National Science Foundation
Directorate for Engineering
Division of Engineering Education and Centers

Committee of Visitors
Review of the Engineering Education and Centers Programs
COV Meeting Date: September 18-20, 2014

COV Recommendations and EEC Response
COV Draft Response to the ENG AdCom, ENG OAD, and EEC Leadership: March 24, 2014
ENG AdCom Meeting and Discussions: April 23-24, 2014
Final COV Report Submission to ENG (EEC and OAD): May 1, 2014
ENG AdCom Chair Transmittal Letter to ENG AD: July 29, 2014

EEC RESPONSE TO THE 2013 COV REPORT

The Committee of Visitors (COV) for the Division of Engineering Education and Centers (EEC) convened at the National Science Foundation (NSF) on Sept. 18 – 20, 2013. The committee was chaired by Dr. David Spencer, a member of the Engineering Directorate Advisory Committee (AdCom). The COV prepared a near-final draft report, by consensus, of its findings according to the NSF COV guidelines. The draft report was sent to the EEC Division Director, Dr. Theresa Maldonado, and Assistant Director for Engineering, Dr. Pramod Khargonekar, as well as to the full AdCom membership on March 24, 2014.

Dr. Spencer presented the COV findings, observations, and recommendations at the Spring AdCom meeting (April 23, 2014). After subsequent extensive discussions of the AdCom by e-mail and teleconference, their letter of transmittal was sent by the AdCom Committee Chair Dr. Pat Farrell on July 29, 2014 to Dr. Khargonekar. It highlights a number of very important consensus recommendations from the COV report to the ENG/EEC division, particularly focusing on Engineering Education in the context of the 2014 NSF Strategic Plan. In addition, there are some recommendations and observations in the EEC COV report that are not highlighted by the Ad Com letter of transmittal.

Therefore, this response by EEC to the COV/AdCom recommendations and observations is divided into two components: responses to the Ad Com letter of transmittal and responses to other EEC COV recommendations and observations documented in the COV report.

Recommendations and Observations from the Ad Com Transmittal Letter

RECOMMENDATION: "The EEC take a leadership role in engineering education, recognizing that many aspects of engineering education activities within EEC may intersect and complement STEM education activities performed by the Education and Human Resources Directorate and thus should be coordinated with EHR partners. We recommend that the EEC engineering education effort remain inside the Engineering Directorate for reasons articulated above."

RESPONSE: We agree fully with this recommendation. A major strategy is to work closely with the Education and Human Resources Directorate. This aligns well with the NSF wide strategy on education related investments. The recently developed IUSE (Improving Undergraduate STEM Education (IUSE)) strategy provides a Foundation-wide framework for developing undergraduate education initiatives for all STEM disciplines. IUSE outlines a set of core principles by which to delve into the challenges in STEM education broadly and in discipline-based education more specifically. Engineering education has unique challenges, as the COV correctly identified. Also, computer science faces similar challenges to engineering, and therefore, it is natural to work with the Computer and Information Science and Engineering Directorate (CISE) as well.

In fact, EEC, in partnership with all divisions in ENG (for the first time!), the Division of Undergraduate Education (DUE/ EHR), and several divisions in CISE, has just launched a multi-year initiative, the "Professional Formation of Engineers," to create and support an innovative and inclusive engineering profession for the 21st Century. Professional Formation of Engineers (PFE) refers to the formal and informal processes and value systems by which people become engineers, including the ethical responsibility of practicing engineers to sustain and grow the profession. PFE is stimulated by the recognition that the engineering profession must be responsive to national priorities, workforce needs and grand challenges – while being open and accessible to all.

Through PFE, we are stimulating a holistic approach to the preparation of engineers for a lifelong career in the profession. The initiative recognizes the integrative, creative capacity of engineers to leverage technology for improving quality of life for people and the planet. Developing this capacity requires a unique set of knowledge, skills and abilities.

In Sept. 2014, a new solicitation (NSF 14-602) – "IUSE/Professional Formation of Engineers: Revolutionizing Engineering Departments (RED)" – was released. It is a signature pilot program along this direction. This funding opportunity enables engineering departments to lead the nation by successfully achieving significant sustainable changes necessary to overcome long-standing issues in their undergraduate programs and educate inclusive communities of engineering students prepared to solve 21st century challenges.

