IEEE-USA POSITION STATEMENT

Maintaining U.S. Leadership in Innovation and Competitiveness

Adopted by the IEEE-USA
Board of Directors, 23 June 2017

IEEE-USA endorses the implementation of legislation encouraging innovation, and supports related federal R&D budget appropriations and regulations needed to restore U.S. technological leadership, promote economic competiveness, expand the U.S. competitive high-tech workforce, and create high-value jobs in the United States. The following actions are required to accomplish these objectives:

1. Increase federal investment and maintain stable, balanced, long-term, federal R&D funding in science and engineering--including university research and education initiatives. Encourage cooperation among universities, federally funded labs, and U.S.-based companies to accelerate commercializing technological advances.

2. Revitalize U.S. high-tech manufacturing, promote public-private partnerships, and establish incentives for businesses to locate their R&D and manufacturing operations in the United States.

3. Provide tax incentives for repatriating profits on the foreign-source income of U.S.-based, multinational corporations that invest repatriated profits into research and development, and infrastructure investment in the United States.

4. Monitor the economic health of the U.S. STEM enterprise, by measuring domestic R&D investment, STEM-related patents, high-tech business formation, net high-tech job formation, workforce skills levels, and the balance of high-tech imports and exports.

5. Strengthen S&T expertise at foreign offices of U.S. agencies; and S&T coordination among those agencies, 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 nearly 200,000 engineering, computing and allied professionals who are U.S. members of the IEEE. The positions taken by IEEE-USA do not necessarily reflect the views of IEEE, or its other organizational units.

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BACKGROUND

Research and Development (R&D) is recognized as the key driver of economic growth, and the lifeblood of national innovation and competitiveness.[1] Economists estimate that up to half of the U.S. economic growth in the past five decades is due to advances in science & technology (S&T). The Bureau of Economic Analysis reports more than a 15 percent return on investments on R&D.

Such advances as integrated circuits, computer science, electro-optics, and signal processing have created such new markets as information technology, the Internet, computer-aided design and manufacturing, laser technology, Global Positioning Systems, high-tech medical diagnostic equipment, and mapping the human genome. The Science, Technology, Engineering and Mathematics (STEM) enterprise is becoming increasingly global, fueled by advances in information technology and telecommunications, and efficient transportation systems. Much of the semiconductor, microelectronics and consumer manufacturing has moved off-shore. But R&D is losing its national identity, due to globalization. And R&D globalization is having an impact on the United States, in spite of its strong R&D infrastructure.

IEEE-USA recognizes the potential for national innovation loss, driven by off-shoring of U.S. R&D. In the 2016 forecast, the total U.S. R&D investment of $514 B, at 2.77 percent of the gross domestic product (GDP), is below that of Sweden at 3.41 percent, Finland at 3.55 percent, and Japan at 3.39 percent. Although China's R&D investment is only 1.98 percent of its GDP, it and India are rapidly increasing their R&D investments. European and U.S. industries off-shoring R&D are fueling India and China's increase in R&D investments. At $396.3 billion, China is the second largest R&D investor. China's GDP of $18.8 trillion is now larger than the United States' at $18.0 trillion, and its R&D budget is projected to surpass the United States in 2026.[2]

Note also that U.S. corporations currently hold some $2.5 trillion in profits overseas. These un-repatriated profits are sometimes used to build and develop foreign infrastructure and technology that ends up competing directly against the United States.

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[1] This background excludes some health sciences activities.

[2] R&D Magazine, 2016 Global R&D Funding Forecast, Winter 2016, page 23. Note also that U.S. corporations currently hold some $2.5 trillion in profits overseas. These un-repatriated profits are sometimes used to build and develop foreign infrastructure and technology that ends up competing directly against the United States.

Among economies with more than 200,000 researchers, the Organization of Economic Co-operation and Development (OECD) estimates that researchers make up the highest workforce proportions in South Korea (1.3%), Japan (1.0%), the United States (0.9%), and the United Kingdom (0.9%). Although China reported a large number of researchers, these workers represent a much smaller percentage of China's workforce (0.2%), compared to OECD member countries. Nonetheless, China and South Korea have shown marked and continuous increases in their workforce percentage employed as researchers."[3] Although, as indicated in Table 1, the United States holds 26.4 percent of global R&D investment, Europe stands at 21.0%; and China, quickly narrowing the gap, ranks third--at 20.4 percent.[4]

Area/Nation	**2014**	**2015**	**2016**
North America	29.1%	28.5%	28.4%
United States	26.9%	26.4%	26.4%
Asia	40.2%	41.2%	41.8%
China	19.1%	19.8%	20.4%
Europe	21.5%	21.3%	21.0%

Table 1. Share of Total Global R&D Spending[4]

[3] National Science Board, Science & Engineering Indicators 2016, page 116.

