**EXECUTIVE SUMMARY**

The committee of visitors (COV) met on May 21-22, 2018 to review the programs in the Electrical, Communications, and Cyber Systems Division (ECCS) in the Directorate for Engineering (ENG), National Science Foundation (NSF). The division is composed of three clusters: Electronics, Photonics, and Magnetic Devices (EPMD), Energy, Power, Control and Networks (EPCN) and Communications, Circuits and Sensing Systems (CCSS).

The COV review of ECCS is structured with the Division's vision in mind to:

- *Address fundamental research issues at the nano, micro and macro scales underlying device and component technologies, energy and power, controls, networks, communications, computation, sensing and cyber systems*
- *Support integration of systems principles in complex engineering systems and networks for a variety of application areas*
- *Ensure education of a diverse workforce to meet the technological challenges of a 21$^{st}$ Century global economy*

The review covers fiscal years 2014 through 2017. Twelve COV members representing the three clusters (4 per division) evaluated 240 jackets which had resulted in 126 awards, 108 declinations and 6 returned without review. Additional material provided for evaluation included: a comprehensive report that contained valuable data in support of the four aspects of the review. This 2018 COV Info Guide Data Book also contained the 2014 COV report and the responses of ECCS throughout the last four years to the issues brought up in this review. The Data Book contains a detailed description of the ECCS vision and of the different clusters' activities. Additional information was provided to the COV through a webinar ECCS organized in early April 2018 which included Division Director Dr. Filbert Bartoli, Division Deputy Director Carmiña Londoño, Senior Adviser Dr. Larry Goldberg, and Division Analyst, Mr. Richard Nash. This webinar set the stage for the COV participants to carry out their tasks in a framework of complete confidentiality. The support of ECCS in terms of logistics and answering questions from the COV has been exemplary and invaluable. The ability of the COV to access jackets in the COV eJacket Module website and access review material and upload their evaluations in the NSF External Collaboration Portal (Sharepoint) was important to provide a common workspace and ensure strict confidentiality throughout the process. We are grateful to ECCS for making the evaluation process so efficient.

On the first day of the review, the COV was greeted by the ECCS Division Director Dr. Filbert Bartoli and Deputy Director Dr. Carmiña Londoño. Division Director, Dr. Bartoli and program directors Dr. Pavlidis (EPMD), Dr. Lin (CCSS) and Dr. Baheti (EPCN) presented an overview of ECCS and of each of the clusters respectively. Data from their presentations are also used in this review.

The 2018 COV report follows the 2018 NSF template for COV reviews. Part I evaluates the quality and merit of the review process. Part II evaluates the process of reviewer selection. Part III evaluates the management of the program under review. Part IV addresses issues related to the portfolio of awards. These four parts are followed by a section with additional broad recommendations on areas that need improvement.

Overall, the COV was very impressed by the leadership, the quality of the clusters in the ECCS, and the overall management of the processes and programs. The service provided by the ECCS Division is exemplary and has positively influenced thousands of careers in engineering and sciences. The on-going commitment of excellence, quality, and to the success of the missions of NSF specifically, and that of the Nation at large are to be commended.

Our observations and recommendations on each aspect of the 2018 COV review process and management of the program are presented below.

I.      **Quality and Effectiveness of the Merit Review**

The quality and effectiveness of the merit review process are essential to the NSF mission, to ensure that the highest quality projects that have the potential to advance the frontier of knowledge and to benefit society beyond the intrinsic importance of advancing knowledge are funded. The NSF merit review process is specific in that it requires an evaluation of the Intellectual Merit (IM) and Broader Impacts (BI).

Consistent with this evaluation criterion, it is therefore essential that each reviewed proposal receives substantive, solids reviews in both Intellectual Merit and Broader Impacts. In particular, reviews of declined proposals should provide constructive comments to help the principal investigators (PIs) improve their proposal for a subsequent submission. Multiple windows or a rolling window for proposal submissions is recommended. In this case, a process that includes responses to reviewers' comments could also be implemented.

The 2011 COV and 2014 COV found that the review of Broader Impacts (BI) "still remained undefined despite many efforts." The 2018 COV agrees with this statement. There is still confusion from the standpoint of the PIs, the reviewers and the program directors (PDs) on what BI entails, and how to assess and evaluate it. We would like to encourage ECCS to increase its efforts to educate the whole community on what BI encompasses, and how its merit is incorporated into the evaluation process.

ECCS has a well-balanced program in terms of unsolicited proposals, CAREER, and EAGER awards. While the first two are reviewed mainly through panels, EAGER is reviewed internally. While we believe that EAGER should be strongly supported, the policies around size and rationale for awards should be further clarified to ensure consistency in the process.

II.      **Selection of Reviewers and their efficacy in the review process**

Overall ECCS has a well-developed process to assemble reviewers. Unsolicited and CAREER proposals are mainly reviewed by panels. EAGER proposals are reviewed internally. In some cases, when the expertise of the panel lacks on specific proposals, ad-hoc reviews are solicited. PDs have an established process to select reviewers using different databases available. In addition to the technical expertise, the PDs also consider geographical, organizational, gender and race diversity in panel composition. The review selection process handles conflict of interests appropriately. PDs are well-trained and are conscientious about ensuring that conflict of interests is managed and resolved.

