



United States Government Accountability Office  
Washington, DC 20548

October 7, 2010

The Honorable John D. Rockefeller, IV  
Chairman  
The Honorable Kay Bailey Hutchison  
Ranking Member  
Committee on Commerce, Science,  
and Transportation  
United States Senate

The Honorable Jeff Bingaman  
Chairman  
The Honorable Lisa Murkowski  
Ranking Member  
Committee on Energy and Natural Resources  
United States Senate

The Honorable Bart Gordon  
Chairman  
The Honorable Ralph M. Hall  
Ranking Member  
Committee on Science and Technology  
House of Representatives

*Subject: America COMPETES Act: It Is Too Early to Evaluate Programs  
Long-Term Effectiveness, but Agencies Could Improve Reporting of  
High-Risk, High-Reward Research Priorities*

Scientific and technological innovation and a workforce educated in advanced technology are critical to the long-term economic competitiveness and prosperity of the United States. In recent years, leaders in government, business, and education have reported their concerns that declining federal funding for basic scientific research could diminish the United States' future economic competitiveness. These leaders have also reported their concerns that our educational system is producing too few students trained in the fields of science, technology, engineering, and mathematics (STEM), which they believe may drive jobs in technical fields—followed by jobs in manufacturing, administration, and finance—from the United States to other countries.

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Congress passed the America Creating Opportunities to Meaningfully Promote Excellence in Technology, Education, and Science Act (COMPETES Act) of 2007<sup>1</sup> with the overall goal of increasing federal investment in scientific research to improve U.S. economic competitiveness. To that end, the act also increased support for education in STEM fields. Specifically, the act authorized \$33.6 billion from fiscal year 2008 through fiscal year 2010, in appropriations to be spent by four federal agencies:

- the Department of Education,
- the Department of Energy (DOE),
- the National Institute of Standards and Technology (NIST) within the Department of Commerce, and
- the National Science Foundation (NSF).

Within these four agencies, the act authorized funding for 24 new programs and the expansion of 20 existing programs to increase federal investment in basic scientific research and STEM education in the United States. The act also authorized the establishment of a new agency—the Advanced Research Projects Agency-Energy (ARPA-E)—within DOE to support transformational energy technology research projects to enhance the country’s economic and energy security.

In addition, the act established specific goals for some of the individual programs and includes a number of reporting provisions. Section 1008 of the act expresses the sense of Congress that each executive agency conducting research in STEM fields should strive to support and promote innovation by setting a goal of allocating an appropriate percentage of its basic research budget toward funding high-risk, high-reward research. The act describes high-risk, high-reward research projects as those that should also (1) meet fundamental scientific or technical challenges, (2) involve multidisciplinary work, and (3) involve a high degree of novelty.<sup>2</sup> With

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<sup>1</sup>Pub. L. No. 110-69, 121 Stat. 572 (Aug. 9, 2007).

<sup>2</sup>Also, Congress is currently considering proposed legislation that would establish additional requirements for prioritizing high-risk, high-reward research. See H.R.5116, §§ 221, 228(c)(2), 246(d)(2), referred to Senate Commerce, Science, and Transportation Committee (June 29, 2010).

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respect to agencies conducting basic STEM research, the COMPETES Act provides for the following actions:

- *Goal setting*—Agencies are annually required to report whether they have set a percentage funding goal for high-risk, high-reward research.
- *Spending toward goal*—Agencies that set such a goal must report whether the goal is being met by the agencies and describe the activities funded.
- *Manner of reporting*—Agencies are required to report this information to Congress along with documents supporting their annual budget.

The COMPETES Act requires GAO to evaluate, within 3 years following its enactment, the effectiveness of authorized programs. To satisfy this reporting requirement, we briefed your staffs on the results of our work on August 5, 2010, and this report provides additional details. Our reporting objectives for this review were to examine (1) the extent to which the four agencies that received funding have obligated and reported funding for new or expanded programs and activities and (2) the effectiveness of the new or expanded programs and activities in meeting the goals of the act.<sup>3</sup>

To examine the extent to which agencies have obligated funds and implemented programs, we reviewed the relevant provisions of the act, program documents, budget information, and interviewed agency officials. To evaluate the effectiveness of new or expanded programs, we reviewed a nongeneralizable, nonprobability sample of seven scientific research and education projects that illustrate authorized programs within each of the four agencies that received funding. We reviewed the mechanisms the agencies are using to measure the projects' effectiveness, and interviewed officials at research universities and a private company to learn how they evaluate research and education efforts. Enclosure I contains a more detailed description of our scope and methodology.

We conducted this performance audit from March 2010 through October 2010 in accordance with generally accepted government auditing standards. Those standards require that we plan and perform the audit to

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<sup>3</sup>For purposes of this review, we defined new programs as those programs authorized by the act to receive their initial appropriations beginning in fiscal year 2008. We defined expanded programs to be existing programs that the act authorized to receive increased appropriations from fiscal year 2008 to fiscal year 2010.

