Report

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HIGHLIGHTS

A New Vision for Center-Based Engineering Research

The future security, economic growth, and competitiveness of the United States depend on its capacity to innovate. Today, the United States faces a complex set of global challenges: threats to the environment, threats to national security, disruptive changes in the workforce, new diseases and health risks, and a rapidly changing world economy and competitive landscape. To help address these problems, the United States can draw upon recent advances in materials, information, robotics, energy, transportation, manufacturing, and health. As these fields of research continue to develop and expand, the lines separating them are increasingly becoming blurred through a phenomenon called "convergence." Finding solutions to the most complex problems we face requires multidisciplinary research teams capable of capitalizing on this convergence.

The National Science Foundation (NSF) recognized the importance of this multidisciplinary approach to research when it initiated the Engineering Research Center (ERC) program over 30 years ago. The ERCs are "interdisciplinary, multi-institutional centers that join academia, industry, and government in partnership to produce transformational engineered systems and engineering graduates who are adept at innovation and primed for leadership in the global economy." ERCs are credited with producing over twelve thousand engineering graduates with interdisciplinary training and entrepreneurial skills, as well as hundreds of millions of dollars of regional and national economic benefits.

NSF is well aware that the world has changed in dramatic ways in the past 30 years. To ensure that the ERCs continue to be a source of innovation, economic development, and educational excellence, NSF commissioned the National Academies of Sciences, Engineering, and Medicine to undertake a study to articulate a vision for the future of NSF–supported center-scale, multidisciplinary engineering research. ***The National Academies' primary recommendation is that NSF should re-invigorate the ERC concept by addressing grand-challenge-like problems whose solutions offer the greatest benefit to society. These ERCs should use the best team-research and value-creation practices, have fewer administrative burdens, and make the investments needed to attract superb, diverse talent.***

Today's ERCs are targeted fairly narrowly on specific technology areas. In this report, the National Academies propose a strategic new direction for the program focused on addressing big, high-impact societal or technological needs. Moving in this direction will raise new issues associated with leading and managing the diverse research teams needed, and it will require a disciplined, systematic effort to ensure that the teams work in concert. These needed improvements in performance could be accomplished by adapting team-research and value-creation best practices, such as those currently used by Defense Advanced Research Projects Agency (DARPA) and top U.S. companies, to a multidisciplinary university center environment.

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NSF funding of ERCs, which amounts to between $3 million and $5 million per center per year, was significant in the mid-1980s, but has declined in real value by almost a factor of three since then due to inflation. At the same time, administrative and reporting burdens on the ERCs have increased. Because the proposed new centers would tackle bigger, more complex problems and likely have more diverse research teams, it follows that their budgets would be larger than those of current ERCs. By placing bold bets on a small number of well-funded, prestigious centers focused on engineering solutions to society's greatest challenges, NSF will create excitement in engineering and scientific communities that will attract the best students, faculty, and industry partners. To emphasize the ambition and the new direction of these center-scale investments, they should be given a new name, possibly Convergent Engineering Research Centers (CERCs).

There may be no optimal, one-size-fits-all structure for CERCs. In this report, three possible models are identified that NSF may want to consider.

- **Grand-challenge-based model.** This type of CERC would be based on finding engineering solutions for an interdisciplinary issue with far-reaching societal impacts. The National Academy of Engineering has identified fourteen of these grand challenges, including "advancing personalized learning" and "providing access to clean water".
- **Prize-based model.** In this model, NSF would oversee a new generation of technology innovators hoping to be the first team to achieve competition milestones and claim a cash prize. The example discussed in the report is Elon Musk's Hyperloop Pod Design Competition.
- **Federal-state-local partnership model.** This model would tap the genius of a broad cross-section of the research community to stimulate local or regional innovation, on topics such as developing practical approaches to dealing with the joint issues of sea level rise and extreme weather events for coastal cities.

This set of funding models is by no means comprehensive, but all focus on big, complicated problems whose solutions will bring large societal or economic impacts. They depend on the convergence of disciplines and on collaborative, diverse research teams. And they will require the resources of the National Science Foundation (NSF) to be combined with those from other sources, including other federal agencies, states, international collaborators, and the private sector.

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