More specifically, the PFE RED pilot seeks to address one of the most critical "target points" to successful professional formation: the engineering "core" – i.e., the middle two years of the four-year undergraduate experience, during which students receive the bulk of their formal technical preparation. The solicitation recognizes that the development and engagement of the entire faculty within a department are paramount to the process, and they must be incentivized. It seeks to

examine and address the departmental cultural barriers to inclusion of students and faculty from different backgrounds, while building students' capacities for 21st Century and "T-shaped" professional skills, including: design, leadership, communication, understanding historical and contemporary social contexts, lifelong learning, creativity, entrepreneurship, and teamwork. It is hoped that, over time, the awardees of this program will create knowledge that can be scaled and adopted nationally across a wide variety of academic institutions.

The $2M investment by EEC for RED is leveraged by a $3M investment from the other four ENG divisions combined, $2M from CISE, and $5M from EHR/DUE. Hence, the $2M EEC investment is leveraged by $10M from other partners. This model reflects what is recommended by the COV and the AdCom.

The EEC program officer leading PFE and RED is also serving in leadership roles for the NSF-wide "Improving Undergraduate STEM Education (IUSE: EHR)" program, which has recently released a new solicitation (NSF 14-588) to address challenges and opportunities that are facing undergraduate STEM education. The program recognizes and respects the variety of discipline-specific challenges and opportunities facing STEM faculty as they strive to incorporate results from educational research into classroom practice, encouraging them to work with education research colleagues and social science learning scholars to advance our understanding of effective teaching and learning of STEM disciplines.

Finally, EEC's Generation Three Engineering Research Centers program (Gen-3 ERC) strives to create a culture in engineering research and education that integrates discovery with technological innovation. The university education mission of the centers involves efforts to help prepare students of diverse backgrounds for effective practice in industry and other sectors and to enhance their capacity for creative and innovative leadership throughout their careers. The pre-college education mission rests on long-term partnerships with K-12 institutions to expose teachers to engineering and deliver engineering concepts and experiences to their classrooms to stimulate student interest in engineering careers. The synergy of an ERC's research and its educational activities enriches the participating universities through the transfer of ERC-generated knowledge into engineering curricula, courses and programs.

EEC will continue to move forward in these directions. That is, EEC will continue to lead strategic discussions on engineering education with other divisions and directorates; share "best practices" between programs (i.e., individual PI projects and center-level projects); and leverage its resources.

RECOMMENDATION: EEC in cooperation with EHR and other Engineering Divisions, should conduct a "Gap Analysis" to assess what needs to be done in engineering education, where and how engineering education and engineering education research needs are being accomplished today, and what gaps and overlaps exist that either leave critical needs unsatisfied, or alternatively result in duplicative work. This analysis should not merely look at the present, but anticipate the future—

perhaps the next 10 years—as needs and expectations for engineering education will likely change substantially over that time.

RESPONSE: We agree with this recommendation. EEC will engage a team of AAAS Fellows, NSF science assistants and group of program officers from all five Engineering Divisions to conduct this analysis. Such a recommendation is particularly timely, given the enhanced emphasis on improving undergraduate education and minimizing duplicative efforts across the agency. The team will further leverage the efforts of NSF's Improving Undergraduate STEM Education (IUSE) "Implementation Team", which has been tasked with developing a baseline analysis of what areas are being supported by FY14 funding.

OBSERVATION: Possibly the most difficult part of a 'gap' analysis of this sort will be to name a small number of key goals for engineering education as a whole. These may already be available and accepted from prior work (e.g. NAE or prior NSF reports) and that work may not need to be replicated, but if gaps are to be identified they need to be referenced to expected or hoped-for outcomes. For example, engineering in general has not been able to attract women or traditionally underrepresented students in proportion to their college attendance. If among the expected outcomes of engineering education is to be able to provide talented and diverse domestic engineers in the numbers needed, the failure to do this may prove one of the larger gaps identified. A comparison of these stated goals with those of the EHR Division and the EEC engineering education effort may illustrate the significant similarities and differences where they occur

