

## Directorate for Engineering Advisory Committee Meeting

National Science Foundation  
Arlington, Virginia  
April 23-24, 2014  
Room 1235

### ENG AdCom Members Present:

Dr. Patrick Farrell (Chair) \*  
Dr. Karen Butler-Purry  
Dr. Robert Chau  
Dr. Andres Clarens  
Dr. Lance Collins \*  
Dr. Peter Cummings \*  
Dr. Alison Flatau  
Dr. Mary Jane Hagenson  
Dr. Enrique Lavernia  
Dr. L. Gary Leal  
Dr. Bruce Logan  
Dr. Ann Savoca \*\*  
Dr. Michael Silevitch  
Dr. David Spencer

### ENG Senior Staff Present:

Dr. Pramod Khargonekar (Assistant Director)  
Ms. Cheryl Albus  
Dr. Samir El-Ghazaly  
Dr. JoAnn Lighty  
Dr. George Hazelrigg  
Dr. Theresa Maldonado  
Dr. Alexandra Medina-Borja  
Dr. Sohi Rastegar  
Dr. Grace Wang

### ENG AdCom Members Absent:

Dr. Linda Abriola  
Dr. Curtis Carlson  
Dr. Mehmet Toner

\* denotes members that were present for day one only

\*\* denotes members that were present for day two only

*Wednesday, April 23, 2014*

The meeting convened at 8:30 a.m.

### CALL TO ORDER

Dr. Patrick Farrell, chair of NSF Directorate for Engineering (ENG) Advisory Committee (AdCom), welcomed everyone to the meeting, noting that a number of members extended their tenure on the committee as a result of the government shutdown in the fall of 2013. AdCom members and ENG senior staff introduced themselves. Dr. Pramod Khargonekar, Assistant Director for Engineering, welcomed new members, reviewed the agenda, asked members to save the date for the next meeting: October 22-23, 2014.

### REVIEW RECOMMENDATIONS OF RECENT ADVISORY COMMITTEE MEETINGS

Dr. Sohi Rastegar, Office Head, Emerging Frontiers and Research Innovation (EFRI), began by inviting the committee to submit specific issues it would like to see addressed by the Directorate at future meetings. He then provided updates to several issues that had been raised at previous AdCom meetings, including

engineering education, the CAREER program, the state of international collaborations, and public access to research. He concluded by stating that the Directorate will provide regular, explicit updates on all consensus recommendations provided by the committee.

### **Discussion**

AdCom members asked for clarification with regard to the nature of the discussion about CAREER awards. Dr. Khargonekar explained that CAREER has become a “prestige program,” so it’s difficult to enact changes without a perception of damage to the brand. ENG has committed to not reduce the amount of money or number of CAREER awards. Members briefly discussed NSF’s role in assuring a smooth transition for grantees after the expiration of their CAREER awards.

AdCom members were interested in learning more about NSF’s strategy for international collaborations, and Dr. Khargonekar described a new NSF-wide strategic framework that is being developed for international partnerships. Other ENG staff provided examples of ENG efforts that have been embraced by the international community, including the Innovation Corps (I-Corps) program and the I/UCRC program. The group emphasized the importance of seeking strategic partnerships that build relationships and facilitate high-quality training for students and early-career researchers. The committee expressed an interest in hearing details of the NSF-wide international plan, when it is released, and how ENG will interpret it.

### **DIRECTORATE FOR ENGINEERING UPDATE**

Dr. Khargonekar began by recognizing the arrival of new staff, including NSF Director France Córdoba, as well as recent departures, and made the committee aware of open recruitment for a number of positions throughout the Directorate. He assured the committee that the Directorate has caught up on most activities after the shutdown, and reviewed the fiscal year 2014 budget, which has grown modestly. He then described a number of major priorities and opportunities driving research today, as well as the societal context in which this research is being conducted. The Directorate has been working to strategically support emerging areas at all levels, from programs to crosscutting NSF activities. He noted the Directorate’s success in providing technology translation pathways, citing the I-Corps program as a runaway success, and concluded by recognizing a number of other challenges for the Directorate and the community, including broadening participating, preserving discipline-based research in multi-disciplinary research environments, and addressing the grand challenges for engineering.