[4] *R&D Magazine*, 2016 Global R&D Funding Forecast, Winter 2016 page 3.

A more telling statistic is the output associated with the STEM enterprises of the major R&D countries, as evidenced in Table 2.[5]

Nation	Scientific & technical journal articles (2013)	Patent Applications Filed (2014)	Trademark Patents Filed (2014)
United States	412,542	285,096	341,902
China	401,435	801,135	2,104,534
Germany	101,074	48,154	70,554
Japan	103,377	265,959	124,602
France	72,555	14,500	90,674
UK	97,332	15,196	54,525
World	2,184,420	1,713,000	4,886,846

Table 2. World Development Indicators: Science and Technology

As of 2015, China's high-tech exports exceeded that of all other major nations [see Table 3].

World Rank	Nation	In $ millions	World Rank	Nation	In $ millions
1	**China**	558.6	**4**	**Singapore**	137.4
2	**Germany**	184.3	**5**	**Korea**	133.4
3	**United States**	154.4	**6**	**France**	132.2

Table 3. Ranking Six Leading Nations in High-Tech Exports[6]

[5] International Monetary Fund, [http://wdi.worldbank.org/table/5.13]

[6] World Bank, World Development Indicators, October 14, 2016

China's high-tech exports are a manifestation of its total commitment to R&D. However, Recommendation #1 is more than justified in keeping the United States in the lead in STEM enterprise.

The International Institute for Management Development released an annual study on international competitiveness, reporting the United States had surrendered its status as the world's most competitive economy in 2016. Several factors contributed to the decline from first to third place, including the lack of business-friendly regulations; economic conditions strengthening the U.S. dollar, in comparison to other international currencies; and the comparatively high U.S. market.

The federal government must establish policies enabling U.S. industry to promote innovation and competitiveness.[7]

The R&D enterprise can be divided into three components: Basic, Applied and Development. The Office of Management and Budget (OMB) defines these components as follows:[8]

- 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.
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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.*

- Development is defined as *systematic application of knowledge or understanding; directed toward producing useful materials, devices, and systems or methods--including designing, developing and improving prototypes and new processes to meet specific requirements.*

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[7] https://www.weforum.org/reports/the-global-competitiveness-report-2016-2017-1

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

As one can see in the following Table, the percentage total R&D invested in basic research by selected countries ranges from 5% to 24%, with the United States on the high side of this range.[9]

Country	Basic ($B)	Applied ($B)	Development ($B)	Total ($B)
United States	76.6 16.8%	90.6 20.8%	271.7 62.3%	456.1
China	14.1 4.8%	33.1 11.3%	245.9 83.9%	293.1
Japan	18.3 12.3%	31.2 21.0%	92.1 62.1%	141.6
Germany	NA	NA	NA	NA
South Korea	58.4 18.1%	10.6 20.3%	11.9 62.1%	80.9
France	13.0 24.4%	19.7 36.9%	18.6 34.8%	51.3
Russia	5.9 14.4%	NA	NA	NA
United Kingdom	5.8 14.9%	18.9 48.2%	14.5 37%	39.2

Table 4. Gross Expenditures in the Year 2012 on R&D (in $Billions and Percentages of Total) for Selected Countries, by Component

[9] National Science Board Science & Engineering Indicators 2016 in $B, (latest data for 2013) page 47.

One can also differentiate R&D, 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 performance portfolio of Basic (BR), Applied (AR) and Developmental Research (DR) was $453 billion in 2013. The portfolio is broken down in Table 5[10].

