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POSITION STATEMENT

MAINTAINING U.S. LEADERSHIP IN INNOVATION AND COMPETITIVENESS

Adopted by the IEEE-USA Board of Directors, 22 November 2013

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; encouraging the development of the skilled, creative and competitive workforce 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 workforce; a planned consistent R&D budget; effective workforce incentives; and measures to increase productivity. Once STEM's operation is understood, ineffective government regulations can be eliminated and legislation to increase the nation's R&D productivity and maintain its preeminence in an increasingly competitive global R&D environment can be written. The U.S. STEM enterprise is the foundation of innovation, competitiveness and economic growth--not only in the United States--but also in the global marketplace.

To ensure this standard continues, IEEE-USA recommends that Congress and the executive branch of the federal government work with private industry and academia to:

1. 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

2. Enact a permanent R&D business tax credit, for industrial research, and for industrial support of university R&D performed in the United States

3. Provide incentives to support and encourage venture capital firms to fund U.S. start-up companies, and discourage off-shoring

4. Continue to support Small Business Innovation Research (SBIR) and Small Business Technology Transfer (STTR) programs

5. Promote measures to encourage and ensure a pool of the best and brightest scientists, technologists, engineers and mathematicians are among the next generation of Americans to enter the STEM field

6. Measure and monitor the economic health of the STEM enterprise by such indicators as employment, unemployment, underemployment, and volume of off-shored STEM jobs and tasks

7. Maintain stable, consistent, balanced, long-term federal R&D funding

8. Strengthen S&T foreign affairs offices to monitor foreign developments in R&D, and to facilitate interaction with the U.S. R&D community, so that vital information can be propagated to the nation’s STEM community

9. Enhance the timeliness and transparency of federal rules and processes that regulate market access to new and emerging technologies, in such fields as health, communications, energy and others.

This statement was developed by the IEEE-USA Research and Development Policy Committee (R&DPC), 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 more than 205,000 engineers, scientists and allied professionals who are U.S. members of IEEE. The positions taken by IEEE-USA do not necessarily reflect the views of IEEE, or its other organizational units.

BACKGROUND

The Science, Technology, Engineering and Mathematics (STEM) enterprise is critically dependant on Research and Development (R&D). R&D is recognized as the key driver 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 past 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.

Such advances 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, high-technology medical diagnostic equipment, and mapping of the human genome. The STEM enterprise 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.

IEEE-USA is cognizant of the potential for the loss of national innovation, driven by off-shoring of U.S. R&D. In 2013, the total U.S. R&D investment [$402.6 B], at 2.66 percent of the gross domestic product (GDP), is below that of Sweden at 3.62 percent, Finland at 3.75 percent, and Japan at 3.48 percent. Although China's R&D investment is only 1.65 percent of its GDP, it and India are rapidly increasing their R&D investments. European and U.S. industries off-shoring of R&D are fueling India and China's increase in R&D investments. Dr. Jeanette Wing spoke urgently on the growing capabilities of China and India in the STEM workforce, infrastructure and ideas. China is getting up to date on college and university facilities. In the 2000-2011 timeframe, there has been a 23% increase in S&T expenditures, with heavy investment in multi-year projects in research and infrastructure. Of the 200,000 annual students studying in the United States, 47% return to China.[1] Although, as indicated in Table 1, the Americas hold 34.8 % of global R&D investment, the United States commanding a 29.6% share, Asia at 34.9% and Europe at 24.6% are fast closing the gap.[2]

	2011	2012	2013	2013 R&D $ as % of GDP
Americas	**34.8%**	34.3%	33.8%	2.04
United States	29.6%	29.0%	28.3%	2.66
Asia	**34.9%**	36.0%	37.1%	1.79
Japan	11.2%	11.1%	10.8%	3.48
China	12.7%	13.7%	14.7%	1.65
India	2.8%	2.8%	3.0%	0.90
Europe	**24.6%**	24.0%	23.4%	1.88
Rest of the World	**5.7%**	5.7%	5.7%	0.87

Table 1. Share of Global R&D Spending [Ref.1]

[1] Dr. Jeanette Wing Vice President, Head of Microsoft Research International, Microsoft Corporation, Asian Perspective on S &T Policy. The 38th Annual AAAS Forum on Science & Technology Policy took place May 2-3 at the Ronald Reagan Building and International Trade Center in Washington, D.C.

