter helicopters in her laboratory. In ECS-9979296, Professor M. P. DeLisio at the University of Hawaii, Manoa, and his colleagues are addressing fundamental research areas that directly impact the next generation wireless technology. The project will involve a large number of graduate and undergraduate students, and the PIs intend to introduce new integrative courses in the area of wireless communications. In ECS-9802260, Professor Scott D. Collins at the University of California, Davis, has developed a miniature Fourier Transform Infrared Spectrometer (FTS) micro-instrument with a spectral resolution of 0.1-cm. The spectrometer is 100th the size and weight (less than 2kg) of a commercial instrument. The FTS is one of the most powerful and versatile techniques available for chemical analysis, and successful development could reduce the cost of systems for environmental monitoring from a thousand dollars to several dollars. NASA plans to test this miniature FTS on future space probes.	SIGNIFICANT

Partnerships that enable the flow of ideas among the academic, public or private sectors. **Comments:** The ECS Division has encouraged the synergy of ideas among the academic, public, and private sectors. We give here a couple of key examples. Example: In ECS–9814230 and ECS–0000163 Chase (ANSER) led the first successful US effort to find a credible approach to implementing Russian concepts of *plasma hypersonics*. Plasma hypersonics is based on using electric field effects to allow airplanes to fly much faster – perhaps fast enough to reach earth orbit *as airplanes*, at a cost far less than what is possible with rockets. This project succeeded, where other efforts failed, because of the new partnerships between aerospace engineering (ANSER and Princeton), plasma engineering (especially at Princeton, which received half the funding, and Ohio State), intelligent control, and the MHD industry (Textron), supported by some technical inputs from NASA and the Air Force. This has also resulted in a follow-up effort (0120617) linking Textron and the ECS PIs to the new industry-funded carbon sequestration efforts at Princeton, developing new high efficiency ways to produce electricity from fossil fuel without emitting carbon dioxide to the environment. In ECS–0130410, Professor Chen-Ching Liu, U. of Washington, led a workshop that brought together the best in new transmission technology from around the world, the best in US-sponsored research, and the industry leaders (ISOs) who have struggled to find new ways to avert electrical blackouts in the Western US and elsewhere, short of a dramatic rise in electricity prices. The proven new technology discussed by the Brazilian participants was very encouraging to the US industry. The discussion of the economic/regulatory/planning environment was quite informative though discouraging to the US researchers. This workshop also helped set the stage for continued NSF-EPRI partnership, through two joint workshops in the spring of 2002 and EPRI participation in the NASA-NSF-EPRI initiative on space solar power.	SIGNIFICANT

B.2.b COV Questions related to IDEAS Areas of Emphasis

For each relevant area shown below, determine whether the program's investments and available results demonstrate the likelihood of strong performance in the future? Justify your argument by providing NSF-supported examples of investment results (with grant numbers) that relate to or demonstrate outcomes for the IDEA goal and relevant indicators in the space below the area of emphasis. If the area of emphasis is not relevant to the activity, do not discuss.

IDEAS AREAS OF EMPHASIS	Demonstrates likelihood of strong performance in future? Select one: Yes, No, Does Not Apply or Data Not Available
Biocomplexity in the Environment Comments: An emerging program in which ECS is providing leadership is the Space Power Initiative that would provide for collection of energy in near space, and the subsequent microwave transmission to terrestrial collection centers. There is a strong environmental element to this program since on the one hand, it minimizes atmospheric contamination from the burning of fossil fuels or use of nuclear generation, and on the other hand it brings with it the issues of environmental risks due to high intensity microwave links through the atmosphere.	LIMITED INVOLVEMENT
Information Technology Research Comments: A number of programs supporting this theme have been supported in ECS in the areas of Scalable Information Infrastructure, Applications in Science and Engineering, and Systems Design and Implementation.	YES
Nanoscale Science and Engineering Comments: ECS Division program directors have been actively involved in the creation of the NSE program. ECS has worked with CISE/EIA in reviewing NIRT (Nanoscale Interdisciplinary Research Teams) proposals with a focus on device and system architecture. In addition, ECS has funded NER (Nanoscale Exploratory Research) in the same technical theme areas. The NNUN is also an important and successful national resource supporting the NSE Initiative.	YES
Interdisciplinary mathematics Comments:	DOES NOT APPLY

Comment on steps that the program should take to improve performance in areas of the IDEAS goal.

The ECS Division program portfolio supports a wide range of projects yielding significant research outcomes. The COV urges the Division to improve its ability to assess impact by enhancing post-award tracking of projects. In addition, the COV is concerned that innovation projects that do not fall within an initiative area, or reside at disciplinary boundaries may not review as well as other proposals. Therefore, means of enhancing the funding of truly innovative projects should be developed.