Analysis of the jackets showed there is significant variability in the quality of panelists' individual reviews. The 2018 COV would like to recommend that a formal process to train reviewers and to rate the quality of their assessment be developed. A document containing best practices, a short video with guidelines or other material that will contribute to improving quality of reviews is needed.

The use of ad-hoc reviewers to fill any gaps in expertise and background strengthens the review process. It is therefore recommended that ad-hoc reviewers be used more frequently, in a consistent manner to further strengthen the process and provide PDs strong support towards making a decision. These reviews should be available to the panel members to include them as part of their discussion.

Panels in their majority take place at the NSF site, although there is a small percentage that are hybrid, i.e. a combination of in-person and virtual participation. The 2018 COV would like to

recommend ECCS evaluates the efficacy of virtual panelists in the review process and develops best practices for both the use of virtual and hybrid panels.

### III.     Management of the program under review

ECCS with its three core cluster programs is effectively managed. The PDs are highly qualified and fully committed to innovation, fairness, and responsiveness to PIs 'bottom up" sourcing of research directions. The 2018 COV recommends that ECCS implements an annual review in thrust emphases and program funding.

ECCS is responsive to emerging areas. PDs attend technical conferences, and some have hosted town-hall meetings to discuss with the community future technical directions. We would like to recommend that these efforts be expanded to include, for example, regular brainstorming sessions with researchers in the field, and workshops to which other leading organizations that may include IEEE, ECEDHA and other funding agencies are invited to help identify and support emerging areas.

The ECCS budget has remained relatively constant over the last four years. In fact, it decreased within the overall ENG budget. The COV is impressed by how the budget is managed in terms of its balance among the different types of awards that it supports. The COV's concern in this area is that within this balance there are limited opportunities for young professionals aside from CAREER. ECCS submitted in 2015 a request to ENG for the re-establishment of Research Initiation Grants, regarding which no decisions have yet been implemented. The COV encourages ECCS to continue pursuing these efforts, which can impact ENG broadly.

An increase of submission windows is recommended by the 2018 COV because it will contribute to consistently sustain PI programs, and better serve young professionals. With an increased number of submission windows, ECCS would like to consider establishing a formal process to allow PIs to respond to reviewer comments, and at the same time to limit the number of resubmissions for a particular proposal.

### IV.     Resulting portfolio of awards

The analyses of jackets, coupled with the information provided in the 2018 Data Book showed the ECCS portfolio across disciplines and sub-disciplines is very well balanced. The ability of the PDs to fund high risk and high reward projects through EAGER is important and should be maintained. The portfolio of awards is also well-balanced in terms of support of research-intensive versus non-research-intensive institutions and its geographical diversity. The percentage of awards to PIs from under-represented groups is encouraging in unsolicited proposals, but warrant further monitoring for targeted solicitations.

ECCS awards are typically three years in duration and on average cover $100,000 per year. This level of support is reasonable. However, it should be noticed that due to increased costs of research, this funding base will inevitably result in reducing the scope of projects. This should be closely monitored. Co-sponsoring with industry, and/or other agencies and cross-cutting programs with other NSF programs should be strategically explored to increase award size and scope. Moreover, these interactions could help broaden the ECCS interdisciplinary portfolio.

### V.     Other Topics Recommendations

The efficacy of ECCS in managing and establishing a review process is well documented, and as described in the previous sessions, the recommendations provided by the 2018 COV are designed to further strengthen the effectiveness of ECCS.

In addition to the issues discussed above, we would like to encourage ECCS to establish a formal process to promote broadening the reach of its cluster programs in terms of identifying emerging areas and consider a CCC-like (Computing Community Consortium) initiative to promote division-wide efforts on identifying emerging topics, new opportunities, and new partnerships that could promote new funding mechanisms. Such structure could also provide the framework to organize workshops and broaden participation.

On ECCS operation and management, the COV would like to stress the importance of having a permanent PD for each of its clusters. This would help with consistency in operation.

On the COV process itself, we thank ECCS for all the materials provided, and the tools available to facilitate the review. We would also like to suggest that in future COVs, some members be assigned sample of jackets, all from a single panel. This will make it possible to identify issues in the dynamics of a panel, including unintended bias (e.g. large vs small institution).

# FY 2018 REPORT TEMPLATE FOR
# NSF COMMITTEES OF VISITORS (COVs)

The table below should be completed by program staff.

