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THE ENGINEERING RESEARCH CENTERS AND THEIR EVALUATION

Cross-Disciplinary Engineering Research Committee
Commission on Engineering and T chnical Systems
National Research Council (U.S.)

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CROSS-DISCIPLINARY ENGINEERING RESEARCH COMMITTEE

Background and Purpose

The Cross-Disciplinary Engineering Research Committee of the National Research Council has been providing assistance and advice to the National Science Foundation's Division of Cross-Disciplinary Research, with respect to the Engineering Research Centers (ERCs) program, almost since that program's inception. An early committee activity involved advising the division on criteria and mechanisms that might be used to evaluate the ERCs. That study resulted in a report, *Evaluation of the Engineering Research Centers* (October 1986), aimed at the crucial third-year review of the first six centers. The committee's recommendations were also used experimentally as a basis for the second annual assessment of those centers.

The division concluded its second-year reviews (one of which was attended by the chairman of the committee) in early 1987. At a meeting in March 1987, division staff summarized informally for the committee the results of that assessment and their findings with regard to the review process itself. They also described a proposed new pattern for making continuing-funding ("refunding") decisions.

The purpose of this report is to convey to the National Science Foundation (NSF) the reactions and further recommendations of the committee with regard to ERC evaluations.

Findings and Recommendations

First, the committee must make some general observations. It notes from the summary of results of the second-year reviews that the most prevalent types of problems found in the centers are managerial and organizational ones. (Three of the four centers in which significant problems were noted at the second-year reviews had these types of problems.) This observation highlights the importance of the nontechnical aspects of an ERC in facilitating its success in technical areas. The review teams found all center directors struggling to solidify the position of the centers within their universities. This pattern is reflected in the fact that, although many faculty are involved in each center, typically only the director and a few others have a firm understanding of, and commitment to, its direction and goals.

Clearly, the ERCs are still in an early stage of development; they are causing change and are also themselves changing. Therefore, the committee reiterates its primary conclusion set forth in the earlier report*—that is, that the evaluation of the ERCs be as constructive as possible, and that it be conducted in such a way that it improves the centers' chances of success. Along the same

* *Evaluation of the Engineering Research Centers* (October 1986).

lines, the NSF must be careful, in general, to avoid "overmanagement" of the centers. The administrative load placed on ERC staff by the evaluation process should be kept as light as possible while still meeting the requirements of a thorough and fair appraisal.

PROPOSED NEW REFUNDING PLAN

The proposed new pattern calls for making a "yes" or "no" decision on funding continuation at the third-year review. "Yes" means that a new 5-year commitment of funds will be made by the NSF (with a similar review at the sixth year); "no" means that funding will be provided for only 2 more years, through the fifth year.

The committee is concerned with the black-and-white nature of this plan. Evaluating research quality during a short time frame can be a subtle matter; evaluating the potential contribution of research to economic competitiveness, over a short period, is nearly impossible. Progress in research will inevitably vary from area to area, and from center to center; indeed, it is partly serendipitous in nature. As stressed in its previous report, the committee believes that 3 years (actually 2.5) is in most cases too short a time in which to judge research accomplishments. The existing centers already represent too large an investment to take any chance of wasting a potential return. However, the committee also recognizes that wherever clear failures can be identified, whether on the basis of research, management, or a combination of areas, the NSF must cut its losses.

Therefore, the committee *recommends* that a third option be established at the third-year review. That option would be to put the center on probation, pending specified improvements, with a final yes or no decision deferred until the fourth year. Funding would then be cut after the *sixth* year if the ultimate decision is negative. The rationale for recommending an additional year of funding in this case is to give the center a 2-year period after the negative decision is made in which to wind down operations or to adjust to greatly reduced funding. One year is too abrupt a cutoff, given the commitments a center will have made to faculty, students, and industries.

COMPOSITION OF REVIEW TEAMS

In the earlier report, the committee recommended that the ERC evaluation teams be made up of five to seven individuals from academe and industry, with a range of skills and knowledge relevant to the task at hand. It specified that the team not include any NSF personnel.

Based on the experience of the second-year assessment, and on discussions with NSF staff, the committee *is persuaded* of the value of having an NSF presence on the review team. This person could function as both an observer and a reference point. Specifically, the NSF staff member could help to keep a continuous focus on the real goals of the evaluation and the criteria for accomplishing it; this should ensure consistency in the reviews across the centers. Furthermore, the NSF would have a greater assurance that the evaluation report is accurate if a staff member were present during the evaluation and discussions.