	Funding	Share Total	Industry	Federal Government	Academia	Non-Profit
BR	$75 B	16%	22%	7%	56%	15%
AR	$87 B	20%	61%	10%	21%	8%
DR	$291 B	64%	87%	8%	3%	2%
All R&D	$453	100%	72%	8%	15%	5%

Table 5. R&D Portfolio of Basic, Applied and Developmental Research Performance in 2013

Finally, industry accomplishes 87 percent of the national developmental performance portfolio, $253 billion, including applying knowledge directed toward producing and manufacturing useful materials, devices and systems, or methods; and designing, developing and improving prototypes and new processes. Yet, given the U.S. budget for industrial development, $292 billion, versus $245 billion for China, U.S. technical exports are, woefully, one-quarter those of China (Table 3). Even more ominous is the percentage of the world's R&D budget--24 percent for the United States, and 20 percent for China--with the latter growing over time.

Several factors have contributed to gradually off-shoring the U.S. industrial R&D portfolio. Advances in computer applications and telecommunication technologies have internationalized R&D. Economically, due to lower labor costs, increasingly favorable business climates, less restrictive environmental and occupational health, safety regulations, and tax incentives in developing countries, multinational and U.S. companies are continuously enticed to establish off-shore R&D sites. Driven by this new-found asset, developing countries are increasing investments in their R&D infrastructure, and in producing homegrown scientists and engineers.

[10] National Science Foundation, 2012 National Patterns (data for 2013)

Although China's R&D investment, measured as a percentage of 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, industries in the United States and Europe 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 soon produce more S&E doctorates than the United States.[11]

Although the quality and expertise of U.S. S&E graduates presently exceed that of developing nations, such as China, overseas STEM education in some developing nations is improving steadily and eventually will rival that in the U.S.

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

As can be seen in the projected 2017 budget (Figure 1 below), the Obama administration proposed $147 billion for R&D. This proposal amounts to 12 percent of the federal discretionary budget of $1,233 billion.

