

Response to 2015 CMMI COV Report

(Language in italics identifies issues to be addressed in annual updates)

I. Introduction: The 2015 CMMI COV Meeting and Committee Report

The Committee of Visitors (COV) met at NSF on May 12 and July 7-8, 2015 to review programs in the Division of Civil, Mechanical and Manufacturing Innovation (CMMI) in the Directorate for Engineering. The COV committee assessed the operations of the CMMI Division in fiscal years (FY) 2012, 2013, and 2014. Dr. Louis Martin-Vega served as COV Chair and Dr. Tony Schmitz served as COV Co-Chair.

The COV was charged to review the division's portfolio, the proposal and award process, and program operations and management for FY 2012-2014. The committee was asked to consider factors such as the selection of qualified reviewers, the use of NSF merit review criteria, documentation of program officer decisions, and areas of emphasis within the portfolio.

During the review, the COV evaluated over 180 proposal actions that were randomly selected over the three-year time period. Data tables summarizing all proposal actions during the three year review period were also provided to COV members as well as the prior 2012 CMMI COV report and the associated Division response. This information, in conjunction with the on-site meetings with CMMI program staff and management, formed the review and basis for the COV Report.

The finalized report was then submitted by the COV Committee Chair to the Chair of the ENG Advisory Committee, Dr. Patrick Farrell.

The CMMI Division wishes to thank the members of the 2015 CMMI COV Committee for their time and effort in thoughtfully reviewing the activities of the Division. CMMI is especially grateful to Dr. Louis Martin-Vega who served as Chair of the COV and Dr. Tony Schmitz who served as Co-Chair.

The Division is pleased with the overall positive assessment of its performance and role in meeting the Foundation's goals. CMMI appreciates the thorough review and the constructive recommendations laid out in the COV Committee Report.

Key recommendations and the Division's response are presented below.

II. Responsiveness to previous COV comments and recommendations

- 1. Recommendation:** The COV found that some concerns from the previous COV still persist and deserved continued attention (Ex. Summary, Section III-4):
 - Reviewers may benefit from more consistency in guidance when evaluating Broader Impacts.
 - The COV found it difficult to locate the workshop reports.
 - Written reviews and panel summaries are not uniform in detail or in the relative emphasis placed on Intellectual Merit and Broader Impacts. The 2012 COV report included some suggestions to ensure that reviewers provide substantive explanations of their assessments, as well as some suggestions to ensure consistency in panel summaries.

Response: These issues are addressed individually in later sections of the response.

III. CMMI Merit Review Activities

i. Understanding the Broader Impact Merit Review Criteria

- 1. Recommendation:** The COV found that there was far more attention placed on Intellectual Merit than Broader Impacts in the reviewer evaluations and that the level of comments on the Broader Impacts could be improved (Ex. Summary, Section I-3). The COV also noted that reviewers did not seem to understand whether NSF desires innovation or effective efforts to satisfy Broader Impacts requirements. The COV recommends communicating clear guidelines for the evaluation of Broader Impacts (Ex. Summary, Section I-7).

Response: *CMMI agrees that many PIs and reviewers have different understanding of both the meaning and the expectations of the Broader Impacts (BI) criteria and CMMI is committed to improving its research community's understanding. In support of that, CMMI will develop a document to be provided to all reviewers and panelists --to be informed by the workshop discussed below-- which emphasizes the current definition of the BI criteria; why and how BI are integral to the review of all NSF proposals; and that NSF does not require that all BI criteria be addressed. The document will clarify that broadening participation is one possible aspect of BI, that the focus is on value added and that it is acceptable for BI activities to build on existing infrastructure.*

CMMI is committed to developing a common understanding among the community and CMMI staff of what constitutes BI and their role in the merit review process. CMMI will fund a workshop to forge a common understanding and strategies for facilitating significant BI for NSF-funded proposals. Planning for the workshop is underway. The workshop recommendations will form the basis for revised guidance to CMMI PIs, reviewers, and PDs.

ii. Quality and Effectiveness of Merit Review Process

1. **Recommendation:** In one case from the sampled jackets, the review analysis was found to be deficient; the program director failed to adequately address both merit review criteria and provided no strengths or weaknesses of the proposal. In another case, the program director provided a thorough review analysis, but provided no rationale for a reduced project budget. (Section I-5, Section I-6)