### **Discussion**

AdCom members expressed concern that, while federal support for basic engineering research is being reduced at other agencies, the budget for ENG is not increasing to accommodate proposals that might once have been sent elsewhere. Dr. Khargonekar explained that the NSF assistant directors work together on the budget request to make sure that the Foundation, as a whole, advances national priorities, and that the Engineering Directorate is very highly regarded. The committee responded that there may ultimately need to be some fundamental changes to the budget formulation process, if ENG hopes to accomplish the goals outlined above.

In response to a question about whether being a co-principal investigator on multiple projects hinders investigators from getting their own funding, NSF staff assured the committee that ENG does not pay attention or penalize for this.

AdCom members were encouraged to see the Directorate's emphasis on increasing opportunities to engage under-represented minorities and women, but some expressed disappointment that more progress has not been made in this area. Dr. Khargonekar assured the committee that this will be a critical component of future plans.

In response to a question about how EFRI projects align with the priorities of the field, Dr. Rastegar explained the process by which new topics are identified and decided upon, and emphasized how these topics are transitioned into core programs.

In response to a question about single investigator projects versus team-based projects, ENG staff explained that the Directorate is interested in funding more interdisciplinary research projects and is evaluating the INSPIRE award mechanism as a potential vehicle for doing so.

### **DISCUSSION OF CONVERGENCE**

Dr. Khargonekar introduced Dr. Fleming Crim, Assistant Director of the Mathematical and Physical Sciences Directorate (MPS), Dr. Farnam Jahanian, Assistant Director of the Computer and Information Science and Engineering Directorate (CISE), and Dr. John Wingfield, Assistant Director of the Biological Sciences Directorate (BIO).

Following introductions by the AdCom members, Dr. Khargonekar introduced the idea of convergence, cross-directorate funding of multi-disciplinary research projects. The assistant directors highlighted several ongoing and new collaborations with ENG, including the cyber-physical systems program (led by CISE), the materials genome initiative (led by MPS), BIO-MAPS (led by BIO/MPS), and the BRAIN Initiative (led by BIO). The panelists emphasized that convergence is already happening in the research community, and that NSF is working to find ways to foster and encourage cross-disciplinary research.

#### **Discussion**

The committee suggested that social and political sciences should be involved in these activities as well. The ADs explained that the other directorates were involved in nearly all of these multi-disciplinary activities and provided examples including cyber-physical systems (led by the Directorate for Social, Behavioral, and Economic Sciences; SBE), cyber-security (SBE), synthetic biology (SBE), preparation of the future work force (led by the Directorate for Education and Human Resources; EHR), and activities surrounding the water-energy-food nexus (led by the Directorate for Geosciences; GEO).

Some AdCom members raised the idea that convergence might encourage retention of students by offering integrated early courses that inspire students and help make real-world connections. The ADs concurred with this possibility.

The session concluded with a discussion about the challenges associated with nurturing individual disciplines versus providing multi-disciplinary training. The committee and senior leadership were in agreement that disciplinary training is essential to multi-disciplinary work, and that convergence does not have to happen at the expense of disciplines.

### **SERVICE SYSTEMS INNOVATION**

Dr. Grace Wang, Division Director for Industrial Innovation and Partnerships, and Dr. Alexandra Medina-Borja, Program Director for Evaluation and Assessment, presented the idea of engineering as a human-

centered service system and made the case that ENG has the opportunity to help address research challenges in this context. Potential areas of research include cyber-physical systems, mathematical modeling and simulation of service systems, understanding human interaction with technology, and fundamental research fostering new technologies. Dr. Medina-Borja closed by describing a recent Partnerships for Innovation (PFI) solicitation in Smart Service Systems and proposing several “grand challenges” for service systems engineering.

### **Discussion**

Some AdCom members with first-hand experience with the recent PFI solicitation expressed concern that the request for proposals was too vague for investigators. Drs. Wang and Medina-Borja responded that “service” is still not a well-defined idea in the engineering community, and assured the committee that NSF will engage the community to improve future solicitations in this arena.

AdCom members raised concerns as to whether this type of research is truly revolutionary or not. The group agreed that it was worth pursuing as an experiment, and they proposed to review results and provide feedback on the activity in a few years.

