POSITION STATEMENT

MAINTAINING U.S. LEADERSHIP IN INNOVATION AND COMPETITIVENESS

Adopted by the IEEE-USA
Board of Directors, 20 June 2008

If the United States is to flourish in the increasingly competitive global marketplace, the federal government needs to focus on ways to improve and broaden the technical expertise of its citizens. IEEE-USA believes that effective competitiveness and innovation policies will sustain U.S. technological leadership and encourage the development of a skilled, creative and competitive work force so critical for U.S. prosperity. Developing such policies can be easily accomplished by better understanding the economic dynamics of Science, Technology, Engineering and Mathematics (STEM). This enterprise includes, for example, reliable statistics on the trends of the U.S. R&D work force; a planned consistent R&D budget; effective workforce incentives; and measures to increase productivity. Once STEM's operation is understood, burdensome government regulations can be eliminated and new laws can be written to increase the nation's R&D productivity and maintain its preeminence in an increasingly competitive global R&D environment, fueled by multi-national corporations.

The U.S. STEM enterprise is the gold standard and the foundation of innovation, competitiveness and economic growth -- not only in the United States -- but also in the global marketplace. To ensure that this continues, IEEE-USA recommends that Congress and the Executive Branch of the federal government work with private industry and academia to:

1. Maintain stable, consistent long-term federal funding of R&D
2. Ensure that the United States invests in the essential domestic human resources and capabilities necessary to lead in research, development and manufacturing technologies crucial to the U.S. economy and national security
3. Foster nationwide NSF-type centers of excellence to exploit regional assets through private and public sector investments, to bridge and accelerate the transition of R&D to the marketplace
4. Continue Small Business Innovation Research (SBIR) and Small Business Technology Transfer (STTR) programs
5. Enact a permanent R&D business tax credit, for industrial research and industrial support of university R&D performed in the United States

6. Reform federal and state regulations to promote historic U.S. risk-embracing innovative technical culture
7. Ensure a strong high-tech work force through educational and employment-based immigration reforms
8. Provide incentives to support and encourage venture capital firms to fund U.S. start-up companies and discourage off-shoring
9. Educate the next generation of Americans to ensure a pool of the best and brightest scientists, technologists, engineers and mathematicians
10. Measure and monitor the economic health of the STEM enterprise by indicators such as employment, unemployment, underemployment, and volume of off-shored STEM jobs and tasks
11. Strengthen embassy science attaché offices to monitor foreign developments in R&D, and to facilitate interaction with the U.S. R&D community

This statement was developed by the IEEE-USA Research and Development Policy Committee and represents the considered judgment of a group of U.S. IEEE members with expertise in the subject field. IEEE-USA advances the public good and promotes the careers and public-policy interests of the more than 215,000 engineers, scientists and allied professionals who are U.S. members of the IEEE. The positions taken by IEEE-USA do not necessarily reflect the views of the IEEE or its other organizational units.

BACKGROUND

Research and Development (R&D) are recognized as the key drivers of economic growth and the lifeblood of national innovation and competitiveness. Economists estimate that up to half of the U.S. economic growth in the last five decades is due to advances in technology. The Bureau of Economic Analysis reports a return on investments of more than 15 percent on R&D.[1] Advances such as integrated circuits, computer science, electro-optics and signal processing have created new markets, including information technology, the internet, computer-aided design and manufacturing, laser technology, Global Positioning Systems, and high technology medical diagnostic equipment. The national technology-based economy is becoming increasingly global, fueled by advances in information technology and telecommunications, and efficient transportation systems. Much of the semiconductor microelectronic and consumer manufacturing has moved off-shore. Now R&D is becoming "globalized," losing its national identity. In spite of its strong R&D infrastructure, the United States is part of this R&D globalization.

The Institute of Electrical and Electronics Engineers - United States of America (IEEE-USA) is cognizant of the potential for the loss of national innovation driven by the off-shoring of U.S. research and development (R&D). The U.S. R&D investment at 2.66 percent of the gross domestic product (GDP) is below that of Sweden at 3.98 percent, Finland at 3.48 percent, and Japan at 3.15 percent. Although China's R&D investment is only 1.44 percent of its GDP, it and India are increasing R&D investment in the coming decade. European and U.S. industries off-shoring R&D are fueling India and China's increase in R&D investments.