Response: *CMMI supports the importance of documentation that explains PD recommendations. CMMI management will continue to provide and improve model review analysis templates for program directors and to emphasize in program director training the importance of complete review analyses. CMMI management continues to be alert to review analyses that do not adequately explain PD recommendations, and to return them to program directors for improvement when necessary.*

2. **Recommendation:** With respect to information provided with a decision to decline funding, there were a few jackets where the rationale focused on ranking alone. In these jackets, insufficient information was provided to the PI regarding how this specific proposal could have been improved such that it would have been more competitive. (Section I-6)

Response: *CMMI will continue to work to ensure that PIs receive useful feedback on declined proposals. PIs receive reviewer comments and panel summaries pertinent to their proposals, and PDs encourage reviewers to be as specific as possible in their remarks. PIs do not receive the PD review analyses, however, and since these provide the basis for the PD recommendations, CMMI encourages PDs to reach out to PIs, encouraging them to contact the PD directly for feedback on the factors leading to the decline and how to improve their proposals.*

iii. Selection of Reviewers

1. **Recommendation:** Based on this limited sample set and given the importance of innovation and commercialization, the COV recommends that additional effort be applied to recruiting reviewers from national laboratories and industry. (Section II-2)

Response: *CMMI agrees that innovation and eventual commercialization are important broader impacts of research. CMMI continues to emphasize to PDs the value of including individuals from industry and the national labs on panels, where possible.*

2. **Recommendation:** The COV discussed the importance of panel demographics for high-quality evaluations and PI feedback. Questions included:
 - How is panel effectiveness related to the diversity of panel member demographics, including discipline, gender, ethnicity, and institution type?
 - What effect, if any, does panel size have on proposal recommendations?

The COV recommends that these issues be considered by CMMI and an appropriate study be completed. (Sections II-1, V-4)

Response: *In organizing panels, CMMI PDs strive for balanced and diverse demographics while also being cognizant of not over-taxing reviewers from underrepresented groups. CMMI PDs also strive for appropriate use of both in-person and virtual or hybrid panels to ensure that panels have the expertise needed for reviewing the proposals, while being mindful to create opportunities for reviewers to participate virtually when they are unable to travel to NSF to participate in person. CMMI does not have sufficient resources to conduct a meaningful evaluation of the effect of the composition of the review panels on review effectiveness. However, while panel reviews play a large role in influencing award decisions, their role is advisory to the program director, not definitive. The program director considers the panel recommendation in the context of a range of other larger issues including NSF priorities, discussing award recommendations with NSF PD cluster colleagues, and with the division director, before an award is made.*

IV. Division and Program Management

i. Best Practices and Benchmarking

- 1. Recommendation:** In order to ensure consistency between programs, which may be directed by IPA or permanent staff, the COV recommends that best practices be captured and made readily accessible to new and existing program directors in an on-going basis. This enables consistent treatment of proposals and the continuation of successful approach and techniques. For example, the distribution of a representative high-quality review to panelists, the use of uniform review templates, and the clear guidance on Broader Impacts could be implemented agency-wide.

The COV emphasizes the need to balance IPAs and permanent program director due to the clear value of the IPA/permanent balance within CMMI. This necessarily requires continuous recruiting efforts by CMMI and financial and administrative support from NSF. (Section IV-1)

Response: *CMMI continues to maintain a balance between permanent staff and rotators as determined by NSF upper management, and provides training and materials to encourage adoption of best practices. CMMI collaborates with other ENG divisions and the community in developing a clearer definition of broader impacts in NSF-funded awards. CMMI is also collaborating with other ENG divisions to enhance the IPA onboarding process to ensure dissemination of best practices.*

- 2. Recommendation:** The COV recommends a benchmarking approach to compare CMMI to other NSF divisions and other comparable funding agencies and private foundations. This benchmarking could highlight both strengths and weaknesses and provide assessments of broader impacts. (Section V-1) The COV also recommends the identification of metrics to assess the outcomes of research

investment and interactions among investments that may potentially yield new areas of research. (Section IV-4)

Response: *CMMI will stay abreast of research approaches and initiatives in other research divisions and other organizations, as appropriate. CMMI will also continue to monitor its portfolio on an ongoing basis to ensure that it reflects emerging research opportunities and societal needs. CMMI will follow the lead of the Office of the Director and the Directorate for Engineering on appropriate tools and metrics for evaluating program outcomes. CMMI will continue to explore emerging tools, as appropriate.*

ii. Community Engagement

- 3. Recommendation:** To help clarify the reorganization to proposers and reviewers, the program web pages should reflect the precise focus of each program and cluster so that they can serve as a roadmap for researchers who are planning to submit proposals to the division. Providing such guidance is particularly important since the division strives for coordination across clusters, divisions, and agencies. These issues should be examined during the next review cycle. (Section III-3)