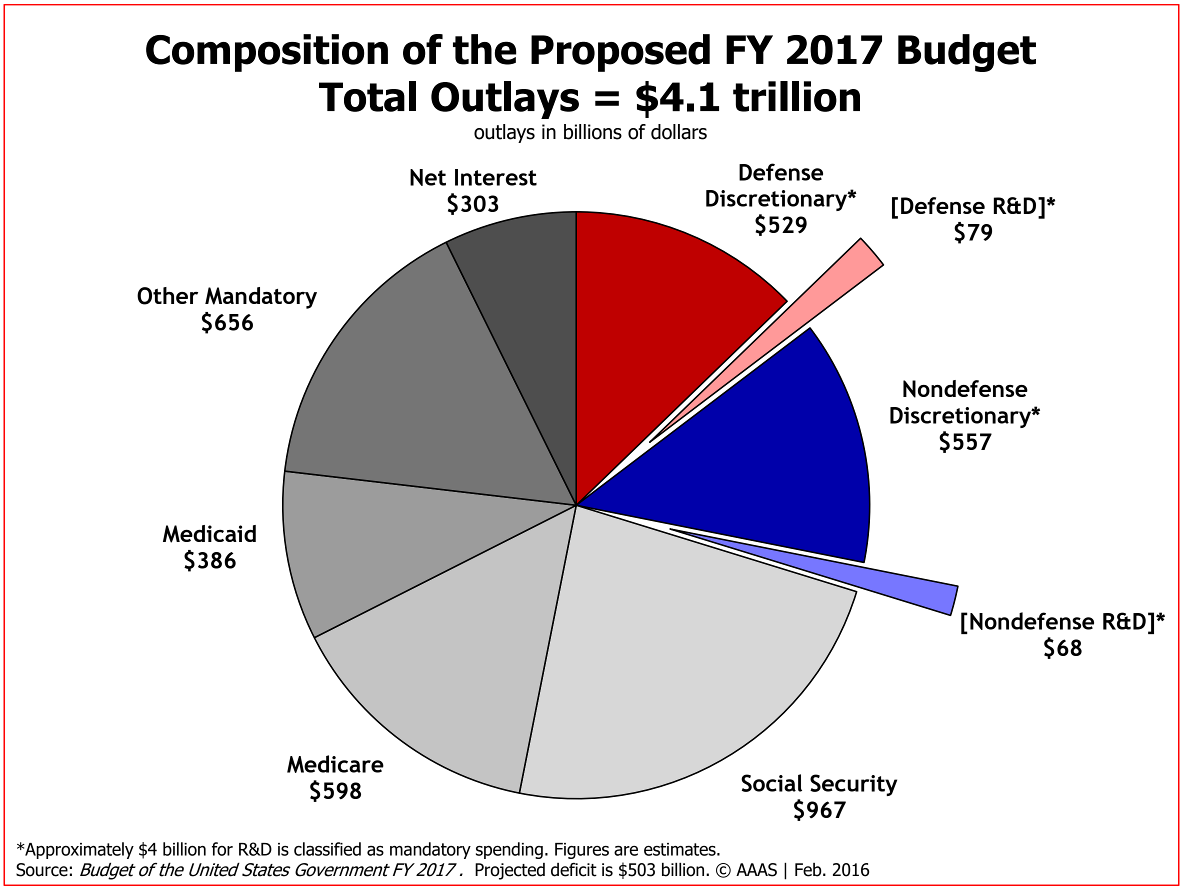

Figure 1. 2017 President's Budget Submission

However, as shown in Table 6 and Figure 2 (below) the total federal R&D budget has been declining over the past few years--a more serious consequence.[12]

[12] National Science Board, Science & Engineering Indicators 2016, Chapter 4. Table 4-1, page10-11 (data up to 2013).

Year	2008	2009	2010	2011	2012	2013
Funding ($M)	120,017	127,180	126,019	123,936	118,817	114,124
Percent Change	-	6%	-1%	-2%	-4%	-4%