### **RESILIENT INFRASTRUCTURE INTERDEPENDENT PROCESSES (RIPS)**

Dr. Sohi Rastegar introduced the RIPS activity as one that emerged from EFRI topic “Resilient and Sustainable Infrastructures” (RESIN), recognizing NSF program officers Joy Pauschke and Bruce Hamilton for their roles in empowering researchers to engage with individuals in other disciplines at annual workshops.

Dr. Kostas Triantis, Program Director for Civil Infrastructure Systems, introduced the RIPS solicitation, a cross-directorate investment designed to address the increasing complex and dynamic nature of infrastructure systems, and to encourage the research community to think of infrastructure in new ways. Several themes emphasized in the solicitation include understanding human components, understanding obstacles to improving infrastructure, improving control, integrity and stability, and exploring the economics and regulations associated with infrastructure. Two types of proposals are being supported by this mechanism, one for preliminary modeling and theory testing, and one for major infrastructure research.

### **Discussion**

In response to a question about whether education is a consideration in this solicitation, Dr. Triantis explained that the RIPS solicitation will not deviate from the NSF-wide merit review criteria, which includes the “broader impacts” requirement, and stated that one of the hopes is that these projects will stimulate education and prepare students who can tackle inter-disciplinary issues.

In response to a question about how researchers will acquire data for these projects, Dr. Triantis stated that researchers will start by using existing databases and may ultimately incorporate surveys and other social science tools to collect social data.

### **TWO-DIMENSIONAL ATOMIC-LAYER RESEARCH AND ENGINEERING (2-DARE)**

Dr. Anupama Kaul, Program Director for Electronics, Photonics, and Magnetic Devices, introduced the EFRI 2-DARE topic by discussing the benefits and limitations of the popular two-dimensional material, graphene. She then illustrated how other two-dimensional materials such as molybdenum disulfide may

address the limitations associated with graphene. Two-dimensional materials have the potential to impact technologies including nanoelectronics, photonics, flexible electronics, solar cells, LEDs, and bio-sensors. She shared information about how the 2-DARE topic was selected, highlighted the international component of this topic, and described EFRI's partnership with the Air Force Office of Scientific Research (AFOSR). Major research thrusts in this solicitation included characterization of material properties, synthesis and nanomanufacturing, and modeling.

### **Discussion**

AdCom members were curious to know where most of the publications in this field are coming from. Dr. Kaul stated that much of the early work came from the international community, and Dr. Rastegar emphasized that the partnership with AFOSR will help NSF access international partners.

In response to a question about the potential for duplication, Dr. Kaul responded that NSF is working other agencies to prevent unwanted overlap.

## **ENGINEERING EDUCATION AND CENTERS (EEC) OVERVIEW**

Theresa Maldonado, Division Director for Engineering Education and Centers (EEC), began her overview of the division by describing the Engineering Research Center (ERC) program, which currently supports 17 active centers across the country. She highlighted a number of research successes from the ERC program, including an FDA-approved retinal implant for the blind and a state-of-the-art tornado warning system. She then discussed the Engineering Education Research program, highlighting inter-agency partnerships, including the National Center for Engineering Pathways to Innovation with partner Directorate for Education and Human Resources (EHR). She concluded with a discussion of the challenges associated with workforce development and broadening participation.

### **Discussion**

In response to a question about whether NSF has supported research on how professional societies engage in the education process, a representative from the National Academies who was in attendance shared that the Academy had just received an NSF grant to examine this exact question.

In response to a question about the state of collaboration between EEC and EHR, Dr. Maldonado stated that the two offices work very closely together, conversing daily. She also pointed out that while EHR is responsible for all fields of STEM education, EEC helps tackle the challenges that are unique to engineering.

## **EEC COMMITTEE OF VISITORS (COV) REPORT**

Dr. David Spencer, chair of the EEC Committee of Visitors (COV) began by explaining that the COV is a team of external evaluators who audit divisions and/or programs. He then stated that the COV found EEC's processes to be excellent, and that they were very pleased with the Engineering Research Centers. According to Dr. Spencer, the COV was less pleased with the progress being made in engineering education and workforce development, citing the fact that little progress had been made over the years in areas including retention and broadening participation. He also noted that not all of the recommendations of previous COVs had been acted upon. The COV recommended that EEC and EHR conduct a gap analysis to determine where overlap exists, and that EEC should consider funding one to five ERCs that focus exclusively on engineering education.