Response: *CMMI agrees that the focus of each program and solicitation should be clear to proposers and reviewers. CMMI maintains up-to-date program descriptions that define the program focus on the CMMI web page. When there are major changes in the cluster organization or in the program content, the web descriptions will reference these changes if it is appropriate. Dear Colleague Letters announcing significant program changes are encouraged in CMMI to bring them to the attention of PIs, as well as announcing changes at outreach opportunities.*

- 4. Recommendation:** Upon reviewing the list of workshops in the program descriptions, the COV felt that these workshops were somewhat narrowly focused, perhaps based on the expertise of the workshop PIs. Moreover, the COV was not able to access reports from some of the workshops and, therefore, could not assess the outcomes in terms of any emerging research opportunities that were identified. Since engagement of the broader research community is vital for identifying emerging research, the COV suggests that the division develop a coherent strategy for such proactive efforts and also broadly disseminate the main discussion thrusts to the research community. (Section III-2)

The COV encourages CMMI to improve dissemination of program agendas, priority research areas, and the overall portfolio approach. Community-wide workshops or, preferably, the grantees conference could be leveraged to improve communication and address these issues. (Section IV-2)

Response: *CMMI agrees with the COV and continues to promote dissemination of CMMI's programs and priority research areas through the website, workshops, and outreach activities. CMMI management will encourage PDs to work with PIs to seek input from the broader community in workshop planning consistent with the intended goals of the workshop. CMMI will modify its guidance on workshops to clarify that PIs are expected to post workshop reports on a public website*

and to make them accessible for a minimum of two years. CMMI will create a section for CMMI-sponsored workshops on the web page and will post links to the workshop reports, as appropriate. A CMMI grantees workshop has been proposed to ENG and is under consideration by the Engineering front office. CMMI also uses a variety of existing vehicles for providing information to the community, such as list serves and in-person PD outreach.

- 5. Recommendation:** The COV strongly recommends re-implementing the CMMI grantees conference as an effective measure to address the need for Program Director visibility within the research community.

Response: *CMMI agrees that the grantees conference holds benefits in terms of seeding collaboration between PIs, allowing program directors to interact with awardees, educating PIs and their students on best practices for research management and broadening participation. CMMI has recently put forward a proposal for reinstatement of the CMMI grantees conference.*

V. Portfolio

i. Award Size and Distribution

- 1. Recommendation:** There is a trend toward somewhat fewer, somewhat larger awards, although smaller awards persist.¹ There also appears to be a trend toward encouraging and awarding more cooperative research projects involving multiple institutions, which the COV commends as a way to both achieve a substantial level of effort to support difficult and important research problems and at the same time broaden participation. The COV recommends that the CMMI division assess the effectiveness of these projects in terms of actual collaboration and results and attempt to identify collaboration success predictors. In summary, the COV believes that the current mixture of award sizes is appropriate and the emphasis on student support, broad participation, and project scope and depth should persist. However, it is also important to monitor the average annual award size relative to the rising costs of university research and student support. (Section IV)

Response: *CMMI is sympathetic to the tension between the rising costs of university research, the increasing numbers of faculty (and proposals), the benefits of collaborative research, and CMMI budget increases that have not kept pace with those needs. CMMI will continue its current award size practice, taking into account, to the extent possible, increasing budgetary needs for student support, broad participation, and project execution. CMMI also recognizes that sustained research and collaborative research leading to significant advances in knowledge may require larger, longer awards, and the division will experiment in a very limited fashion with introducing this funding opportunity to its unsolicited research competition. CMMI agrees that defining, measuring, and*

¹ CMMI 2015 COV Data Book, Table 4: Average Award Size and Duration of CMMI Competitive Awards, FYs 2005-2014 (EIS Award Size Duration Report), p. F-24.

predicting meaningful collaboration is a valuable goal, but is sensitive to the difficulty in achieving this, especially in fundamental research, and especially in the near term.