[1] Bureau of Economic Analysis/National Science Foundation: "R&D Satellite Account: Preliminary Estimates," Okubo, Robbins, et al.

The United States Research and Development (R&D) industry can be divided into three components: Basic, Applied and Development. The Office of Management and Budget (OMB) defines these as follows[2]:

> *Basic Research* is defined as systematic study directed toward fuller knowledge or understanding of the fundamental aspects of phenomena, and of observable facts without specific applications towards processes or products in mind. Basic research, however, may include activities with broad applications in mind.
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> *Applied Research* is defined as systematic study to gain the knowledge or understanding necessary to determine the means by which a recognized and specific need may be met.
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> *Development* is defined as systematic application of knowledge or understanding, directed toward the production of useful materials, devices, and systems or methods, including design, development and improvement of prototypes and new processes to meet specific requirements.

The R&D portfolio of basic, applied and developmental research is $312 billion, of which the federal portion is 31 percent, and industry is 69 percent. **(See Table 1.)** Industry provides 90 percent of developmental research, 62 percent of applied research, and 16 percent of basic research. Despite the potential for the industrial developmental portion of the nation's R&D portfolio being off-shored, the United States can still maintain its global leadership in science, technology and innovation.

Table 1. R&D Portfolio of Basic, Applied and Developmental Research

Character	Industry (millions)	Total dollar sector value (millions)	Industrial percentage	Percent of net industrial sales[3,4,5]
Basic	$9,551	$58,356	15.9	0.43
Applied	$35,975	$66,364	61.8	1.62
Development	$168,939	$187,349	90.2	7.59
TOTAL	$214,465	$312,069	68.7	

The characterizations of the R&D Industry as Basic, Applied and Development are not unique. The R&D Industry can be also differentiated according to sector; i.e., federal, commercial, academic; or by Area; i.e., natural sciences, life sciences, engineering, mathematics, etc.

The national basic research (BR) portfolio, amounting to $58,356 million dollars is spread among academic and national federal laboratories, and to some extent, industrial laboratories. Some of these monies are spent on international projects, such as international satellite missions, the Department of Energy's contribution to the International Thermonuclear Experimental Reactor and a multitude of others. Because of strict grant and proposal requirements, it can be

[2] OMB Circular No. A–11 (2006), Section 84, pg 8-9
[3] These are net sales for high technology industries; automotive manufacturing, chemicals, computer/electronics and related services, aerospace/defense and R&D services and excludes pharmaceutical companies.
[4] NSF Science & Engineering Indicators: 2006 page 4-17, Table 4-4.
[5] Based on year 2003 domestic net sales of $2,224,473 million.

assumed that the federal portion of the BR budget has low probability of being "off-shored." The remainder, 15.9 percent or $9,551 million dollars[6], is at the discretion of industrial policy-makers to be off-shored.

The national applied research portfolio is also spread among academia, national federal laboratories and industrial laboratories. Of the total of $66,364 million, $35,975 million, or 61.8 percent, is funded by industry,[7] and is potentially available for off-shoring.

Finally, 90.5 percent of the national developmental portfolio or $168,939 million is funded by industry,[8] which includes the application of knowledge directed toward the production and manufacturing of useful materials, devices and systems or methods, and the design, development and improvement of prototypes and new processes.

Several factors have contributed to the gradual off-shoring of the industrial R&D portfolio. Advances in applications of computer and telecommunication technologies have internationalized the task of performing R&D. Because of lower labor costs, a favorable business climate, less restrictive environmental and occupational health, and safety regulations and tax incentives in developing countries, multinational and U.S. companies are enticed to establish off-shore R&D sites to exploit these economic factors. Developing countries, driven by this new found asset, are increasing their investments in their R&D infrastructure and in the production of homegrown scientists and engineers. Although China's R&D investment, at 1.44 percent of its GDP, is well below that of the United States, it and India are substantially increasing R&D investments in the coming years. At the same time, the United States and Europe and industries are increasing their R&D investment in China and India.

In 1975, China produced almost no Science & Engineering (S&E) doctorates. However, between 1995 and 2003, first year Ph.D. students in China increased by a factor of six, from 8,139 to 48,740. If this growth continues, China will produce more S&E doctorates than the United States[9] Overall, the U.S. share of world S&E Ph.D.s will fall to about 15 percent by 2010. Nonetheless, the character, quality and expertise of U.S. S&E graduates exceeds that of other developing nations, such as China.