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| **Date of COV:** May 21-22, 2018 |
| **Program/Cluster/Section:** |
| **Division:** Division of Electrical, Communications, and Cyber Systems (ECCS) |
| **Directorate:** Directorate for Engineering (ENG) |
| **Number of actions reviewed:** 240 <br><br> **Awards:** 126 <br><br> **Declinations:** 108 <br><br> **Returned without Review (RWR):** 6 <br><br> |
| **Total number of actions within Program/Cluster/Division during period under review:** <br><br> **Awards:** 1,692 <br><br> **Declinations:** 4,707 <br><br> **Returned without Review (RWR):** 88 <br><br> **Grand Total:** 6,487 |
| **Manner in which reviewed actions were selected:** <br><br> The 2018 ECCS COV focused on fiscal years 2014 through 2017. <br><br> COV members were assigned jackets by way of a stratified random sampling of proposals, awards, and returns-without-review (RWR) within the ECCS Division. ECCS's three core programs ("clusters") – Electronics, Photonics, and Magnetic Devices (EPMD), Communications, Circuits, and Sensing-Systems (CCSS), and Energy, Power, Control, and Networks (EPCN) -- were reviewed, in addition to major ECCS solicitation activities across fiscal years 2014 through 2017. |

**COV Membership**

| | Name | Affiliation |
|---|---|---|
| **COV Chair or Co-Chairs:** | **Dr. Carmen Menoni (Chair)**<br>**Dr. Rashid Bashir (Co-Chair)** | **Colorado State University**<br>**University of Illinois** |
| **COV Members:** | *EPMD Subcommittee*<br>**Dr. Jeffrey Bokor**<br>**Dr. Claire Gmachl**<br>**Dr. Gilbert Hawkins**<br>**Dr. Dwight Streit**<br><br>*CCSS Subcommittee*<br>**Dr. Petar Djuric**<br>**Dr. Sarah Rajala\***<br>**Dr. Cynthia Furse**<br>**Dr. J.C. Chiao**<br><br>*EPCN Subcommittee*<br>**Dr. Zhihua Qu**<br>**Dr. Mariesa Crow**<br>**Dr. Anuradha Annaswamy**<br>**Dr. Kevin Tomsovic**<br><br><br>\*member of 2018 ENG AdCom | **University of California - Berkeley**<br>**Princeton University**<br>**Eastman Kodak (retired)**<br>**University of California - Los Angeles**<br><br><br>**Stony Brook University**<br>**Iowa State University**<br>**University of Utah**<br>**University of Texas - Arlington**<br><br><br>**University of Central Florida**<br>**Missouri University of Science & Tech.**<br>**Massachusetts Institute of Technology**<br>**University of Tennessee** |

# INTEGRITY AND EFFICIENCY OF THE PROGRAM'S PROCESSES AND MANAGEMENT

Briefly discuss and provide comments on *each* relevant aspect of the program's review process and management. Comments should be based on a review of proposal actions (awards, declinations, returns without review, and withdrawals) that were *completed within the past four fiscal years*. Provide comments for *each* program being reviewed and for those questions that are relevant to the program(s) under review. Quantitative information may be required for some questions. Constructive comments noting areas in need of improvement are encouraged.

## I. Questions about the quality and effectiveness of the program's use of merit review process.
Please answer the following questions about the effectiveness of the merit review process and provide comments or concerns in the space below the question.

| QUALITY AND EFFECTIVENESS OF MERIT REVIEW PROCESS | YES, NO, DATA NOT AVAILABLE, or NOT APPLICABLE |
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| 1. Are the review methods (for example, panel, ad hoc, site visits) appropriate?<br><br>Comments:<br><br>The overall impression of the 2018 COV is that the review methods used by the ECCS Division are appropriate. The majority of the proposals are reviewed by panels, receiving three reviews each on average, and in addition a panel summary. The remainder is internally reviewed. The internally reviewed proposals are EAGER (Early-concept Grants for Exploratory Research) proposals, agenda-setting workshops, and requests for travel support. The panels enable discussion of the individual proposals' merits and at the same time contribute to homogenize opinions of the panelists in terms of the evaluation criteria. A few percents of the competitive proposals also receive external ad-hoc reviews. External ad-hoc reviews are solicited by the program directors (PD) in occasions in which the panel members have insufficient expertise in the proposed research area. Most of the panels are on-site. A smaller proportion is hybrid (on-site plus virtual participants).<br><br>Panelists are selected from different disciplines, ECE/EE, Mechanical and Aerospace Engineering, Physics, and related disciplines. Reviewers are selected by the PD using a combination of methods that include: their knowledge of members of the technical community, an NSF database of grants recipients, references in the proposal, and other databases such as Web of Science. In addition to technical expertise, the PD takes into consideration gender and ethnic diversity. Geographical diversity, as well as the type of organization (R1, R2, R3 universities, national labs, and industry), are also accounted for in panel composition.<br>The panel review is thorough, with diverse reviewers of appropriate technical background. The COV praises the PDs for these efforts and encourages them to continue with these practices. | YES |