[2] 2013 Global R&D Funding Forecast, Battelle [www.battelle.org]

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:[3]

- *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 toward processes or products in mind. Basic research, however, may include activities with broad applications in mind.

- *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.

- *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 characterizations of R&D as Basic, Applied and Development are not unique. R&D 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 nation's total R&D portfolio of Basic (BR), Applied (AR) and Developmental research (DR) is $402.6 billion, of which the federal portion is 35 percent, and industry is 65 percent. **(See Table 2.)**[4]

Sector	$ in Billions
Industrial	**261.7**
---Basic	17.5
---Applied	36.7
--- Development	207.5
Federal	**140.9**
--Fed Basic	31.7
--Fed Applied	31.6
--Fed Development	75.2
Total U.S. R&D	402.6

Table 2. R&D Portfolio of Basic, Applied and Developmental Research [facilities in total federal R&D] budget constitute $2.3 billion. [5]

[3] OMB Circular No. A–11 (2006), Section 84, pg 8-9

[4] The breakout % for industry are based on 2009 data, see Appendix.

[5] White House Office of Science and Technology Policy, April 10, 2013, Table 1.

Industry provides 73 percent of developmental research, 54 percent of applied research, and 35 percent of basic research funding. However, compared to the total U.S. funding, industry spends a paltry 4.3 % on basic research, compared to 7.9% by the federal government. The federal (BR) portfolio, amounting to $31.7 billion, 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 and the Department of Energy's contribution to the International Thermonuclear Experimental Reactor.

Finally, 73% of the national developmental portfolio, $207 billion, is funded by industry, 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. R&D has been internationalized by advances in applications of computer and telecommunication technologies. Economically, because of lower labor costs, increasingly favorable business climates, 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 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 1.65% 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.[6] Overall, the U.S. share of world S&E Ph.D.s is projected to fall 15% in 2010. Nonetheless, the character, quality and expertise of U.S. S&E graduates exceed that of other developing nations, such as China.

Continued focus on high-quality STEM education is essential to maintaining U.S. leadership in innovation. "But the way a country organizes its R&D and the connection between research activities and business is also likely to affect innovation and 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. Still, eventually numbers may dominate organization." [7] 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."[8]

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[6] Data and taxonomies from the NSF Survey of Graduate Students and Post doctorates in Science and Engineering (GSS) 2002, National Science Foundation.

[7] 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

[8] "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.

While R&D is an important factor in the growth of the economy, the U.S. risk-embracing culture of challenges, explorations, experimentations and opportunities to excel are key motives in innovation. Freedom to pursue one's ideas and develop the entrepreneurial culture of American society is critical to further U.S. economic goals. Alex de Tocqueville's observations in *Democracy in America* (1840), that Americans pursue material gains and private pleasure with "feverish ardor" are still relevant.

Angel Capital (AC), or business angels, and Venture Capital (VC), are special types of equity finance-- typically for young, high-risk, and often, high-technology firms. AC investors are wealthy individuals with experience in creating new companies, and are the most likely sources for early-stage start-ups. The majority of angel groups prefer to invest in high-tech industries such as medical devices, software and biotechnology A recent study showed that firms receiving angel funding are somewhat more likely to survive for at least four years, and that angel funding is positively related to the likelihood of subsequent external investment.[9]

VC, defined as equity or equity-linked investments in young, privately-held companies, occurs at a later stage than angel investment, and venture capitalists seek to gain returns on their investment in the form of an initial public offering (i.e., sale of stock), or company.

Unfortunately, AC and VC investments peaked in 2006 and 2007, thereafter plummeting some 75 % in 2010![10,11] Because industrial sector funding of R&D decreases during times of economic distress [the dot.com and 2008 financial recessions], the federal government must maintain its commitment to R&D by protecting the SBIR and STTR capitalization programs.[12] To this end, IEEE-USA supports SBIR and STTR programs that already nurture this activity, and we encourage the expansion of such programs.