Some argue that R&D productivity depends on the number of S&E workers applied to a problem. This misguided logic implies that doubling the number of engineers on a project leads to a greater business advantage and productivity. "But the way a country organizes its R&D and the connection between research activities and business is also likely to affect productivity. The close ties between U.S. universities and business, and the well-developed system of competition for research funding arguably gives the United States an advantage in turning research input into useful commercial output.

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[6] This amounts to a paltry 0.43% of net industrial sales.
[7] This amounts to only 1.62 percent of net industrial sales.
[8] This is 9.64 percent of net industrial sales.
[9] Data and taxonomies from the NSF Survey of Graduate Students and Post doctorates in Science and Engineering (GSS) 2002, National Science Foundation.

Still, eventually numbers may dominate organization."[10] In addition, "the main drawback of Chinese applicants for engineering jobs is the educational system's bias toward theory. Chinese students get little practical experience in projects or teamwork, reducing China's pool of young engineers suitable for work in multinational corporations to 160,000."[11] In this case, doubling the work force does not lead to a doubling of productivity.

While R&D is an important factor in the growth of the economy, the U.S. risk-embracing culture of challenges, explorations, experimentations, no social indictments upon failure, and opportunities to excel are key motives in innovation. Alex de Tocqueville in *Democracy in America* (1840) observed that Americans pursue material gains and private pleasure with "feverish ardor". Indeed, the Organization for Economic Cooperation and Development reports that the United States, unlike most rich nations, has not reduced the average work week in the past quarter century! It is primarily for these reasons that foreign scientists and engineers flock to the United States for fame and fortune.

Much of the recent policy debate in the United States regarding the impact of globalization has centered on workforce preparation and the need for American industry to sustain innovation. Increased federal spending on R&D only addresses part of the problem. Increasing production of STEM workers will be beneficial only if high-skilled, well paid jobs await them. If the U.S. companies continue to move their R&D off-shore, there will be less demand for U.S. STEM workers. That decrease, in turn, may cause unemployment or underemployment. U.S. students will abandon STEM as future professions, resulting in a vicious cycle of the United States losing its supply of future scientists and engineers. A solution is to increase R&D productivity, which implies enticing the most brilliant students into the STEM professions. Unfortunately, there are little or no consistent databases that measure the economic health of the STEM enterprise. For instance: What is the total number of employed, unemployed and underemployed S&E workers? What is the volume and nature of high technology jobs moving off-shore? Or how productive are U.S. S&E workers, compared to those of other nations?

The R&D portfolio is also a vital element of national security. Much of the advanced war fighting capabilities are the result of defense R&D in the last few decades. Technologies such as radar, jet engines, nuclear weapons, night vision sensors, smart weapons, precision guided munitions, stealth, global positioning system, unmanned aerial vehicles, and information technology for network-centric warfare all came out of defense R&D. At $84.5 billion and $30.8 billion for DOD and NIH, respectively, the R&D budgets now account for more than 78.1 percent of all 2009 federal spending on R&D. Needless to say, off-shoring the defense R&D portfolio is not in our national interests.

However, federal funding for R&D in all other engineering and science fields has been flat or declining for more than 30 years. To be optimally successful, the nation's investments in research must be balanced across engineering and science; between short-term needs for practical applications of state of the art technologies; and between longer-term searches for promising future technologies.

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[10] Richard B. Freeman, Working Paper 11457 [http://www.nber.org/papers/w11457] NATIONAL BUREAU OF ECONOMIC RESEARCH, 1050 Massachusetts Avenue, Cambridge, MA 02138, June 2005, pg. 23

[11] "China's Looming Talent Shortage: To make the move from manufacturing to services, China must raise the quality of its university graduates", Dians Farrell and Andrew J. Grant, Mckinsey & Company, Inc. pg 2.

Finally, R&D leaking through national boundaries is an inescapable trend in the economic climate of a global market and multi-national industries. Ideas and innovation will spring up outside of U.S. borders. These pockets of ideas and innovation need close monitoring by the U.S. R&D community. The most likely party to accomplish this important task is the U.S. Department of State, through its science attaché offices in our foreign embassies. These offices should be adequately staffed by expert S&E personnel, either permanent or rotated from the national, academic and industrial laboratories. The science attaché offices need to report to proper federal authorities, such as the Executive Office of Science & Technology Policy. Then, vital information can be propagated to the nation's R&D community.