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| Recommendations:<br><br>The effectiveness of hybrid panels should be studied to ensure that these panels meet the same high-quality standards as on-site panels.<br><br>A process should be developed to incorporate ad-hoc reviews into the proposal discussion in a uniform way across panels.<br><br>In the case the PD contacts the PI for further discussion as it occurs when proposals are recommended for funding, all written contact with the PI should be documented in the eJacket. | |
| 2. Are both merit review criteria addressed<br><br>   a)  In individual reviews?<br><br>The 2018 COV found that in most of the proposal jackets, the individual reviews addressed both review criteria. However, the BI section consistently received less detailed attention from the reviewers. While the intellectual merit was clearly identified and evaluated, the BI in a moderate percentage of the jackets were not reviewed well. In some cases, the reviews merely repeated the content of the proposal or discussed them in a superficial manner.<br><br>   b) In panel summaries?<br><br>The panel summaries addressed both review criteria in most jackets. The panel summaries captured the discussions of the panels very well regarding strengths and weakness. There were a few instances in which the panel summary offered little specifics on BI. However, the quality of the panel summaries was in general much higher than the individual reviews.<br><br>   c) In Program Officer review analyses?<br><br>The program officers' review analyses added context when panel reviews were lacking in specificity and details. These analyses were very complete, providing strong support to the award decision.<br><br>Recommendations:<br><br>The PDs should put in place a process to ensure all reviewers provide substantive comments. This is essential not only for a fair review process but also to mentor principal investigators of proposals that do not receive an award. One possible action on this could be that the proposal lead reviewer ensures that the other reviewers substantiate their reviews with meaningful feedback.<br><br>There is still confusion about the nature of BI from all stakeholders - PIs, reviewers, and PDs. A metric is necessary to evaluate BI within the overall evaluation scheme. | YES, ALTHOUGH THERE ARE EXCEPTIONS |

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| There needs to be better transparency, including community discussion, of what BI encompasses and its merit to the proposed work. This includes having a well-organized NSF website that provides details on best practices in BI, such as material and training on how to incorporate BI for both proposers and reviewers. Review panels should have a substantive discussion on BI as part of their consideration.<br><br>Criteria for proposals being triaged should be standardized. Triaging could be utilized further to increase the quality of discussions and reviews on the other proposals. | |

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| 3. Do the individual reviewers giving written reviews provide substantive comments to explain their assessment of the proposals?<br><br>The majority of individual reviews were thoughtful and provided objective evaluations of intellectual merit. A small, but significant, group of reviews did not provide substantive feedback. The BI evaluations were frequently less detailed than the reviews of intellectual merit.<br><br>Proposals that receive a "do not recommend" or are triaged, do not get a detailed panel summary. This lack of feedback is somewhat disconcerting as these are the proposals that need constructive feedback.<br><br>Recommendations:<br><br>Reviewers should be strongly encouraged to focus on evaluative statements rather than technical summary statements.<br><br>Proposals that are triaged should have at least one substantive review that provides constructive feedback. | YES – with notable exceptions |
| 4. Do the panel summaries provide the rationale for the panel consensus (or reasons consensus was not reached)?<br><br>The panel summaries typically provided a rationale for the decision and accurately captured reviewers' comments. The panel summaries gave more information about the rationale for the ranking. However, how differences between reviewers were resolved was not always captured in the panel summary.<br><br>Recommendations:<br><br>There should be continued efforts to ensure high-quality summaries that accurately capture panel discussion. | Yes |

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| 5. Does the documentation in the jacket provide the rationale for the award/decline decision?<br><br>[Note: Documentation in the jacket usually includes a context statement, individual reviews, panel summary (if applicable), site visit reports (if applicable), program officer review analysis, and staff diary notes.]<br><br>The PD review analysis was generally thorough with clear context and summary of panel discussions and recommendation. However, there was some minor variability in the consistency of reviews/concerns and the rationale for the final decision for funding.<br><br>Recommendation:<br><br>The PD should discuss the differentiation factors between the 'recommended' and 'not recommended' decisions. This should include rationale on how the decision fits with the overall portfolio and funding priorities/strategies as well as program broader impacts. | Yes |

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| 6. Does the documentation to the PI provide the rationale for the award/decline decision?<br><br>[Note: Documentation to PI usually includes context statement, individual reviews, panel summary (if applicable), site visit reports (if applicable), and, if not otherwise provided in the panel summary, an explanation from the program officer (written in the PO Comments field or emailed with a copy in the jacket, or telephoned with a diary note in the jacket) of the basis for a declination.]<br><br>The documentation to the PI provided the rationale for the award/decline decision quite well. However, in some cases of declination of low-ranked proposals, insufficient feedback was given to the PI (e.g., individual reviews and the panel discussion had insufficient content).<br><br>It was observed from the PI history that several declined proposals were later funded. This is a good indication that the documentation provided was helpful for the PI to improve her/his proposal.<br><br>Recommendations:<br><br>In the case of declination, the information provided to the PIs should be more detailed and include information on how the PIs could improve their proposal for a subsequent submission. | Yes |
| 7. Additional comments on the quality and effectiveness of the program's use of merit review process:<br><br>Returning to multiple submission windows should be considered. | |

| While we believe that EAGER should continue to be strongly supported, the policies around size and rationale for the EAGER program should be further clarified. | |
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**II. Questions concerning the selection of reviewers.** Please answer the following questions about the selection of reviewers and provide comments or concerns in the space below the question.

