IEEE-USA strongly recommends sustained, balanced support for fundamental research in science, technology, engineering and mathematics (STEM). Such research provides the foundation for scientific discovery and progress. It helps assure technological leadership and innovation, and avoid unanticipated foreign developments of emerging and disruptive technologies in both the defense and the civilian sectors. Federal investment in long-term, high-risk, high-payoff fundamental research is particularly important today to maintain the United States’ global competitiveness.

IEEE-USA recommends that Congress and the president work with industry and universities to:

- Maintain a healthy, stable and balanced STEM fundamental research investment, including modern laboratories and equipment. Support engineering and physical science research, which has waned over the past few decades. Fundamental research funding should increase at a rate no less than that of the Gross Domestic Product.

- Encourage interagency coordination of S&T-related activities, with shared information and planning. Stimulate multiple approaches at the early research phase.

- Streamline regulations governing federally funded research to reduce administrative overhead.

- Continue to support STEM education to meet U.S. competitive needs in the global economy.

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 serves the public good and promotes the careers and public policy interests of more than 200,000 engineering, computing and technology professionals, who are U.S. members of IEEE. With more than 400,000 members in over 160 countries, IEEE is the world’s largest technical professional society. Positions taken by IEEE-USA do not necessarily reflect the views of IEEE, or its other organizational units.
BACKGROUND

Nobel Prize-winner Robert Solow’s pioneering study showed that more than half, and perhaps as much as 85 percent, of productivity growth in the United States in the first half of the 20th century could be attributed to technical advances.1 Other studies indicate that 50 percent or more of the nearly seven-fold real growth the country has enjoyed, since the end of World War II, is attributable to technological innovation resulting from investments in research and development.2

Fundamental research underpins technological progress. "Fundamental research” means basic and applied research in science and engineering, the results of which ordinarily are published and shared broadly within the scientific community-- as distinguished from proprietary research---and from industrial development, design, production and product utilization, the results of which ordinarily are restricted for proprietary or national security reasons. In turn, the Office of Management and Budget defines Basic and Applied research, as follows:

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.

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.4

As President Reagan observed, “Although basic research does not begin with a particular practical goal, when you look at the results over the years, it ends up being one of the most practical things government does… Major industries, including television, communications and computer industries, couldn't be where they are today without developments that began with basic research."5 Lasers, the Global Positioning System, Stealth technology, and the polio vaccine (to name just a few) are other advances based on fundamental research.

Many others share this recognition of the importance of science and engineering research, including President Obama. "We’ve got to seize every opportunity we have to stay ahead, and we can't let other countries win the race for ideas and technology of the future." He went on to praise robotics, space exploration, and organ regeneration research.6 Likewise, Sen. John Rockefeller emphasized, “There can be absolutely no question that investing in science and technology, in innovation, and in educating our young people is critical to maintaining our

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4. Office of Management and Budget, Circular A-11, Part II, Sec. 84.
nation’s global leadership... The money that we put into basic research, into understanding the world around us, has a real-world impact.⁷

Rep. Lamar Smith succinctly stated the rationale for federal government support of basic research: “The federal government provides the largest share of funding for basic research. This is a role for which government is uniquely suited. That’s because our federal research agencies do not have to make investment decisions based on quarterly profit and loss statements. In other words, government funds the basic research that is the seed corn for our economy.”⁸

Economic growth as described by Solow¹ and others² requires stable support for research as a fraction of the Gross Domestic Product (GDP). Research funding that does not at least keep pace with the GDP inevitably has a decreasing impact on future GDP growth. Unfortunately, federal support of science and engineering research trended downward from 1970 to 1995, and has gyrated wildly, since then.⁹ See Fig. 1.