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obtain sufficient, appropriate evidence to provide a reasonable basis for our findings and conclusions based on our audit objectives. We believe that the evidence obtained provides a reasonable basis for our findings and conclusions based on our audit objectives.

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## Results in Brief

The four agencies that received funds authorized under the COMPETES Act obligated about \$30 billion for new and expanded research and education programs and activities from fiscal year 2008 to fiscal year 2010; scientific research obligations totaled about \$27 billion and STEM education obligations totaled about \$3 billion. Three of the four agencies we reviewed—DOE, NSF, and NIST—conducted basic scientific research. However, they did not consistently set a percentage funding goal to support high-risk, high-reward research—something that Congress provided they should do. In addition, two of these three agencies did not report this information with their annual budget submissions, as the law provides. Agency officials provided us with information indicating that they faced challenges in defining such research, and as a result, each program applied the criteria in the act differently. In addition, the directors of the Office of Management and Budget (OMB) and the Office of Science and Technology Policy (OSTP) jointly issued a memo in August 2009 specifying that agencies conducting science research should explain in their budget submissions how they will support such activities and cooperate with them to develop datasets on federal science and technology investments, although this memorandum did not direct agencies on how to do so or direct them to set a percentage goal.

Because the new programs authorized and funded under the COMPETES Act have only recently received and obligated funding, and because of the difficulties we and others have reported as being inherent in measuring outcomes of research and educational programs, it is too early to assess the effectiveness of these programs. However, all four of the agencies we reviewed are taking steps to oversee the implementation of various projects and monitor their progress. For example, the agencies are collecting various types of project data to monitor progress toward cost, schedule, and program outputs.

We are recommending that DOE, NSF, and NIST each set a goal for funding high-risk, high-reward research and that the agencies coordinate in doing so. We are also recommending that the agencies include information on high-risk, high-reward research with their annual budget requests, which are available to the public.

In commenting on our draft report, Commerce agreed with both recommendations and NSF agreed with the recommendation to report to Congress. Additionally, OSTP, DOE, and NSF expressed concerns about aspects of our recommendation that agencies funded under the COMPETES Act identify a percentage goal for funding high-risk, high-reward research. Despite these concerns, we believe that agencies should seek to provide the information, as expressed in the sense of the Congress as provided in the act, and therefore believe this recommendation remains valid.

**Agencies Obligated about \$30 Billion for Research and Education Programs but Have Not Consistently Reported about their High-Risk, High-Reward Research Activities**

The four agencies obligated funds and implemented new and expanded research and education programs and activities. However, the three agencies that conduct basic STEM research did not consistently report about their high-risk, high-reward research activities to Congress as the act provides they should. In addition, the directors of OMB and OSTP jointly issued a memo specifying that agencies conducting science research should explain in their budget submissions how they will support such activities.

**Research Obligations Totaled about \$27 Billion, and Education Obligations Totaled about \$3 Billion**

We found that the four agencies obligated about \$30 billion under the act—scientific research obligations totaled about \$27 billion, and STEM education obligations totaled about \$3 billion. Table 1 shows the distribution of these funds for the four agencies.

**Table 1: Obligations by Agency of Appropriations Authorized by the COMPETES Act**

(Millions of current-year dollars)

	FY 2008 obligated	FY 2009 obligated	FY 2010 obligated <sup>a</sup>	Total
<b>Scientific Research Programs Total</b>	<b>\$5,753.2</b>	<b>\$8,560.2</b>	<b>\$13,133.8</b>	<b>\$27,447.2</b>
NSF	5,020.1	7,629.8	6,366.9	<b>\$19,016.8</b>
DOE <sup>b</sup>	0	4.2	5,350.8	<b>\$5,355.0</b>
NIST	733.1	926.2	1,416.1	<b>\$3,075.4</b>

	FY 2008 obligated	FY 2009 obligated	FY 2010 obligated <sup>a</sup>	Total
<b>STEM Education Programs Total</b>	<b>\$768.3</b>	<b>\$932.7</b>	<b>\$890.0</b>	<b>\$2,591.0</b>
NSF	766.3	930.5	887.8	\$2,584.6
Department of Education	2.0	2.2	2.2	\$6.4
<b>Total</b>				<b>\$30,038.1</b>

Source: GAO analysis of these agencies' data.

<sup>a</sup>Fiscal year 2010 obligations include estimated obligations until the end of the fiscal year. Estimates were provided by DOE, NIST, and the Department of Education in July 2010, and by NSF in April 2010.

<sup>b</sup>ARPA-E did not receive appropriations until fiscal year 2009. In addition, authorization of funding in the COMPETES Act for DOE's Office of Science applied only to fiscal year 2010; funding for the Office of Science was authorized for prior fiscal years including fiscal year 2008 and fiscal year 2009 in the Energy Policy Act of 2005 (P.L. 109-58).