| SELECTION OF REVIEWERS | YES, NO, DATA NOT AVAILABLE, or NOT APPLICABLE |
|---|---|
| 1. Did the program make use of reviewers having appropriate expertise and/or qualifications?<br><br>ECCS has a well-developed process to assemble review panels. The reviewers seem to have the appropriate expertise and qualifications. As a result, their reviews are useful and valuable to the decision-making process for funding. In some cases, when there was a lack of expertise in the panel, ad-hoc reviews were solicited. These reviews are made available to the panel members.<br><br>The PDs use different resources to identify reviewers. These include their knowledge of experts in the community, the NSF reviewers database, the list of references in the proposal, and other databases such as the Web-of-Science. The PDs strive to ensure diversity among types of institutions, geography, seniority, gender and ethnicity (based on available data).<br>Analysis of the jacket materials showed significant variability in the quality of the individual reviews.<br><br>The workload of PDs in assembling panels is large and they should be commended for these efforts.<br><br>Recommendations:<br><br>A formal process needs to be developed to train reviewers and to rate the quality of their assessments.<br><br>A greater use of ad-hoc reviewers could be employed to fill any gaps in expertise and background. If a reviewer felt uncomfortable with his/her ability to assess a particular proposal, that reviewer should be encouraged to request an ad hoc review be performed. The number of reviewers doing this should be tracked by the PDs.<br><br>As a strategy to reduce the load of a PD in assembling panels, ECCS could implement a process to broadly solicit reviewers (a "call for reviewers"). This would allow prospective reviewers to volunteer for service, thereby enabling the PD to select from this broader pool. This is particularly important in specialized calls for proposals. This would also add transparency to the reviewers' selection process while at the same time allow recruitment of members from the community at large, e.g., early career faculty. ECCS should also continue with its efforts to increase participation of women and under-represented minorities in panels. | Yes |

| Data Source: Jackets | |
|---|---|
| **2. Did the program recognize and resolve conflicts of interest when appropriate?**<br><br>The COV is impressed with the rigor through which conflicts of interest are identified and resolved. PDs are well-trained and are conscientious about ensuring that COIs are well managed. | |
| **3. Additional comments on reviewer selection:**<br><br>One of the most challenging problems of a PD is to find and assign reviewers with the appropriate expertise to ensure a fair evaluation of all proposals.<br><br>The analysis of the jackets showed most reviewers are from academia. Some of the panels include experts from industry and national labs, which makes the panels more diverse.<br><br>ECCS occasionally uses virtual panels, or hybrid panels (which include a few virtual participants) to ensure necessary expertise, increase diversity, or overcoming travel difficulties.<br><br>Recommendations:<br><br>ECCS should continue monitoring the effectiveness of virtual panels.<br>In addition, it is recommended that ECCS produces a best practice document including examples of evaluative and substantive reviews of the technical merit and broader impact of the proposed research activity. Some efforts along these lines are already in place by some PDs. Such document will contribute to increase quality and consistency of reviews and mitigate other important matters such as implicit or explicit bias. | |

**III. Questions concerning the management of the program under review**. Please comment on the following:

| MANAGEMENT OF THE PROGRAM UNDER REVIEW |
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1. Management of the program.

The management of the ECCS program is of high quality. ECCS is organized into three core cluster programs, each with a relatively small number of PDs. This organization appears to be an efficient way to aggregate the proposals received so that PDs in each cluster are cognizant of the details of their cluster's business flow, and also remain cognizant of the activities of the other clusters. PDs are highly qualified and committed to innovation and fairness. The responsiveness to PI "bottom-up" sourcing of research directions is highly commendable. The PDs have discretion and use it wisely.

From FY2014-2017 ECCS received a large number of competitive proposals that were managed through the merit review process. ECCS also received EAGER and CAREER and workshop proposals. There is a very stringent process that checks compliance for every proposal and only a few had been returned. EAGER and workshop proposals undergo an internal review process. CAREER proposals are reviewed in panels. The total ECCS budget has been relatively constant over the last four years. In relation to the total ENG budget, the ECCS budget decreased over the last four years. The portfolio awards distribution is well balanced among CAREER, EAGER, and unsolicited proposals. It is also well balanced in terms of success rate for research-intensive (R1), and non-research intensive R2 and R3 institutions.

The division holds yearly retreats to review program management issues. This is a very important and valuable exercise for streamlining the operation of the division and assessing the different programs.

Recommendations:

ECCS should develop metrics for the internal assessment process and document best practices. The COV believes it is important for ECCS management to use the results of the yearly retreat to review the balance of resources within and between clusters and to assess possible changes in thrust emphasis.

An aspect of the management, which the COV considers important, is the solicitation, hiring, training, and evaluation of PDs. Having a website, for example, that includes all materials used for program director training could be considered "best practices" and used within the community, even outside of NSF. This could be transformational. Furthermore, such process could provide continuity to the cluster management, especially in situations where all cluster PDs are rotators as is the case in CCSS presently.

The COV supports strongly the EAGER proposals and recommends a more transparent solicitation and review process be developed.

In terms of special programs, the COV would like to see the Research Initiation Program be re-established to ensure new PIs have a fairer share in successful competition for awards. Research Initiation will augment the impact of CAREER in supporting the establishment of research programs of new PIs.

ECCS could also evaluate the possibility of graduate student support beyond the typical three-year award, in the form of a continuation grant. This could enable funded research programs to support a graduate student to completion and furthermore, could have an impact in the quality of proposal submissions and perhaps reduce the number of submissions.

The COV also discussed the one-time yearly submission window of ECCS and did not find data supporting claims that it would reduce the number of submissions and increase the quality of proposals, as the total number of proposals and success rates have remained fairly constant. The COV recommends that ECCS consider increasing the number of soliciting windows.