**Discussion**

AdCom members discussed the nature of the problems faced in engineering education, and agreed that the scope of these problems was such that it would be difficult for EEC to overcome alone. EEC's strategy should focus on where it can make a difference. There was a brief discussion of lessons learned from the Vanderbilt ERC for engineering education, specifically with regard to establishing the correct metrics to measure success. Due to the complexity of the issues, the AdCom decided it would be best to form a working group on engineering education, as opposed to attempting to come up with specific recommendations at this meeting.

**IMPROVING UNDERGRADUATE STEM EDUCATION (IUSE)**

Dr. Joan Ferrini-Mundy, NSF Assistant Director for Education and Human Resources (EHR), began by outlining three priorities for collaboration between ENG and EHR, including (1) improving undergraduate education, (2) broadening participating in engineering careers, and (3) understanding engineering learning. She described the new Improving Undergraduate STEM Education (IUSE) program, the goal of which is to ensure that all NSF investments in undergraduate education align with agreed-upon cross-directorate goals and outcomes, and outlined a new initiative based on the successful I-Corps model, called I-Corps for Learning (I-Corps L), that seeks to create education innovation and bring it to scale.

**Discussion**

Some AdCom members who were familiar with the IUSE solicitation communicated their frustration with the vagueness of the wording. NSF staff acknowledged receiving similar feedback from others in the research community and committed to considering more prescriptive descriptions and possible implementation of a pre-proposal process.

In response to a question about whether EHR would consider implementing "systemic initiatives" that have the potential to impact K-12 education across jurisdictions, Dr. Ferrini-Mundy discussed the challenges associated with these initiatives, including their expense, political difficulty, and the fact that these initiatives tended to favor states with state-wide curriculums. She expressed interest in recycling effective elements from these initiatives.

AdCom members then initiated a discussion about diversity and increasing underrepresented groups in STEM careers. Some members offered possible reasons progress has stalled in this area, ranging from Supreme Court decisions to workplace inflexibility. Dr. Donna Riley, Program Director for Engineering Education, referred the committee to the book "Race, Rigor, and Selectivity in US Engineering," by Amy E. Slaton, as means to understand the nature of this problem.

**PROFESSIONAL FORMATION OF ENGINEERS**

Dr. Donna Riley, Program Director for Engineering Education, began by defining the idea of the Professional Formation of Engineers (PFE) as the processes by which individuals become engineers. These processes include informal and formal education, as well as non-education activities. EEC has identified PFE as a critical part of fostering the next generation of engineers and seeks to contribute to PFE in order to (1) build capacity for research, (2) understand the changing processes in the education/workforce ecosystem, (3) strengthen "target points", and (4) increase welcome and access for underrepresented groups.

**Discussion**

AdCom members expressed the importance of working with accrediting organizations, such as the Accreditation Board for Engineering and Technology (ABET), to effect changes in education. Dr. Riley conveyed that there are precedents for this, and that ABET has been involved in the current discussions.

In response to a concern that students should see themselves not only as “engineers,” Dr. Riley expressed that EEC expects investigators to come up with ideas for how to deal with this, particularly in situations when an “engineer” identity might chafe with other identities.

AdCom members and ENG staff discussed frustrations about the slow pace of institutional change with regard to diversity and broadening participation, despite all the efforts over decades. Some members suggested choosing department chairs and/or search committees who prioritize broader participation would help accelerate changes.

Dr. Theresa Maldonado asked AdCom members whether a prize competition, similar to the National Academy of Engineering’s “Gordon Prize” might be effective in exerting change. AdCom members agreed that such an award, provided to a department as opposed to an individual, could demonstrate that this is something that is valued by NSF.

AdCom members and ENG staff briefly discussed the role of the Maker Movement as a potential entry-point for STEM careers.

Several AdCom members stated that, while attrition is a problem, there are also significant transfers *into* engineering programs, and conveyed that it is important to recognize that some student groups are thriving in engineering programs.