B.3.a COV Questions for TOOLS Goal

OUTCOME GOAL for TOOLS: Providing "broadly accessible, state-of-the-art and shared research and education tools."

TOOLS INDICATORS	PROGRAM ACHIEVEMENT Select one: SIGNIFICANT, NOT SIGNIFICANT, DOES NOT APPLY or DATA NOT AVAILABLE
Provision of facilities, databases or other infrastructure that enable discoveries or enhance productivity by NSF research or education communities; Comments: The ECS Division has been particularly successful in the funding of shared research infrastructure. The two primary examples given below are models for national shared infrastructure programs. The National Nanofabrication Users Network (NNUN) user base has nearly doubled over the past 4 years. During the past year, the total number of unique users has increased from 1444 to 1729 (~20%). The two main external user categories (academic and industrial) both grew substantially, with ~57% growth in industrial users and ~37% growth in external academic users. Over 1100 graduate and undergraduate students were educated in experimental nanofabrication as users of these facilities. Dozens of large corporations and small start-up companies have been able to prototype new product ideas. Each year over 40 undergraduates utilize the NNUN facilities through the REU program. To stimulate participation by U.S. researchers, the NSF (ECS-9910873) with NIST and DARPA provided approximately $1 million each in funds over five years to the Optoelectronics Industry Development Association to support competitive solicitations for U.S. researchers to request services and tools (64 grants were made). The international participation in JOP grew at a steady pace as the program developed, eventually involving some 105 enrolled users and 29 enrolled industrial suppliers in both countries. A large number of novel prototype devices and associated circuits were acquired by researchers: 85 transactions involving 189 prototype devices, both international and domestic; and 801 interface circuits were procured with U.S. funds and distributed to researchers. Six joint Expert Workshops were held in emerging optoelectronic technology areas. The broker system helped streamline the process for handling export, import, and intellectual property issues for international interactions.	SIGNIFICANT

Provision of broadly accessible facilities, databases or other infrastructure that are widely shared by NSF research or education communities; Comments: The NNUN is clearly a highly successful example. The NNUN model was used to develop the NEES program. The shared facility model has influenced many universities and other organizations, such as Sandia National Laboratories (nanofabrication facilities in Albuquerque), to open their facilities to external users. Building on the successful model of the now concluded JOP, NSF and DARPA have just funded a proposal from the Optoelectronics Industry Development Association (ECS-0138518) to establish a Photonics Technology Access Program (PTAP). PTAP continues the JOP concept of a broker activity, initially as a domestic-oriented program, to support a broad range of important photonics application areas, including telecommunications, sensing, health, computing, and education.	SIGNIFICANT
Partnerships, e.g., with other federal agencies, national laboratories, or other nations to support and enable development of large facilities and infrastructure projects; Comments:	DOES NOT APPLY
Use of the Internet to make SMET information available to the NSF research or education communities; Comments: DesCArtES: Distributed Center for Advanced Electronics Simulations (ECS-9802730) is an electronics simulation collaborative program between the University of Illinois, Stanford University, Purdue University and Arizona State University. Numerous software programs have been developed that cover a range of issues from nanoscale electronics to optoelectronics. The collaborative has a good relationship with NNUN, increasing the impact of both programs.	SIGNIFICANT
Development, management, or utilization of very large data sets and information-bases; Comments:	DOES NOT APPLY

Development of information and policy analyses that contribute to the effective use of science and engineering resources.
Comments: The NNUN holds an annual meeting once a year in the fall with their Advisory Board and NSF representatives. In addition, there is a semiannual meeting that is held at NSF in the spring. These meetings provide insight, awareness, and understanding of NNUN operations. They also provide ideas and input that help NSF Program directors influence the planning of activities in nanofabrication areas. The NNUN is the most successful network of NSF and is used as an example in initiating other network-type programs such as NEES.

The ECS Division utilizes World Technology Evaluation Center (WTEC) studies to evaluate national and international research directions and emerging technologies. WTEC evaluates the state of a specific technology using a carefully selected panel of experts. Panelists are leading authorities in their field, are technically active and knowledgeable about U.S. and foreign research programs. As part of the assessment process, panels visit and carry out extensive discussions with foreign scientists and engineers in their laboratories.