Table 6. Federal R&D Funding: National Trends

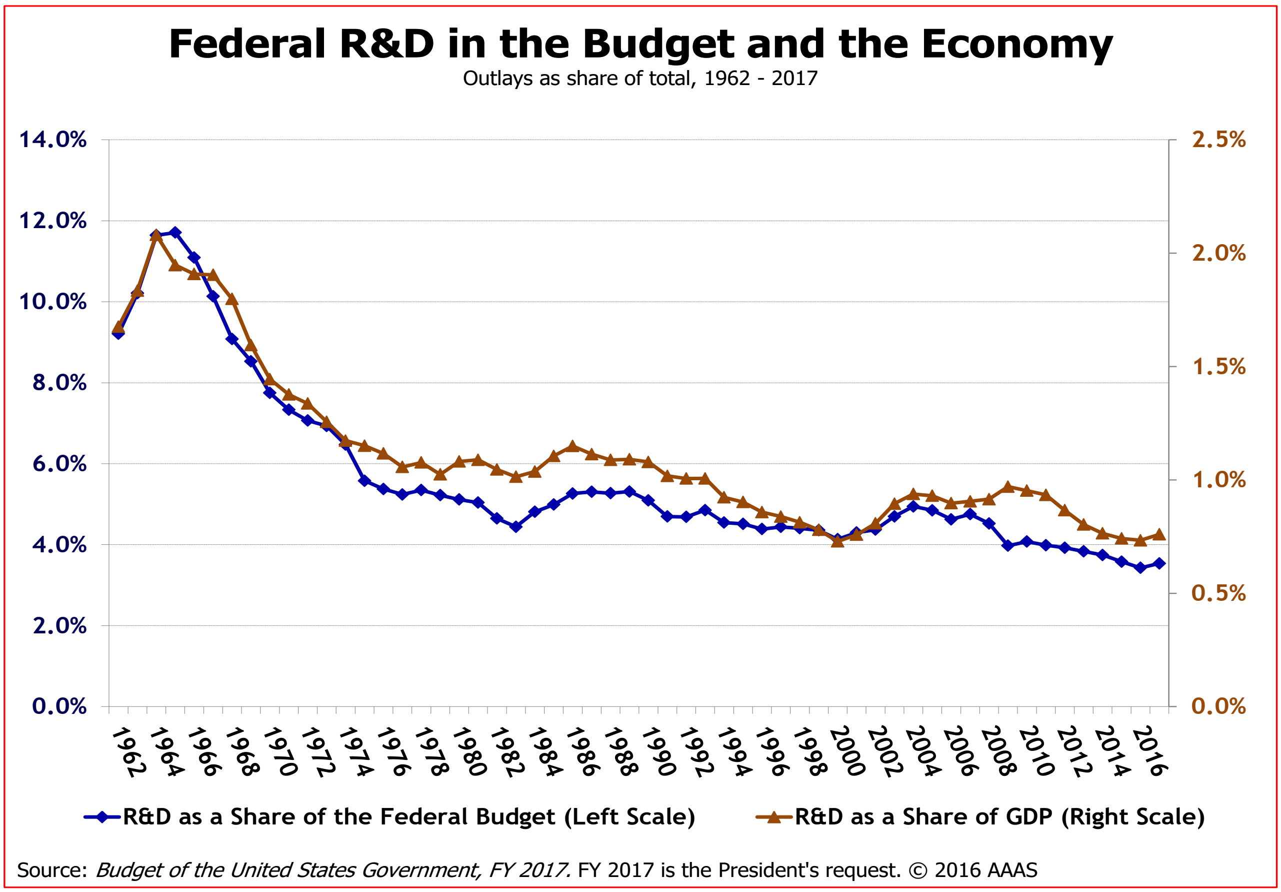

Figure 2. Decline of federal government appropriated R&D funds over five decades, as part of the total federal budget

	FY 2016	FY 2017	Change FY 16-17	
			Amount	Percent
Defense S&T (6.1-6.3)[13]	77,963	79,824	+1,861	+2.4%
Basic Research	33,510	32,791	-719	-2.1%
Applied Research	37,794	37,511	-283	-0.7%
Total R&D	147,343	150,126	+2,783	+1.8%

Table 7. R&D in $ Millions in the federal budgets (excludes New Mandatory $ in 2017).[14]

Angel Capital (AC) 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 such high-tech industries 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.[15]

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

[13] DOD $ include DOE Atomic Energy defense, whose budget increased by 23.7% over 2016

[14] AAAS, updated September 2016, from OMB data

[15] 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.

VC investments peaked in 2006 and 2007, thereafter plummeting some 75 percent in 2010.[16] To offset this decline in part, IEEE-USA supports SBIR and STTR programs that nurture this technology transition to business start-ups, and we encourage expanding such programs.[17]

In the increasingly competitive global economy, other nations utilize tax incentives to encourage business R&D spending. The United States has taken proactive measures, such as a permanent R&D tax credit, to ensure a strong domestic science and technology research and development base,[18] but more should be done.[19]

Both national and international federal, academic, and private sectors have accomplished the STEM enterprise—a unique R&D ensemble. It is the driving force for economic and social advancement for humankind. Much of the recent policy debate in the United States regarding globalization's impact has centered on workforce preparation, and the need for American industry to sustain innovation. Increased spending on R&D addresses only part of the problem. Increasing production of STEM workers will be beneficial, if high-skilled, well-paid jobs await them. U.S. companies continuing to move R&D off-shore, will cause less demand for U.S. STEM workers. In turn, that decrease may cause unemployment or underemployment. U.S. students will abandon pursuing future STEM professions, resulting in a vicious cycle of the United States losing its supply of future scientists and engineers.

Improving policies requires a deeper understanding of the economic impact of the STEM enterprise. Achieving these goals requires an in-depth analysis of such indicators as the reliable statistics relative to the U.S. Research and Development (R&D) workforce, a consistent and predictable budget, effective workforce incentives, and measures to encourage increased productivity improvement. Once the operation of the STEM enterprise is prioritized

[16] 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.

[17] IEEE-USA Position Statement, "Small Business Innovative Research", 2014, http://ieeeusa.org/policy/positions/index.html#rd.

[18] IEEE-USA Position Statement, "Permanent Extension of the R&D Tax Credit", 2013.

[19] R. Atkinson and S. Ezell, *Innovation Economics*, Yale University Press, 2012.

and appropriately supported, the United States can establish a pathway toward maintaining its lead in the increasingly competitive, global R&D environment.

In light of Table 1, numerous valuable ideas and innovations will spring up outside the United States, and the U.S. R&D community should monitor them closely. The foreign offices of various U.S. departments and agencies are one mechanism for accomplishing this monitoring. Expert S&T personal should adequately staff these offices-- either permanently, or rotating employees from government, academic and industrial laboratories. Any information gained should be made available to the U.S. STEM enterprise.

The Air Force Office of Scientific Research's International Office[20] and the Office of Naval Research's Global Office[21] have long histories of building international ties in science and engineering. Recently, the Department of State has expanded its efforts in "Science and Technology Cooperation."[22] Some other agencies also have international science and engineering outreach activities. Building upon these commendable programs, and enhancing cooperation among them, would be of high value to U.S. R&D.

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[20] http://afrl.dodlive.mil/international-programs/

[21] https://www.onr.navy.mil/en/Science-Technology/ONR-Global.aspx

[22] https://www.state.gov/e/oes/stc/