#### **TOPICS FOR DISCUSSION WITH NSF LEADERSHIP**

The AdCom identified four topics to discuss with NSF leadership: (1) the low success rate of ENG proposals and the proposal window cycle, (2) the unique challenges faced by ENG as other federal agencies suspend programs for fundamental engineering research, (3) strategies for leveraging opportunities with industries and foundations, and (4) the nature of NSF’s investments in education programs.

The meeting adjourned for the day at 5:47 p.m.

*Thursday, April 24, 2014*

The meeting reconvened at 8:30 a.m.

#### **PERSPECTIVES FROM THE OFFICE OF THE DIRECTOR**

Dr. Khargonekar welcomed NSF Director Dr. France Córdova, and Deputy Director Dr. Cora Marrett.

Dr. Córdova greeted the Advisory Committee and shared a number of items she would like the AdCom to weigh in on, including: broadening participating, broader impacts, collaborations and partnerships, and grand challenges.

Dr. Bruce Logan expressed concern about the low success rate of ENG proposals, as compared to the rest of the Foundation, and inquired as to whether there might be a better way to evaluate proposals. Drs. Córdova and Marrett agreed that it was worth looking into, and that perhaps ENG could be a leader in experimenting with new models of evaluation.

Drs. Leal and Clarens brought some specific challenges faced by ENG to the Director's attention, including the fact that other agencies are reducing funding opportunities for basic engineering research, which will presumably increase the proposals NSF/ENG receives. Dr. Córdova requested a succinct summary about how engineering research funding has changed in the last 20 years, and the effects that may be having on discovery and innovation.

Dr. Lavernia asked about opportunities to leverage partnerships with industry and foundations. Dr. Córdova suggested engaging first in selected areas, for example, broadening participation. Dr. Marrett proposed that the AdCom help form a specific strategy for leveraging external partnerships.

AdCom members shared concerns about the lack of progress in engaging underrepresented groups in engineering careers. Many on the committee expressed that EEC alone does not have the resources to tackle this issue, and felt that it will take direct intervention from the leadership to exert change in this area. The AdCom shared their plan to create a working group to address this issue, and Dr. Córdova stated that she would like to focus heavily on broadening participation during her tenure at NSF, and would welcome the recommendations of the committee.

## **NSF STRATEGIC PLAN AND STRATEGIC REVIEW PROCESS**

Dr. Pamela O'Neil, Deputy Performance Improvement Officer, Budget Office outlined the new NSF-wide strategic plan and strategic review process, emphasizing that the plan would be used as a tool for communication, program and budget planning, and accountability in staff performance plans.

### **Discussion**

Some AdCom members expressed concern that changes to strategic plans may represent "change for change's sake," and questioned the utility of revising goals and performance objectives so frequently. Dr. O'Neil responded that the agency reports deeply on progress toward different objectives each year, and that the idea is to create an inspirational plan that does not drill down to individual directorates or divisions. NSF is required to create a five-year plan every three years.

Dr. O'Neil responded to concern about the six-month submission-to-decision time on proposals in the current plan by stating that although OMB is enthusiastic about this policy, NSF will review to make sure that it does not compromise customer service or the quality of research supported.

## **TRANSPARENCY AND ACCOUNTABILITY**

Dr. Mark Weiss, Division Director for Behavioral and Cognitive Sciences (SBE), described the new policy established with the help of the Transparency and Accountability Working Group that requires program directors to re-write award titles and abstracts to make them more accessible to lay stakeholder groups, including the public at large and Congress.

### **Discussion**

AdCom members asked about the motivation behind this new policy. Dr. Weiss conveyed that the titles and abstracts are often too technical and do not clearly describe the work being done. While one goal is to preempt misinterpretation of the research, a broader motivation is to increase the accessibility of this information for all stakeholders. AdCom members suggested engaging the research community in this effort, as individual researchers communicate about their work on the web too.

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Dr. Peter Arzberger, Senior Science Advisor in the Office of the Director, then described the importance of conveying how funding decisions are made within a broader context of balancing a portfolio. Issues surrounding this aspect include defining portfolios, determining how portfolios are used, and evaluation.