The COV encourages ECCS to search for a permanent PD for CCSS.

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

ECCS is responsive to emerging areas. Based on the information provided to the COV, ECCS identifies emerging research and education opportunities through the participation of the PDs in conferences and workshops, some of which involve inter-agency participation. The workshop proposals are one metric of this effort and the topics seem well chosen. EAGER, as well, drives the inclusion of new areas. The large fraction of unsolicited proposals ensures "crowd-sourcing" of new research ideas as well.

The workshops centered on emerging research and education opportunities appear critical in making the programs responsive to these opportunities, perhaps more so than the challenge to the PDs to gather data on their own. An assessment metric of these efforts would provide PDs and ECCS evidence of the efficacy of the workshops. It would seem workshops comprising representatives of external organizations, including private and public companies benefiting from the NSF charter, would provide a different and helpful way of responding to the integration of emerging research and education opportunities and to assessing the responsiveness of the programs.

The EPCN PDs have been very active in engaging the research communities, including IEEE PES, IEEE CSS, and ECEDHA that correspond to the core research thrusts by attending annual conferences, giving talks about NSF programs, hosting workshops on emerging research themes, and engaging researchers, especially junior faculty members.

EAGER/RAPID funding mechanisms provide opportunities for supporting new and promising research topics. These mechanisms could be further utilized to encourage/support multi-disciplinary research in emerging topics.

Recommendations:

A formal, well-defined, transparent process needs to be established to bring emerging ideas into ECCS that would include:
- Ideas for workshops solicited broadly (possibly through a formal, regular, call for proposals).
- Ideas solicited through a "Dear Colleague Letter." Inviting this on a regular basis could bring emerging ideas to the attention of program managers.
- Events that will gather researchers the field to discuss future directions with PDs. More strategic thinking sessions could be beneficial, and NSF should consider ways to expand the strategic new direction thinking of ECCS.
- PDs could exploit their participation at conferences for organizing a well-publicized workshop or town-hall meeting that will enable PDs to learn from the community on recent advances, to

solic and/or share ideas. These activities will also enable the PDs to give a brief update on their program, and answer questions/gather feedback from the community.
- Extend best practices of EPMD in engaging other organizations to the other two clusters.
- Division and Directorate online materials (website, etc.) should have detailed and up-to-date information that is regularly updated for all programs. The power points and description by the PDs were clear and compelling about their programs. The websites need development.

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

Recommendations:

Program planning and prioritization heavily build upon submissions from individual PI's; the system is fair and reasonable. The annual retreats, portfolio analyses, as well as workshops provide a comprehensive planning and prioritization process. The recommendation is to make the planning and programming process more transparent to the research community.

The current method of portfolio analysis (which boils down to most NSF customers as 'how the budget will be spent') seems dated and locally focused. It is certainly good to have annual retreats, director inputs, dear colleague letters and COV suggestions, but these seem insufficient by today's data-driven standards. The COV recommends there be comparisons to how other countries are selecting their portfolios and assessment of their success. ECCS should use analytics to examine the consequences of various portfolio choices. Hopefully, the new framework for portfolio analysis seeking to employ automation elements and artificial intelligence will start a new direction.

The EAGER - RAPID proposal support system seems worthwhile. The approval rate is quite high. The operations are clear, but the presentation of an overall strategy for building the portfolio seems lacking.

4. Responsiveness of program to previous COV comments and recommendations.

By and large, the recommendations of the 2014 COV were responded to successfully. Nevertheless, some topics keep coming up (virtual panels, Broader Impact, research initiation grants).

1. The submission window for unsolicited proposals:

The 2014 COV expressed concern about the impact of a single window per annum relative to the ability of junior faculty members to successfully compete for grants. It recommended ECCS collect more data and modify the timing of submission and submission window as needed to achieve the desired outcomes and to consider developing a Research Initiation Grant program.

Over the last four years, ECCS collected data on unsolicited proposals and determined the number of proposals continually increases. In the 2015 ECCS annual division retreat, ECCS decided to continue with a one submission window while continuing to monitor data. In response to establishing a program for young investigators, ECCS drafted and submitted to ENG and NSF a draft of the program, which is still being evaluated.

The question of the efficacy of a single annual window remains unanswered, and it is not clear what, if any, formal assessment is currently underway to determine if this window mechanism is the best for ECCS. A formal assessment process should be defined and implemented. For instance, other directorates are testing out mechanisms that include rolling windows (no deadlines), pre-proposals, and multiple windows. The COV's opinion is that one submission a year is not sufficient and recommends ECCS investigate the possibility to expand submission windows. If there were several submission windows, ECCS should consider mechanisms for assessing responses to previous reviews on resubmissions.

2. Use of Panels

The previous COV recommended assessment of how virtual, hybrid and face-to-face panels are functioning. The ECCS division reviewed these concepts internally, and the consensus was to continue face-to-face panels.

With enhanced technology at the new headquarters in Alexandria, a virtual reverse site review was conducted for the NNCI sites.

There is a need for continued assessment of the effectiveness of virtual reviews and for identification of opportunities to improve virtual reviews. ECCS may want to consider putting out a call for proposals to formally assess and study the ECCS review processes.