The strategic plan driving the evolution of the ECS research portfolio includes a continual assessment of scientific and technological areas in order to identify new thrust areas that should be supported, as well as areas to be de-emphasized or transitioned to other agencies. Technical Workshops and Initiatives are a prime means of identifying and exploiting important new research opportunities. These opportunities are increasingly interdisciplinary, and generally involve interdivisional, inter-directorate, and interagency collaborations and partnerships. Many of the key advances in electrical and communications systems will require multi-disciplinary approaches, and interagency synergism and common interests are leveraged to fund advances in technology for different organizational goals. The division sponsored several workshops this year. A few examples are listed below:

(1) NSF-ADVANCE Institutional Transformation and Leadership Grantees' Workshop on "ADVANCE: Advancing Women in Academic Science and Engineering Careers" at NSF, Arlington, VA, April 22-23, 2002
(2) ECS-SRC "Mixed Signal Grantees workshop" was jointly sponsored by NSF and the Semiconductor Research Corporation (SRC) held in Orlando, Florida on May 16-17.
(3) Mini-Workshop on "Sensors, Communications, and Computing (SCC)", attended by 33 participants from universities, DARPA, AFOSR, NIST and NSF.
(4) Urgent opportunities for enhancing the Transmission Grid: A case study for California and Brazilian Grid., Palo Alto, CA, *October 10-13, 2001*

SIGNIFICANT

Comment on steps that the program should take to improve performance in areas of the TOOLS goal.

The NNUN and the JOP program are models of successful infrastructure shared-facility programs. The ECS Division will be expanding the NNUN and will be modifying the JOP program. Continued support for these programs is encouraged.

B.3.b COV Questions related to TOOLS Areas of Emphasis

For each relevant area shown below, determine whether the program's investments and available results demonstrate the likelihood of strong performance in the future? Justify your argument by providing NSF-supported examples of investment results (with grant numbers) that relate to or demonstrate outcomes for the TOOLS goal and relevant indicators in the space below the area of emphasis. If the area of emphasis is not relevant to the activity, do not discuss.

TOOLS AREAS OF INVESTMENTS	Demonstrates likelihood of strong performance in future? Select one: Yes, No, Does Not Apply or Data Not Available
Major Research Equipment (MRE) Comments:	DOES NOT APPLY
Major Research Instrumentation (MRI) Program Comments: The ECS supports innovative research as part of the MRI program. An example is given in ECS-9724371 (MRI), Professor R.W. Cohn at the University of Illinois. Professor Cohn is developing custom lithography at the nanoscale by exploiting anodic oxidation and wet etching of Si. He has fabricated structures with features as small as 15 nm and intends to create spatially modulated gratings for advance WDM systems.	SIGNIFICANT
Science & Engineering information, reports, and databases Comments:	DOES NOT APPLY
Scientific databases and tools for using them Comments:	DOES NOT APPLY
National SMETE Digital Library Comments:	DOES NOT APPLY

B.4 Please comment on any program areas in need of improvement.

The COV commends the NSF ECS Division for performing a very good job in program development. However, the COV found that the ECS Division was significantly under-funded to accomplish its objectives. Budgetary deficiencies are a key point to be addressed to allow for program growth in this very active area of science and technology development. The ECS program directors are very active and extremely motivated. However, there are some specific areas for empowering program directors and enhancing performance and outcomes. These are listed below

The ECS Division program directors have created strong initiatives that are at the forefront of ECS-related fields. Continued leverage and partnership with other Divisions in the Engineering Directorate and other Directorates (such as CISE) will enhance the outcomes and impact of these programs. It was the perception of the COV that the share of resources at ECS from Foundation-wide initiatives, such as ITR and NSE, were extremely modest. The help of the Engineering AD to increase this share is recommended. New areas for initiatives in Intelligent Microsystems, Embedded Systems and Software, and SOC Architecture have been identified as a means of complementing efforts in CISE. While program development aligned with the NSF strategic plans and outcomes is excellent, execution can be improved by continued increase in budget.

A continued focus on increasing grant size and duration will enhance the impact of the awards. In addition, improving mechanisms for strengthening the support of innovative projects is needed. For example, increasing the SGER program and strengthening the ability of the program director to make appropriate award decisions should be considered.

Judging long-term impact in support of continued program development will be improved by enhanced post-award tracking.

Award budgets were observed to be uniformly reduced from the proposed amount. Efforts should be made to ensure alignment with actual research costs.

While continued improvement and focus is observed for increasing the participation of underrepresented groups, the focus should not be reduced.

B.5 Provide comments as appropriate on the program's performance in meeting program-specific goals and objectives, which are not covered by the above questions.

Overall, the performance was judged to be very good. Specific strengths for ECS are in the support of young researchers, in the support of tools (specifically the NNUN program) and in the development of strategic research initiative areas.

B.6 NSF would appreciate your comments for improvement of the COV review process, format and report template.

The COV panel felt that audit information could be best collected and analyzed prior to the visit (for example, the determination of how many reviewers and program directors used Criterion 2 in evaluation). The COV recommends that visits in the future focus more on reviewing jackets and interacting with the program directors. This will allow an enhanced review of support of people, ideas, and tools.