- 2. Recommendation:** The COV notes that the CAREER award distribution is somewhat concentrated with respect to receiving institutions. Five universities received more than 20% of all CMMI CAREER awards over the three-year assessment period and Very High Research institutions received 78% of the funds.² CAREER award proposal success rates vary dramatically across institutions (from 0% to 36% among the top institutions by number of submitted proposals).³ The COV recommends that the CMMI continue and strengthen efforts at the institution level to help broaden the success of CAREER proposal efforts. For example, it may be helpful to compile best practices for mentoring and preparing CAREER proposals and to share these best practices across all universities/institutions. (Section IV)

Response: *CMMI will continue to hold a CAREER proposal writing workshop in which potential PIs are able to ask questions regarding CAREER guidelines, interact with NSF program directors and participate in mock panels. Workshop applicants from underrepresented demographic categories as well as institutions have been well represented at the workshops. CMMI has identified best practices for preparing CAREER proposals from the perspective of the PI, which are shared during the proposal writing workshop and on the CMMI website. However resources are not available at this time to compile best practices from the perspective of the institution. Additionally, efforts are being made to use CAREER success rates along with other characteristics to target institutions for outreach activities.*

ii. Large-scale research infrastructure investment

- 1. Recommendation:** The usual approach has been to engage commercial partners in maintaining infrastructure investments in broadly conceived public/private partnerships, but private companies may not be consistently able or willing to accept that role. Long-term maintenance of infrastructure becomes especially challenging because, if it is denied or delayed in large-scale investments, the benefit of the original investment may be lost or the leadership of US science and engineering may be superseded by other nations willing to make that investment.

One alternative may be for the NSF to broaden its effort to create partnerships with other federal agencies in maintaining infrastructure investments, as it has done successfully with the Natural Hazards Research and Application Center at the University of Colorado, Boulder. A second alternative may be for NSF or the infrastructure host institution to engage private philanthropic foundations, such the Carnegie Foundation or the Rockefeller Foundation, in a shared effort to

² CMMI Division Overview, CAREER Award Profile 2010-2015table, slide 27.

³ CMMI 2015 COV Data Book, Figure 29 CMMI CAREER Proposal Load, Success Rate and Award Funding by Institution, FY 2012 – FY 2014, p. F-30.

support the maintenance of research infrastructure that addresses fundamental issues of public interest. (Section IV)

Response: *CMMI will explore NSF practices for collaborating with other agencies and the private sector for ongoing support of research infrastructure.*

- 2. Recommendation:** As fundamental questions of science and engineering become increasingly complex and global, the need to frame a research agenda that stretches beyond national borders is essential. Questions such as the search for safe energy, clean water, clean air, and the design of resilient, sustainable communities cannot be addressed by a single nation alone. The example set by NASA working in collaborating with other nations to design and create international partnerships that enable the construction of the large-scale infrastructure required for global space exploration offers a constructive alternative. Space exploration is only one example of fundamental research that benefits from the participation of international partners in the design, development, and maintenance of large-scale research infrastructure. (Section IV)

Response: *CMMI supports collaboration with foreign researchers in which each country supports its own research effort. NSF's new head of the Office of International Science and Engineering is developing guidelines for international research consistent with the goals and mission of NSF under the direction of Director Cordova. CMMI will determine its actions and opportunities when those guidelines are completed and shared across the Foundation.*

- 3. Recommendation:** In a larger sense, a fundamental challenge for the NSF is to anticipate the major research questions of the next 20, 50, and 100 years, and design and adapt its research infrastructure to address the increasingly complex issues that are essential to maintain and sustain the planet under the strain of a burgeoning population and fragmentation of local norms and values. The use of exploratory workshops and interdisciplinary venues for iterative processes of discovery, validation, and documented information exchange could become an essential element of identifying the next set of issues for research investment and the socio-technical infrastructure needed to support continuing inquiry and learning. (Section IV)

Response: *CMMI agrees with this challenge and will continue to address it.*

iii. Emerging research challenges and opportunities

- 1. Recommendation:** Opportunities exist for CMMI to participate in a number of emerging research areas. As Dr. Goodings outlined in her presentation to the COV on May 12, 2015, emerging research opportunities and challenges for CMMI lie in advanced manufacturing, understanding the brain, infrastructure engineering for multi-hazards, smarter cities, smarter health, international, and best practices for broadening participation. In fact, CMMI is already participating in cross-cutting initiatives related to some of these areas, e.g., Scalable Nanomanufacturing (SNM) and Critical Resilient Interdependent Infrastructure Systems and Processes (RIPS/CRISP). The COV agrees that

the identified topics are important and timely opportunities and endorses CMMI's efforts and participation in these areas. Additional opportunities to consider are in the areas of the materials genome initiative and applications of engineering in the service economy.