RESPONSE: We agree with this observation. We will use the results garnered from the "Gap Analysis" (described above) to help inform the development of key goals. Documented key issues of previous analyses in undergraduate engineering education include engagement, retention, and persistence to degree completion as well as skill gaps with immediate industry needs and lack of diversity of students. The cited example above regarding the engagement of traditionally underrepresented students is particularly challenging. EEC proposes to leverage the PFE program with its Broadening Participation in Engineering (BPE) funding opportunity to carefully identify the real barriers to inclusion in various engineering disciplines and then to develop impactful programs to address these barriers. The BPE Program is a key Directorate-wide activity to support the development of a diverse and well-prepared workforce of engineering graduates, particularly those with advanced degrees. The BPE Program currently funds projects to engage and develop diverse teams that can offer unique perspectives and insights to challenges in engineering research and education. Thus, BPE knowledge coupled with PFE innovations hopefully will be an important and scalable strategy.

EEC recognizes that broadening participation in engineering disciplines is a systemic issue, with a need for wide-ranging and comprehensive interventions at all levels of the educational system. In alignment with the goals of the Engineering Directorate (ENG), EEC will target efforts that seek to understand: 1) how a diverse engineering student body, professional workforce, and faculty impact engineering innovation and productivity; 2) the underlying issues affecting the differential

participation rates in engineering; and 3) what experiences and interactions enhance/inhibit underrepresented groups' persistence to degree and career interest. EEC, in cooperation with our colleagues in the EHR directorate, will engage the NAE and ASEE to explore implementation plans that target such issues and establish communities of practice that can help produce sustainable BPE-related improvements.

OBSERVATION: This "Gap Analysis" and a comparison to NSF skills, abilities, and resources, as well as work contributed by those outside of NSF, should suggest where and how NSF intervention could have the most impact and contribute significantly to the kinds of innovations identified. For example, it is not quite possible that successful innovations that directly address some of the key gaps identified in #2 have already been piloted successfully, but they have not seen widespread use, nor given past history, are they likely to. This dissemination issue could be one NSF is well equipped or could become well equipped to address.

RESPONSE: Getting the best evidence-based practices out to potential adopters where those practices can benefit large numbers of engineering students or learners, rather than just in a few classrooms or informal learning organizations, can benefit from taking an entrepreneurial approach. There are a number of analogous elements between trying to bring product discoveries to market and getting learning innovations into broad practice that NSF can leverage to help promote widespread use of promising educational learning practices.

To challenge researchers to think beyond their research results and toward broader adoption of STEM education and learning innovations, NSF's Innovation Corps Teams Program is soliciting proposals that take discoveries and promising practices from engineering education research and development and promote opportunities for widespread adoption, adaptation, and utilization. These I-Corps for Learning (I-Corps L) Teams will receive support - in the form of mentoring and funding - to accelerate innovation in learning that can be successfully scaled, in a sustainable manner. Through these efforts, we will get some indications on approaches that are effective in scaling and wide-scale adoption engineering teaching and learning research.

RECOMMENDATION: The AdCom also recommends that EEC and the Engineering Division begin to plan for ways to respond robustly to the gaps identified in the work of #2. It is possible that a concentrated program like an Engineering Research Center (ERC) on a key aspect of the engineering education challenge would be critical. In anticipation of that possibility, we should begin to identify reallocation opportunities to redirect resources toward critical education actions identified.

RESPONSE: EEC and ENG will explore and discuss the potential for creating an ERC that is focused on the education, development, training, and professional formation of engineers. Results from the work done under earlier recommendations will provide the necessary information to make an informed decision on this recommendation. It will be critical to have a clear understanding of the goals and objectives and expected impacts from such Center scale investment(s). The gap analysis,

for example, will inform this discussion on the value-added of center investments in engineering education.

Other Recommendations and Observations from EEC COV Report

OBSERVATION: "Some inconsistencies were observed for the Broadening Participation Research Initiation Grants in Engineering Program (BRIGE)."

RESPONSE: The BRIGE program has been terminated. Dr. Bev Watford was recruited as program director for the Broadening Participation in Engineering program. She brings great expertise and experience in broadening participation issues. Broadening participation in engineering remains a major priority for EEC and ENG.