3. Supplemental funds program

It would be advisable to create an assessment plan (and implement it) for ongoing assessment of the REU/RET programs, and for a broader range of programs.

The Cornell study was a good assessment of REU/RET programs and could be used as metric for ECCS which does not count with similar statistical results.

4. Broader impacts

This is an area that requires substantial attention from ECCS and NSF. The 2014 COV pointed out that "Broader Impact has remained undefined despite many efforts. In fact, there is a belief that the effort to address the concerns of the previous COV did not make the understanding better." The 2013 COV pointed out that there is inconsistency in the understanding among PIs and reviewers of what makes a proposal successful. The recommendation was to encourage ECCS to consider that 'Broader Impacts' be achieved within the PD's portfolio and within the individual proposals to produce better outcomes and focus the research community in breakthrough science and engineering that has potential to change the world in the near and long-term.
ECCS responded to this review by "Acknowledging the importance of Broader Impacts and organizing in 2016 a workshop for the ECE community and other ECCS stakeholders in which a session was dedicated to key speakers and grantees who described their experience and perspective on broader impacts. This was followed by breakout sessions that dealt with an understanding of the economic and social values of ECCS-supported research and with metric on how to assess broader impacts". The results of this report were not available to the 2018 COV. However, a video was shown whose objective is to educate reviewers on how to evaluate BI.

Training/transparency/clarification is still incomplete across the community including the NSF panels/reviewers. A better method to evaluate BI is needed (perhaps separate ratings for BI), possibly a separate BI plan (like the data management plan). Accountability of BI is still limited and BI understanding is non-uniform. Proposals are still funded with high IM and low BI. The ECCS

could consider forming and charging a specific ad-hoc committee to develop a plan to clarify the purpose of and forms of evaluation of BI.

    5. Unsolicited grants

The 2014 COV encouraged ECCS to protect the integrity of the unsolicited proposals program, both in funding and duration. Analysis of ECCS data from unsolicited awards in FY11-FY13 and FY14 and FY15 did not find the significant change from prior years in either award amount or duration.

Particularly because the amount of funding for unsolicited grants has remained static, getting a Ph.D. student funded through graduation is extremely difficult. It is recommended that the NSF create a program to provide supplementary funding for Ph.D. student completion.

Concern was raised about the high acceptance rate of the EAGER proposals. The ECCS management responded that the process for submission of EAGER proposals includes consultation with a program officer to evaluate the appropriateness of funding, and therefore the proposals submitted have a high rate of success.

The 2014 COV raised a question about how the program directors manage potential COIs relative to technical expertise. This is a responsibility of the program directors and is included in their selection of reviewers on a panel.

**IV. Questions about Portfolio.** Please answer the following about the portfolio of awards made by the program under review.

| RESULTING PORTFOLIO OF AWARDS | APPROPRIATE, NOT APPROPRIATE, OR DATA NOT AVAILABLE |
|---|---|
| 1. Does the program portfolio have an appropriate balance of awards across disciplines and sub-disciplines of the activity?<br><br>The balance of awards across EPMD, CCSS, and EPCN and the research disciplines are appropriate and appear balanced. The success rate is about the same for all three cluster areas.<br><br>The awards are well-balanced by the strategy cited, based on the number of proposals submitted to each cluster. The strategy behind the award balance should be regularly re-evaluated based on national priorities and articulated.<br><br>The ability of the Program Directors to fund high risk and high reward projects through EAGER is important and should be maintained. | Yes |
| 2. Are awards appropriate in size and duration for the scope of the projects?<br><br>The award amounts, ~\$100,000/year, have stayed more or less stagnant over the four years under consideration while the cost of research assistants (graduate and undergraduate students and post-doctoral researchers), indirect costs, and other expenses have grown. In general, the size and duration of the awards are reasonable for the scope of the projects, but the divergence between the increasing costs of doing research and stagnant award sizes needs careful monitoring.<br><br>Co-sponsorship from industry and/or other agencies and cross-cutting programs with other NSF programs should be strategically explored to increase award size and scope. | Yes |
| 3. Does the program portfolio include awards for projects that are innovative or potentially transformative?<br><br>The jacket assessment and COV data show that awards are strongly based on innovative and potentially transformative research. The research portfolio is aligned with national needs and supports a thriving innovation ecosystem.<br><br>There is a strong commitment to supporting research that is innovative and potentially transformative. Individual reviewers vary in their willingness to | Yes |