### **Discussion**

AdCom members asked about the role of the program directors in directing versus responding to emerging research areas. Dr. Arzberger told the committee that program directors engage the research community in identifying emerging areas through workshops and conferences so that the field as a whole may advance.

The group was skeptical as to whether the new policy would halt all misunderstanding of the research, but it was pleased with the potential impact these changes could have on the way NSF communicates about research investments with the public. The AdCom encouraged the Directorate to engage partners (professional societies, journals, etc.) in the effort to communicate research in accessible language.

## **REPORT ON SUPPORT FOR STATISTICAL SCIENCES AT NSF (StatSNSF)**

Dr. Alison Flatau, ENG Advisory Committee representative to StatSNSF, shared an overview of the StatSNSF committee's proposed report, which will be finalized in July 2014, in order to solicit feedback from the AdCom. Dr. Flatau outlined the nature of data science in the context of NSF and described a number of challenges in this arena, including potential shortages in data scientists, fragmentation and reproducibility of data, and the necessity to foster effective collaboration across disciplines. The StatSNSF committee recommends creating a mechanism to coordinate data science research across the Foundation, creating new initiatives that address data science and new opportunities for participation of data scientists in interdisciplinary research, creating programs to train the data science workforce, and requiring data analysis plans (when appropriate), and providing appropriate resources to program officers.

### **Discussion**

AdCom members questioned whether all engineering projects would generate data that is of interest to this type of endeavor and discussed issues including data storage and accountability. It was proposed that investigators might benefit from a simple checklist that could help determine whether specific projects are appropriate for data collection and dissemination. Some members suggested engaging industry partners in this endeavor.

## **INDUSTRIAL INNOVATION AND PARTNERSHIPS (IIP) OVERVIEW**

Dr. Grace Wang, Division Director for Industrial Innovation and Partnerships (IIP), provided an overview of the division's role in driving the expansion of U.S. innovation capacity by (1) providing technology

translation pathways through mechanisms like the Accelerating Innovation Research (AIR) program and Small Business Tech Transfer (STTR) program, (2) stimulating strategic partnerships through programs including the Industry/University Cooperative Research Centers (I/UCRC), (3) catalyzing technology commercialization through programs such as the Small Business Innovation Research (SBIR) program, and (4) cultivating innovative thinking and entrepreneurship through programs including I-Corps.

#### **Discussion**

AdCom members did not have any questions for Dr. Wang.

#### **IIP COMMITTEE OF VISITORS (COV) REPORT**

Dr. Tom Knight, IIP Committee of Visitors chair, expressed that the COV was very impressed with both the processes and balance of portfolios in IIP. Dr. Michael Silevitch outlined several recommendations regarding the quality of the review process, specifically with regard to strengthening broader impact evaluation and coaching for applicants who receive decline decisions, and discussed several recommendations for the selection of reviewers, including increasing diversity of perspectives and expanding the pool of panelists. Dr. Knight shared several recommendations with regard to program management, encouraging the division to develop metrics, expanding pre-proposal outreach to new investigators, and documenting best practices for coaching and review. He also described recommendations about the portfolio of awards, including the need to incorporate metrics to measure broadening participation efforts, and improving outreach to people without prior NSF funding.

#### **Discussion**

AdCom members and ENG staff discussed the challenges associated with forging relationships between small businesses and universities, including intellectual property issues and differences in time lines.

#### **ADCOM MEMBER TOPICS**

The committee established three major themes that will form the basis of AdCom working groups:

- establishing what has changed in terms of federal investments in basic engineering research across Federal agencies, and suggesting actionable and strategic recommendations the AdCom might make associated with those changes; ,
- how to move the needle in engineering education—most specifically AdCom recommendations in response to the EEC COV report;
- recommendations regarding re-thinking “broadening participation” and how the AdCom suggests setting expectations for this aspect of proposals as well as assessing work in funded programs and in broadening participation within engineering.

The initial goal is for each group to draft a one-page summary, to be shared with Dr. Khargonekar and possibly the Director’s office, within the next month.

#### **CLOSING REMARKS AND WRAP UP**

Dr. Khargonekar thanked AdCom members for their substantive contributions and encouraged the committee to submit topics the committee would like the Directorate to respond to at the next meeting.

The meeting adjourned at 2:35 p.m.