The full impact of decreased research funding is not felt immediately but after a lag time of a few decades. According to Congressman Smith: “Since World War II, the United States has led the world in R&D spending. As a direct result, the United States has continued to be first in the world in science and innovation. And our industries and our workers have continued to be the leaders in aerospace, the Internet, computer science, health care, engineering, and a host of other important areas. Our place at the head of the global table, however, is not ordained. We must earn it. We must continue to invest wisely. For the first time since the 1940s, we are no longer

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winning in crucial areas of science and technology. Our share of worldwide high-tech jobs is decreasing. China’s high-tech exports nearly triple those of the United States.\(^8\)

The Organization for Economic Co-operation and Development (OECD) Science, Technology and Industry Scoreboard lists the United States as tenth in Research and Development, as a fraction of the GDP.\(^10\)

According to the National Research Council, “The nation will increase the performance of its research enterprise by providing steady, predictable streams of funding for research over time. The last decade has seen damaging fluctuations in research appropriations.”\(^11\) The impact is, of course, particularly severe for young researchers. Under such circumstances, students question whether the United States remains committed to technological advancement, and whether a career in STEM is a wise choice. “Stable and predictable federal funding encourages talented students to pursue scientific careers, keeps established researchers engaged over a career, and attracts and retains foreign talent. It also supports a diversity of institutions that both fund and conduct research, as well as essential scientific infrastructure—the tools necessary for conducting research. Stable resources are increasingly important to future competitiveness, given the rising investments in research by other countries.”\(^12\)

Stable resources include “essential scientific infrastructure--the tools necessary for conducting research”,\(^12\) Universities, in particular, often find it difficult to keep their research instrumentation up to date.

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Federal support of research also has become unbalanced. As Fig. 2 (above) makes clear, federal support for engineering and physical sciences research has declined even more sharply than support for research as a whole.

A healthy economy requires innovative research in a range of disciplines. “Truly transformative scientific discoveries often depend on research in a variety of fields. Maintaining broad expertise among those who conduct research also sustains the innovation system, because technological problems often arise in the development of an innovation that requires research for their solutions. Research and innovation are symbiotic in this way.” More specifically, as emphasized in Rising above the Gathering Storm, “special attention should go to the physical sciences, engineering, mathematics and information sciences and to Department of Defense (DOD) basic-research funding.” (IEEE-USA also advocates increased DOD S&T funding.) A nation that leads in medical research but lags in other key areas will not fare well in the long-term. Balance is required.

Better coordination of federal funding agencies would stretch existing research funds further. The National Research Council has emphasized that “no agency, office, or committee within the Executive Branch or Congress systematically monitors the breadth of federal research investments across disciplines and scientific fields in ways that can support the goal of balance and sustainability of the overall scientific research enterprise.”

Enhanced cooperation among agencies might include shared information, coordinated planning and funding, sources for informing the general public of scientific advances and their impacts, “international benchmarking … to reveal scientific areas pursued elsewhere that may not be adequately supported in the United States,” research and innovation indicators (perhaps building upon STAR METRICS), experiments involving novel research funding strategies, and standardization of proposal submission and reporting requirements. “Much stronger research collaboration between university researchers and federal laboratories, not only those that harbor large, experimental facilities, but the other general-purpose laboratories as well,” would also be of value.

With respect to international benchmarking, there is no substitute for U.S. scientists and engineers attending international research conferences, including those the government employs.

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Although recommending a specific process for coordination among federal S&T funding agencies is not within the scope of this policy paper, IEEE-USA notes that Neal Lane, a former presidential science adviser’s suggestion, has merit: “The National Science and Technology Council (NSTC), and its coordinating committees have done good work, for example, in helping to organize the National Nanotechnology Initiative in the Clinton administration, but the NSTC needs more clout. The administration and Congress should consider authorizing the NSTC, and providing a line of funding in the White House Office of Science and Technology Policy budget for NSTC staffing and activities--such as reports, workshops and seed funding for interagency cooperative R&D efforts.”  

Federal support of fundamental research can have increased impact by reducing the administrative burden associated with managing this research. Administrative workload placed on federally funded researchers at U.S. institutions is interfering with the conduct of science. A 2005 Federal Demonstration Partnership (FDP) survey of investigators found that principal investigators (PIs) of federally sponsored research projects spend, on average, 42 percent of their time on associated administrative tasks. Seven years later, and despite collective federal reform efforts, a 2012 FDP survey found the average remained at 42 percent. The National Research Council has already identified reducing this excessive burden as a top-10 priority, and both the Association of American Universities and the National Science Board, have recommended actions that the federal government can take.

The importance of a well-qualified STEM work force has been addressed effectively in many studies. Here, we note the essential role of fundamental research in STEM education. Most STEM graduate students, many undergraduates, and even some high school students are involved in federally funded research.

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