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| take risks. Program directors do a good job of balancing all the feedback in their recommendations.<br><br>In the opinion of the COV, the overall portfolio appears well-balanced between high risk / high payoff awards (such as EAGER), awards that support the development of long-term faculty research (such as CAREER), strategic programs (such as cross-cutting solicitations) and emerging ideas (such as from the unsolicited proposals and workshop funding). However, it is not clear that a formal means of portfolio assessment exists. | |
| 4. Does the program portfolio include inter- and multi-disciplinary projects?<br><br>ECCS has been making and receiving large investments in cross-cutting programs. It actively co-funds proposals with other ENG Divisions and NSF Directorates. ECCS participates in additional cross-cutting programs including ERCs, STCs, NNCI, and several topical solicitations. Inter- and multi-disciplinary projects are aligned well with national needs. | Yes |
| 5. Does the program portfolio have an appropriate geographical distribution of Principal Investigators?<br><br>ECCS funds programs throughout the country, correlating roughly with population density. | Yes |
| 6. Does the program portfolio have an appropriate balance of awards to different types of institutions?<br><br>The balance of the portfolio between institution types appears appropriate. Adding an early career research initiation program could better support PIs from all types of institutions in the early stages of their research careers. | Yes |
| 7. Does the program portfolio have an appropriate balance of awards to new and early-career investigators?<br><br>A new investigator is defined as an individual who has not served as the PI or Co-PI on any award from NSF (with the exception of doctoral dissertation awards, graduate or post-doctoral fellowships, research planning grants, or conferences, symposia, and workshop grants).  An early-career investigator is defined as someone within seven years of receiving his or her last degree at the time of the award.<br><br>CAREER awards are an important component of ECCS portfolio with a success rate for beginning investigators which is larger than if they were to compete in the unsolicited proposals program. The support and success rates for early career faculty are reasonable. | Yes |

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| The COV recommends the addition of a research initiation grant program to provide support for new and early-career investigators. In combination, this program and the CAREER program could significantly enhance the opportunities for new investigators, and in particular, of those in less research-intensive institutions whose success rate in the unsolicited program is low. | |
| 8. Does the program portfolio include projects that integrate research and education?<br><br>The program portfolio promotes the integration of research and education, especially through the broader impacts requirement. CAREER awards are particularly strong in this integration. Most proposals discuss education, although details were often limited.<br><br>The jacket assessment shows that proposals that provide innovative means of integrating research and education are rated highly.<br><br>Clarifying broader impact expectations could further improve this integration. | Yes |
| 9. Does the program portfolio have the appropriate participation of underrepresented groups[1]?<br><br>ECCS program portfolio has a representation of PIs from underrepresented groups. The acceptance rate of awards that go to unsolicited proposals with minority involvement is competitive, although lower than that of proposals without minority involvement. This warrants monitoring. | Yes |
| 10. Is the program relevant to national priorities, agency mission, relevant fields and other constituent needs? Include citations of relevant external reports.<br><br>The program is relevant to national priorities, agency mission, relevant fields and other constituent needs. The broader impact continues to make sure that the projects are important and significant with societal impact.<br><br>Most of the proposals had a reasonably long-time horizon (5-10 years) for the application. They all seemed to be addressing national needs in term of technology development. | Yes |

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[1] NSF does not have the legal authority to require principal investigators or reviewers to provide demographic data. Since provision of such data is voluntary, the demographic data available are incomplete. This may make it difficult to answer this question for small programs. However, experience suggests that even with the limited data available, COVs are able to provide a meaningful response to this question for most programs.

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| 11. Additional comments on the quality of the projects or the balance of the portfolio:<br><br>The quality of projects and balance of portfolio are appropriate. Adding a new early investigator research initiation grant program may improve the balance of support for early investigators, particularly from non-research-intensive institutions. | |

## V. Other Topics

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

The effectiveness of the once-a-year proposal submission window is not clear. COV strongly recommends reconsidering multiple submission windows as the annual window results in too long of a cycle if a proposal is not funded the first time, especially for younger or early career faculty. In this case, a resubmission policy with responses to comments could also be implemented.

2. Please provide comments as appropriate on the program's performance in meeting program-specific goals and objectives that are not covered by the above questions.

COV recommends that ECCS considers a CCC (Computing Community Consortium) -like initiative to promote division-wide efforts for a workshop on emerging topics, create new opportunities and partnerships, and new funding mechanisms for the ECCS research community.

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

COV recommends that ECCS consider implementing a Research Initiation Grant for the first time PIs, provided it does not reduce current success rates.

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

COV recommends that every program have a permanent program director at all times. For example, we recommend that CCSS hire a permanent director as soon as possible to provide continuity of expertise and knowledge.

It is also our belief that the inconsistent individual reviews and the lack of clarity around broader impact and its inconsistent review are intertwined, and are due to the lack of structure in the individual reviewer form itself. We would suggest that the review form follow the five review criteria specifically and the reviewers are given a template to fill it with strengths and weaknesses around each review criteria. We also suggest that a 6th criteria be added to judge the broader impact action plan so that each PI is incentivized to develop a plan around the broader impact. Each reviewer can also provide a rating of each of the criteria and also an overall rating. This, along with a clear description and video of broader impacts, and a renewed focus on ensuring that reviewers follow up with a quality individual review, can all ensure an improvement in the overall process and quality of the individual review.
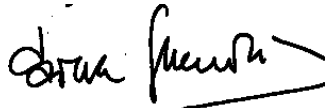
5. NSF would appreciate your comments on how to improve the COV review process, format and report template.

The process is generally quite good. However, the completely random assignment of jackets to each COV member makes it difficult for the COV to identify issues such as biases or other non-ideal dynamics within panels. It is suggested that in future COVs, some members might instead review a sample of jackets, all from one single panel.

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**SIGNATURE BLOCK:**

For the 2018 ECCS COV

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Chair

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