

A PROPOSAL TO ASSESS THE CAPACITY OF THE U.S. ENGINEERING RESEARCH ENTERPRISE TO MEET THE FUTURE NEEDS OF THE NATION

Summary

The National Academy of Engineering (NAE) proposes convening a panel of engineering leaders to conduct a “fast-track” assessment of (1) the past and potential future impact of the U.S. engineering research enterprise on the nation’s economy, quality of life, security, and global leadership, and (2) the adequacy of public and private investment to sustain U.S. preeminence in basic engineering research. A two-decade decline in the share of federal R&D investment accounted for by engineering, and the perceived erosion of basic, long-term engineering research capability in U.S. industry and federal laboratories, pose serious questions about the long-term health of U.S. engineering research. To address these concerns, this nine-month initiative will document and evaluate recent contributions of U.S.-based engineering research to the nation’s interests, assess its potential contribution to emerging national challenges and opportunities, and outline a national strategy for ensuring that the engineering research foundations of American global economic, military, scientific, and technological preeminence remain rock solid in the face of rapid, often disruptive, societal and global change. An NAE panel will put forward findings, recommendations, and a national action plan designed to engage all major constituents of the U.S. engineering enterprise.

By month six, the NAE panel will circulate the report to a broad cross-section of the nation’s engineering community for feedback and refinement. The panel will submit the final report to the National Science Foundation by month nine, and complete public dissemination by the end of the ninth month. The NAE requests \$290,953 in funding from the National Science Foundation to cover the estimated cost of the nine-month project.

Under the terms of Master Agreement No. 0239565, the National Academy of Sciences requests support for Assessing the Capacity of the U.S. Engineering Research Enterprise to Meet the Future Needs of the Nation. The work will be conducted by the National Academy of Engineering Program Office.

Background

In the past decade, NAE, engineering professional societies, and other members of the nation’s engineering community have invested considerable efforts and resources in increasing public understanding of engineering and how engineering has improved the quality of life and security of all Americans (NAE, 2002). These efforts have been documented as a history of astounding engineering achievements that have resulted in enormous societal benefits, from electrification to automobiles, highways, and airplanes to water supply and distribution systems to agricultural mechanization to modern communications and information devices and systems to health technologies and beyond (Constable and Somerville, 2003).

Looking ahead, future engineering achievements may have an equal if not more revolutionary impact on society (NAE, 2004). Researchers in engineering are on the verge of new frontiers.

The integration of vast computing power, massive data sets, and powerful simulation and analytic techniques will enable society to predict and control the behavior of the complex physical, biological, social, and environmental systems. Moreover, with emerging nanomanufacturing techniques, new materials and systems can be designed and constructed atom by atom. These new capabilities promise to remake the way people live, work, and interact.

Whether looking backward or looking forward, assessments of the impact of engineering reflect a broad array of engineering activities, from basic to applied research to development to design to production, distribution and marketing in these and other revolutionary technological achievements. Yet, the critical role of fundamental engineering research, which has laid the foundations for new technologies, new science, new products and services, is often overlooked.

Recent U.S. technological history is replete with examples of novel engineering concepts, designs, and inventions, often resulting from long-term basic engineering research undertaken without specific commercial objectives in mind, that have enabled the development of new technologies and ultimately led to multibillion dollar industries, helped create millions of new jobs, and benefited countless lives. Indeed, the U.S. capacity for fundamental engineering research has been essential to one of the defining strengths of the U.S. economy and defense base over the past century, namely, the nation's capacity for "breakthrough" innovation, for creating entirely new technologies and new industries, and with them new pillars of economic growth, prosperity, and national security. In network systems and communications, transportation and logistics, finance and insurance, and every other major sector of the economy, engineering research, often together with research from other fields, has sewn the seeds of innovation and growth. Even in the health sector, the results of basic engineering research have been critical to leveraging the nation's colossal investment in the medical and life sciences (NAE, 2003).

The Need for an Assessment

Despite this impressive history, there are reasons to be concerned about the continued vitality of the nation's long-term engineering research enterprise. The dramatic shift in the composition of federal R&D investment over the past two decades away from engineering has raised concern about the continued ability of basic engineering research to keep pace with, complement, and leverage the nation's large life science investment (Merrill and McGear, 1999). At the same time, there is growing unease with the perceived erosion of basic engineering research in industry and the decline of corporate laboratories, as well as the perceived decline in the basic, long-term research capacity of the national laboratories (DOE, 2003). In the face of intensifying global economic and technological competition, unprecedented international security and environmental challenges, and the rising capabilities of national engineering enterprises worldwide, the U.S. engineering community must take stock of the health and vitality of the nation's engineering research enterprise.

Goals and Objectives

To this end, NAE will undertake a "fast-track" assessment of the past and potential future impacts of the U.S. engineering research enterprise on the nation's economy, quality of life, security, and global leadership, and the adequacy of public and private investment to sustain U.S. preeminence in basic engineering research. The nine-month initiative will engage all major segments of the

engineering community¹: (1) to document and evaluate how recent contributions of U.S.-based engineering research has advanced broad societal objectives; (2) to assess the potential of engineering's contribution to emerging national challenges and opportunities; and (3) to outline a national strategy/road map to ensure that the engineering research foundations of American global economic, military, scientific, and technological preeminence remain strong in the face of rapid, often disruptive societal and global change.

Project Design and Work Plan

NAE President Wm. A. Wulf will appoint a panel of approximately 11 experts composed of engineering leaders from academia and industry to execute the study. Panel members will reflect a diversity of disciplinary and sectoral backgrounds, institutions, and regional perspectives. All of the panel members will be volunteers. Staff for the project will be provided by the NAE Program Office.