Advanced manufacturing has received much recent attention and activity, including support by the White House⁴. It is expected that this area, including obtaining a fundamental understanding of additive manufacturing and its most appropriate application domains, will continue to expand. CMMI is in an excellent position to take the lead due to its focus on advanced manufacturing. (Section IV)

Research funded by CMMI plays a central role in the advancement of national priorities for domestic manufacturing, the mitigation of evolving hazards, and the development of systems-based solutions for a range of techno-societal issues. CMMI is uniquely positioned to chart a national course for resiliency and sustainability in the 21st century. (Section IV)

Response: *CMMI endorses the COV sentiment and continues to play a lead role in initiatives for advanced manufacturing, next generation materials, multi-hazard, smarter cities and other key areas in the CMMI portfolio and to participate actively in NSF cross cutting initiatives and activities to broaden participation. In addition to these areas of emphasis, CMMI is supporting push topics in the areas of CyberManufacturing, multi-scale and multi-physics (research that bridges length and time scales to apply fundamental physical principles to understand and predict bulk mechanical properties of material systems), and systems engineering.*

VI. CMMI Leadership Opportunities

- 1. Recommendation:** The COV found that CMMI is in an excellent position to take the lead in NSF with respect to advanced manufacturing, including obtaining a fundamental understanding of additive manufacturing and its most appropriate application domains (Executive Summary).

Response: *CMMI recognizes the importance of advancement in manufacturing as a national priority and currently houses three core programs within an advanced manufacturing cluster: Materials Engineering & Processing (MEP), Manufacturing Machines & Equipment (MME), and NanoManufacturing (NM). These programs have awarded over \$150M in research funding in the past 4 years. Additionally, CMMI will continue to lead and contribute to cross-divisional efforts including Scalable NanoManufacturing (SNM), CyberManufacturing, and Designing Materials to Revolutionize and Engineer our Future (DMREF). CMMI will also continue to take efforts to lead in the area of additive manufacturing by supporting workshops to identify research priorities. Recent workshops in this area include: Additive Manufacturing for Health, The United States and Germany Collaborative Research in Advanced Manufacturing, Finding Pathways from NSF-funded Basic Research to DOE-funding Applied Research on Additive Manufacturing, Advanced Manufacturing for*

⁴ <https://www.whitehouse.gov/administration/eop/ostp/pcast/docsreports>

Smart Goods, Advanced Manufacturing for the Oil and Gas Energy Industry, and Environmental Implications of Additive Manufacturing.

- 2. Recommendation:** The COV found that CMMI is uniquely positioned to lead in the areas of addressing socio-technical issues through research in the mitigation of hazards, resiliency and sustainability (Ex. Summary).

Response: *CMMI agrees with the COV and will continue to serve as a leader in these areas. CMMI currently houses five core programs within the resilient and sustainable infrastructure cluster: Civil Infrastructure Systems (CIS), Geotechnical Engineering and Materials (GEM), Structural and Architectural Engineering, Infrastructure Management and Extreme Events (IMEE), and Engineering for Natural Hazards (ENH). These programs have awarded over \$140M in research funding in the past 4 years. Additionally, CMMI supports large-scale research infrastructure through the Natural Hazards Engineering Research Infrastructure (NHERI) and will continue to lead and contribute to cross-divisional efforts including Critical Resilient Interdependent Infrastructure Systems and Processes (CRISP), Interdisciplinary Research in Hazards and Disasters (Hazard SEES) and Coastal Science, Engineering and Education for Sustainability (Coastal SEES).*

- 3. Recommendation:** The COV found that CMMI has the opportunity to take a leadership role with respect to broadening participation efforts within mechanical engineering. Citing the growth of the discipline along with low participation among underrepresented groups, the COV recommended identifying best practices and partnering with related efforts for broadening participation (Ex. Summary, Section IV-4).

Response: *With respect to broadening participation in departments of mechanical engineering, CMMI looks to the Engineering Education and Centers Division for leading innovation in this given their primary responsibility for ENG's engineering education activities. However CMMI pledges to be alert to opportunities that support those efforts.*