PREPARATION OF REVIEW TEAM MEMBERS

A common problem during the second-year assessment was the fact that many reviewers had a poor understanding of the nature of cross-disciplinary research. As a result, during the reviews they tended to revert to a disciplinary viewpoint in discussions with the ERC researchers. Another difficulty was that many reviewers were not familiar enough with the features of the original center proposal to evaluate the center on the basis of its prior plans and promises.

To provide more orientation and a better understanding of the cross-disciplinary aspects of the center's research, the committee *recommends* that the NSF bring the review team together beforehand for approximately one-half day of formal preparation. In addition, it would be helpful for the evaluation team to include one or more members of the original proposal review panel.

NEED FOR UNSTRUCTURED TIME

Within the 2 days allotted for site visits there is necessarily a great emphasis on formal presentations and structured group discussions. Little time remains for informal, task-oriented interviews with center staff, students, and industrial affiliates. However, such

close individual contacts are essential to give reviewers an authentic sense of how the center functions, how it is viewed, and so on. The committee therefore *recommends* that time be allotted for such unstructured contacts.

It is clear to the committee that, given the need for both reviewer orientation *and* unstructured interviews, 2 days is not enough time to conduct a thorough site visit. It recognizes the difficulty of obtaining even 2-day time commitments from busy individuals. The committee must point out, however, that the national importance of the ERC program makes it imperative that the reviews not be rushed. If it is not possible to devote more than 2 days to the site visit, then careful compression of some of the formal presentations might afford additional time.

HANDLING OF EVALUATION CRITERIA

Using a combination of the committee's earlier report,* the Cooperative Agreement with the ERCs, and the ERC Program Announcement, the staff of the Division developed a list of evaluation criteria for the centers. These were the criteria the staff used in conducting the second-year assessments. A question arises as to whether the ERCs should be provided with these criteria (as revised) prior to the third-year evaluation. There is a concern that, armed with the criteria, centers could misrepresent their activities and programs to place them in a more favorable light. Nevertheless, the committee *recommends* that the NSF send the criteria to the centers before the evaluation. Having the criteria in hand will simply permit the centers to organize their own preparations and presentations in a more efficient manner. The committee feels confident that misrepresentation will not be a significant factor.

HANDLING OF PROSPECTIVE PLANNING PROPOSAL

During the third-year review the NSF intends to ask each center to prepare a "prospective planning proposal" for its activities during the next 5 years. This document would include the center's goals, its strategy for meeting these goals, and an estimate of the resources required. It would contain a minimum of boilerplate and background justification, and would be used as one basis

* *Evaluation of the Engineering Research Centers* (October 1986).

for the refunding decision. The Committee *recommends* that the NSF obtain this proposal from the centers in advance and provide responses and comments back to the centers prior to the site visit.

It should be noted that the requirement to address future plans in detail will add even more time to the site visit.

REWARD STRUCTURE FOR CROSS-DISCIPLINARY RESEARCH

Some people believe that the question of tenure and promotion for those engaged in cross-disciplinary research is a critical issue in the prospects for long-term success or failure of the ERCs. In some institutions, untenured faculty believe that they devote themselves to research in such centers only at some risk to their careers. As a result, such faculty participate only nominally in the real thrusts of the center, while maintaining strong ties to their disciplinary departments and depending on the departments for advancement. Yet, if the ERCs are to succeed, it is imperative that there be enough focus on their research activities and goals to enable them to operate effectively.

This problem is a tricky one for the NSF; it is inappropriate for the Foundation to dictate to the ERCs on the critical issue of tenure within universities. However, the NSF can ask for statements of intent in this regard. In the first-year selection process, for example, the NSF asked (after the selections had been made) for letters of commitment from universities with respect to the reward structure for cross-disciplinary research. Although it would be preferable to have such statements in the proposal itself, it is probably not permissible to include the policy on these matters in the contract with the university.

It is thus very difficult to handle this issue as an element of evaluation. Some members of the committee feel that the NSF should not make a 5-year continuing funding decision without addressing it. How to do so directly is not apparent. For the time being, the committee can only *suggest* that the NSF be vigilant in observing the progress of young faculty members through the ERCs and in seeing that the faculty evaluation process is fair. That is, the NSF should make it clear that the Foundation will post-audit the ERC faculty without attempting to prescribe how universities should deal with the issue. The committee also plans

to conduct a workshop on this subject in the spring of 1988, and soon will convey to the NSF the results of that meeting.