The expert panel, with the support of NAE staff, will hold three face-to-face meetings and multiple teleconferences during months one through five to review existing documentation, take testimony from expert witnesses, prepare a report with findings and recommendations for action, and develop and execute a plan for the dissemination and communication of the report to all major stakeholders in the nation's engineering research enterprise.

As part of their fact-finding effort, panel members and supporting NAE staff will prepare and/or commission several background papers and take testimony from experts on a range of topics:

- data and trend analysis concerning engineering research, education, practice, employment, and composition of the engineering workforce
- the evolving composition of federal and private-sector R&D funding, with a specific focus on investment in basic engineering research and its implications for the long-term health of the nation's engineering research enterprise
- the recent contributions and impact of particular fields of engineering research and development on economic growth, national security, quality of life, and other societal objectives
- the potential contribution of engineering to emerging societal opportunities and challenges and the changing priorities for engineering research and education

Drawing on its fact-finding activities and the expertise of its members, the panel will prepare a consensus report that includes findings and recommendations for action for all major constituents of the U.S. engineering enterprise. In parallel, the panel will develop a detailed plan for communicating and disseminating the findings and recommendations to the intended audiences. The primary audiences include the engineering community, broadly defined, which encompasses engineering educators, researchers and research administrators in industry, academia, and federal laboratories, and other leaders in industry, private foundations, and public R&D funding agencies, federal and state policy makers, and the general interested public.

¹ The engineering community encompasses engineering colleges, faculty, and students; government S&E agencies and laboratories; engineers in industry, both large and small; engineering societies; and nonprofit organizations and foundations.

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Report Review

The final stage of the process, that of review, will take place in month six. The report review falls under the auspices of an NAE-appointed Report Review Monitor (RRM). The task of the RRM is to vouch for the credibility of any written products by verifying that the board or panel has fully considered the evidence pertinent to the issue under review, that its conclusions and recommendations are supported by the body of the report, that the report is clearly written and responsive to the panel's charge, and that its level of discourse is appropriate for the intended audience.

Every NAE report is reviewed by individuals who are not involved in the authoring body's work. A report may not be released to an agency or the public until the RRM signifies that the institutional review process has been completed satisfactorily.

Reports resulting from this effort shall be prepared in sufficient quantity to ensure their distribution to the sponsor and to other relevant parties, in accordance with Academy policy. Reports may be made available to the public without restrictions.

Credentials of the NAE

The National Academy of Engineering is a nonprofit, nongovernmental society of distinguished engineers engaged in engineering, science, and policy research, and dedicated to the furtherance of engineering and technology and to their application in service to the nation. The NAE was established in 1964 under the congressional charter granted in 1863 to the National Academy of Sciences to advise the federal government on scientific and technical matters. The NAE executes its service to the nation in two primary ways:

- In concert with the National Academy of Sciences, its sister organization, the NAE directs and oversees the work of the National Research Council. The NAE was established under the congressional act of incorporation, signed by President Lincoln in 1863, that established the National Academy of Sciences to advise the federal government on scientific and technical matters. These activities are undertaken at the request of the federal government and supported by federal grants and contracts.
- Through the NAE Independent Program (Program Office)—a self-initiated program of studies, symposia, and public information activities—the NAE examines issues that are at the forefront of engineering and technology and their impact on society. The issues considered are those that will shape the future but that often extend beyond the current interests and agendas of relevant stakeholder groups. The work of the Program Office is supported with funds from the private sector, public sector, and NAE Fund.

The NAE's unique strength is its ability to call upon the *pro bono* services of its more than 2,000 peer-elected members and Foreign Associates—senior professionals in business, academia, and government who are among the world's most accomplished engineers. The NAE uses its convening abilities to bring together its members with other experts to address pressing issues of

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national and international concern and to communicate relevant findings to policymakers and the broader public by way of symposia, workshops, consensus studies, and published reports.

Over the past five years, the NAE has published more than 20 reports that have informed government policymakers, industry leaders, and university faculty and administrators about a wide variety of policy issues. These issues have included the effects of product liability law on the management of innovation in industry, the implications of recent trends in technological innovation and international competition for U.S. technology and trade policies, the potential of technological innovation for improving corporate environmental performance, the role and importance of small high-tech companies in the U.S. economy, the contributions of academic research to industrial performance, and cutting-edge developments in engineering and technology involving the nation's emerging engineering leaders.

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Federal Advisory Committee Act (FACA)

The Academy has developed interim policies and procedures to implement Section 15 of the Federal Advisory Committee Act, 5 U.S.C. App. § 15. Section 15 includes certain requirements regarding public access and conflicts of interest that are applicable to agreements under which the Academy, using a committee, provides advice or recommendations to a Federal agency. In accordance with Section 15 of FACA, the Academy shall submit to the government sponsor(s) following delivery of each applicable report a certification that the policies and procedures of the Academy that implement Section 15 of FACA have been substantially complied with in the performance of the contract/grant/cooperative agreement with respect to the applicable report.

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Public Information about the Project

In order to afford the public greater knowledge of Academy activities and an opportunity to provide comments on those activities, the Academy may post on its website (<http://www.national-academies.org>) the following information as appropriate under its procedures: (1) notices of meetings open to the public; (2) brief descriptions of projects; (3) committee appointments, if any (including biographies of committee members); (4) report information; and (5) any other pertinent information.

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Estimated Project Cost

The total estimated cost of this nine-month activity is \$290,953.