The increasingly competitive nature of the emerging global economy with other nations utilizes tax incentives to encourage business R&D spending. It is mandatory that the United States take proactive measures, such as a permanent R&D tax credit, to ensure a strong domestic science and technology research and development base.[13]

The STEM enterprise is a unique ensemble of R&D accomplished by the federal, academic and private sectors, both national and international. It is the driving force for economic and social advancement for humankind. Much of the recent policy debate in the United States regarding the

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[9] Kerr, W.R.; Lerner, J. and Schoar, A. 2010. "The Consequences of Entrepreneurial Finance: A Regression Discontinuity Analysis." Working Paper No. 10-086. Harvard Business School.

[10] Data from *PitchBook*, Seattle WA; tabulations by IDA Science and Technology Policy Institute, December 2011. Note: Industries include: Software; Pharmaceuticals & Biotechnology; Semiconductors & Networking; and Computer Hardware.

[11] See Research & Development Innovation, and the Science and Engineering Workforce, National Science Board, [A Companion to Science and Engineering Indicators 2012].

[12] IEEE-USA POSITION STATEMENT, "Small Business Innovative Research" *Adopted by the IEEE-USA Board of Directors, 4 March 2010*

[13] IEEE-USA POSITION STATEMENT, "Permanent Extension of the R&D Tax Credit ', *Adopted by the IEEE-USA Board of Directors, 25 June 2010*

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 U.S. companies continue to move their R&D off-shore, there will be less demand for U.S. STEM workers. In turn, that decrease 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. The economic health of this enterprise is of importance to all people. Policies and regulations must be derived from basic incorruptible data and measures to maintain a healthy and productive STEM enterprise. Unfortunately, few or no consistent databases exist 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?

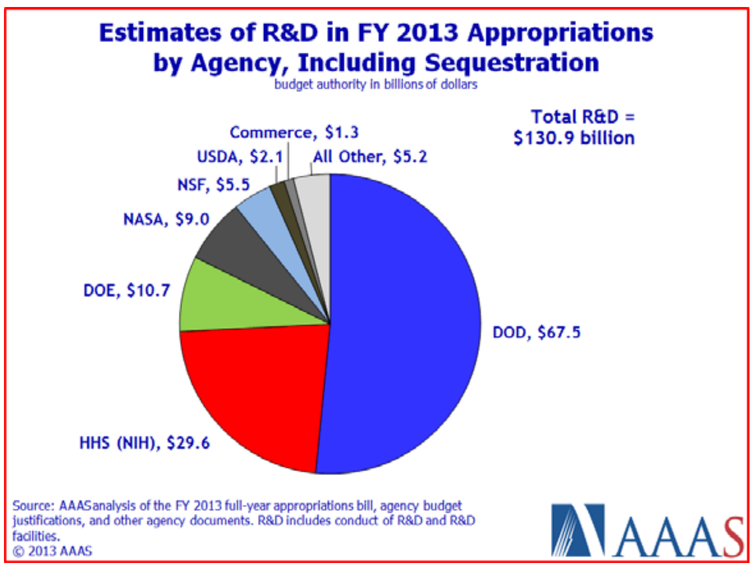

Figure 1. Federal outlays for R&D funding by Agency (AAAS)

The R&D portfolio (Figure 1) is also a vital element of national security. Many advanced war-fighting capabilities are the result of defense R&D in the past 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 $67.5 billion and $29.6 billion for DOD and NIH, respectively, the R&D budgets now account for more than 74% of all 2013 federal spending on R&D. 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.

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 parties to accomplish this important task are the foreign affairs offices of various U.S. departments and agencies. These offices should be adequately staffed by expert S&T personnel--either permanent, or rotated from the national, academic and industrial laboratories. The information gained should be made available to the U.S. STEM enterprise.

Appendix: A

	Industrial	Federal	Universities	Others	Total
Character	$ M [%]	$ M	$ M	$ M	$ M
Basic	16.5 [6.7]	40.5	10.8	8.2	76
Applied	34.3 [14]	30.1	3.5	3.4	71.3
Development	196.5 [79.3]	53.8	.8	2	253.1
Totals	247.3	124.4	15.1	13.6	400.4

Table 3. U.S. R&D expenditures by performing sector, character of work [2009].[14]

[14] NSF Science and Engineering Indicators 2012.Chapter 4, Research and Development: National Trends and International Comparisons. pg 4-14