DISTRIBUTION OF FUNDS

The committee notes signs of a tendency for some ERCs to function as "little NSFs" with respect to the distribution of center funds, parceling out those funds among the separate engineering disciplines and departments. This practice runs counter to the goals of the ERC program; it detracts from the intended system-oriented, cross-disciplinary nature of ERC research. The Committee therefore *recommends* that the evaluation include careful consideration of the pattern of fund distribution by center management. Accordingly, the NSF should request from the center, in advance of the site visit, a complete summary of its expenditures, by recipient (faculty member and project), since the center's initiation.

EDUCATION PROGRAMS

The development of education programs involving both graduate and undergraduate students is a major element of the ERC concept and goals. The involvement of students in cross-disciplinary research and in the codification of new knowledge into courses, seminars, and textbooks has been clearly set forth in each Program Announcement as a prominent requirement, and all successful ERC proposals have specified plans for achieving this objective.

However, the committee has seen indications that the education programs in some ERCs are not developing as well as expected. A survey of the first 11 centers, the results of which were summarized at the meeting of the American Society for Engineering Education in June 1987, showed that 5 out of the 11 centers had fewer than 10 undergraduates directly involved in the center during the regular school year. The number of new graduate courses that could be traced to the center is in some cases quite small (or zero), whereas in most cases fewer than three undergraduate courses have evolved and no textbooks have been initiated as a result of center activity. Only two of the thirteen centers say that their best students are applying to work with the center.

Although the committee recognizes that these activities and trends often take more than 2 years to develop satisfactorily, it is

troubled by the statistics. Therefore, the committee *recommends* that the review team focus carefully on the substance, scope, and quality of the center's education program. Specific qualities and characteristics are set forth in the criteria that each center will have been provided, and the center should be able to describe the nature and progress of its program in considerable detail.

COMMUNICATION AND INTERACTION

Because the ERCs are expected to function as agents of cultural change within academe, it is important for the evaluation to consider the amounts of interaction and communication the ERCs foster among participants from different departments. Collocation of faculty and graduate students working in the center is the ideal way to facilitate this. However, temporary scheduled collocation, joint seminars, and other forms of interaction can also stimulate effective interaction.

Communication with the university as a whole is another element of the "cultural mission" of the centers. One point to be noted with regard to the expenditure of center funds is that the director should have enough flexibility in the expenditure of funds to permit this and other forms of proselytizing. Furthermore, the nature of the interaction between the center and industry should be assessed from the standpoint of communication. The key element is the *quality* of the dialogue between them. Admittedly this is a subjective matter, but it should not be difficult to obtain a clear impression from interviews with participants, especially the industrial representatives.

Summary

The primary objective of the third-year evaluation should be to verify that the center is making strong progress toward meeting its long-term, overall goals. In its presentations to the review team the center should be quite specific about what it is doing and what it plans to do—in research, in education, and in its interactions with the industrial and academic communities.

Central to the evaluation must be a focus on the quality of the research and teaching. One of the expectations must be that the ERCs will enhance the intellectual content and technical excellence of the nation's academic engineering programs. Such excellence is central to the goal of the ERCs—defined by the NSF as ". . . providing fundamental knowledge which can contribute to the solution of important national problems, and for preparing engineering graduates with the diversity and quality of education needed by U.S. industry."

However, it is important for the reviewers to realize that a program of leading-edge research often takes some time to jell. The length of time required varies according to many factors, including the nature of the research and the degree of momentum present when the center was formed. It will also take time for the center directors to winnow out the center faculty who are merely

"along for the ride" and create a staff that is fully committed to the principles and goals of the ERC program.

Over the long term, evaluation of the ERCs should determine whether the centers are producing better engineers who through superior engineering practice will enhance the international competitiveness of U.S. industries. Such evaluations, however, can only be made over the course of a decade or more, as ERC-trained students graduate and make their mark on the nation's engineering enterprise. In the time frame of 3 years, the reviewers can only attempt to judge progress in that direction.

Lastly, it will take time to graft the center firmly onto the body of the university, and to solve the problems of institutional support and acceptance that any organization inevitably faces when it challenges the academic status quo. Taking these considerations into account will demand a well-prepared review team ready to devote the amount of time necessary to produce a fair and in-depth evaluation of these fledgling centers.