OBSERVATION: "The long standing confusion regarding how to best interpret and implement the intent of Criterion 2, Broader Impacts, remains an issue… It is our belief this issue should be addressed at the Engineering Directorate and the NSF Director level, since it appears to be a widespread issue of concern." "Detailed guidelines for the review of Broader Impact statements could be developed and disseminated." "We strongly recommend that reviewers for all programs have expertise in Broader Impacts on a par with Intellectual Merit. Broader Impact evaluations should be of such quality that this criterion is judged with consistent competency with that of Intellectual Merit evaluations."

RESPONSE: Broader Impacts presents a potential opportunity to make substantial impacts on engineering education and broadening participation issues. We have been in discussions with the research community on these possibilities. In April 2014, NSF organized a conference entitled "Broader Impacts Infrastructure Summit". A report from this conference is under preparation. This report will form the basis for efforts to deal with the concerns expressed above.

RECOMMENDATION: We recommend that NSF seek methods to make volunteering for a panel easier, maintain an electronic data base of potential reviewers, collect expertise information,…, perhaps team with other agencies or professional societies … and add a button to the front page of Proposal submissions to 'volunteer for a review panel."

RESPONSE: The ENG Directorate is developing an internal system that can serve as a reviewer database for the program directors. One objective for this system is to ensure a diversity of reviewers for every panel and ad hoc evaluation of the proposals submitted. In addition, EEC will explore working with professional societies, including those that target underrepresented groups, to identify excellent reviewers with the proper expertise.

OBSERVATIONS: "The issue of insufficient funding for engineering education was stressed in the 2010 COV report and in the 2007 COV report before it. … The COV believes the budget at EEC is woefully inadequate to meet the NSF's Strategic Goals in the area of engineering education. More staffing and more reliance on full time NSF employees would be appropriate with reduced reliance

on AAAS and Einstein Fellows. EEC must staff and organize to efficiently manage a larger level of activities."…"Looking at the organizational charts for EEC, particularly for Engineering Education, it is obvious that there are a large number of rotators and temporary personnel as compared to the full time NSF employees. For example, for Engineering Education, Donna Riley is the only full time NSF employee." "The COV sees a shortage of technical, financial and human resources within EEC to lead the work efforts for all the engineering areas that need attention. For example, the Engineering Education sector (cluster or group) within EEC expends only about $10-15M of the Division's total $125M."

RESPONSE: The budget for engineering education and broadening participation in the EEC Division is a significant limitation. The ENG AdCom also took this into account in its overarching recommendations as discussed earlier. NSF and all its Directorates are operating in a highly constrained budgetary environment for the last few years.

It should be noted that the EHR Directorate makes substantial investments in engineering education. A recent analysis for FY14 showed that across its 4 divisions, EHR grants pertaining to engineering were as follows:

EHR:		$155,395,697 total
	DUE:	$75,602,979
	DRL:	$40,437,803
	DGE:	$20,912,552
	HRD:	$18,442,363

Thus, significant investments are being made toward different aspects of engineering education. Moving forward, the key strategy is to collaborate with colleagues in EHR to maximize the value of all of NSF investments in engineering education and broadening participation. The Professional Formation of Engineers initiative is a path forward and provides a conceptual framework for strategic alignment. The best example of success along this strategic direction is the new IUSE:RED pilot program described earlier in this response. We also note that the EHR Directorate invests approximately $155M annually to advance different aspects engineering education. Therefore, from the ENG/EEC viewpoint, there is potential for positive impacts by working closely and strategically with colleagues in EHR.

The leadership in ENG and EEC will examine staffing and workload issues carefully. Suitable actions will be undertaken to address these issues in the coming year.

Acknowledgement
The ENG Directorate and the EEC Division wish to thank the COV and the ENG AdCom for their due diligence and great care in examining the challenges faced by the division, especially in engineering education and broadening participation. The challenges are not easy. The fact that the COV report was unusually delayed reflects the level of deep thought and careful guidance offered by the COV

and the AdCom. Furthermore, the ENG Directorate and the EEC Division wish to thank Dr. Joan Ferrini-Mundy, AD for EHR, and Dr. Susan Singer, Division Director for EHR/Division of Undergraduate Education, for their unscheduled meeting with the COV during its meeting in Sept. 2013. Finally, as EEC Division Director, I would like to acknowledge ERC Program Director, Dr. Carmiña Londoño, and Science Assistant, Mr. Brad Clements, for their outstanding leadership in organizing and persisting through this process.