We found that the agencies funded a broad range of research from conceptual basic science to near-market efforts. For example, basic scientific research included NIST's research in precise measurement, which may result in a range of applications for advances in computing power and accurate timekeeping—advances that may in turn have broad economic benefits, such as improving electric power delivery or radiation detection. Near-market research included ARPA-E funding for projects designed for more specific applications, such as advancing residential energy efficiency or reducing the costs of generating renewable energy.

The agencies' obligations for STEM education programs totaled about \$3 billion, and were primarily funded through NSF. These programs included the Robert Noyce Teacher Scholarship Program, which seeks to encourage STEM majors and professionals to become Kindergarten through 12th grade (K-12) mathematics and science teachers. In addition, the Department of Education obligated about \$6 million for the Teachers for a Competitive Tomorrow program, which is designed to help student teachers in STEM fields and critical foreign languages, and help professionals earn master's degrees in teaching, which would in turn provide certified teachers to educate K-12 students.<sup>4</sup>

<sup>4</sup>The Department of Education's Teachers for a Competitive Tomorrow program provides funding for both undergraduate- and graduate-level students.

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Agencies Have Not Consistently Reported Spending on High-Risk, High-Reward Research to Congress and Have Defined This Research Differently

The three agencies we reviewed that conducted basic scientific research in STEM fields have not consistently reported to Congress on spending supporting high-risk, high-reward research.<sup>5</sup> Furthermore, we found that the agencies defined this research differently, which led to their using different approaches for defining high-risk, high-reward research. Specifically, for these three agencies, we found the following:

**DOE.** DOE's Office of Science did not set a goal to fund high-risk, high-reward research, and reported this in its annual budget submissions. DOE officials noted that the agency has a long history of supporting basic research, which has resulted in significant scientific and other accomplishments. With respect to goal setting under the act, DOE's Office of Science reported to Congress that it did not set a percentage funding goal for high-risk, high-reward research. By doing so, DOE's Office of Science met the reporting requirement. However, information provided by the Office of Science during our review indicated that it considers a significant proportion of its research to be high-risk, high-reward. In our discussions with officials from the Office of Science, they expressed concern that high-risk, high-reward research was difficult to define. Furthermore, officials stated that individual research projects included both high-risk, high-reward elements, along with other elements, which made it difficult to identify how much funding supported the high-risk components. DOE officials also stated that defining high-risk, high-reward research depends largely on the particular scientific and technical field and the stage of research. With regard to reporting spending toward its goal, because DOE did not set a percentage funding goal, it was not required to report such spending. With respect to the manner of reporting, DOE reported this information with its annual budget documents.<sup>6</sup>

DOE's ARPA-E does not fund basic scientific research, and, as such, officials did not set a percentage goal of basic research. Instead, ARPA-E officials told us that the agency predominantly funds research and development that has moved beyond basic scientific research, but is not yet commercially viable. These types of projects have not routinely

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<sup>5</sup>This reporting requirement does not apply to the Department of Education as it does not conduct or fund basic scientific research in STEM fields.

<sup>6</sup>Department of Energy, FY 2009 Congressional Budget Request, Volume 4, Science, DOE/CF-027 (Washington, D.C., February 2008), 15; and Department of Energy, FY 2010 Congressional Budget Request, Volume 4, Science, DOE/CF-038 (Washington, D.C., May 2009), 12.

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received funding from public or private sources. ARPA-E officials told us that they focus on research projects that have potentially high rewards and some high-risk elements, such as a high risk that there may not be a market for the resulting technologies and a high risk that certain technological hurdles will not be easily overcome.

**NSF.** NSF did not set a goal to fund high-risk, high-reward research, but did not report this in its annual budget submissions. With respect to goal setting, NSF met this aspect of the reporting requirement by reporting that it had not set a percentage funding goal to support high-risk, high-reward research. NSF officials noted that high-risk, high-reward research was not easily defined. NSF did not report what percentage of its budget for basic research was being allocated toward this type of research, as the act provides that it should, because NSF maintains that there is no formula that could establish an appropriate percentage of basic research that should be high-risk, high-reward. Instead, NSF referred to what it calls “potentially transformative research”—which it defines as high-reward research that may or may not be high-risk. NSF explained that potentially transformative research is similar, but not synonymous with, high-risk, high-reward research. NSF reported that it plans to spend at least \$94 million in fiscal year 2010 on this research—less than 2 percent of its fiscal year 2010 research budget. In addition, NSF officials reported that they believe it is most effective to foster a research climate conducive to potentially transformative research. With regard to spending toward its goal, because NSF did not set a goal for high-risk, high-reward research, it was not required to report spending. With respect to the manner of reporting, NSF officials told us they did not provide its report with its annual budget submission but instead submitted it in separate letters to congressional leaders, which are not readily available to the public.<sup>7</sup> NSF included similar information in one of its recent publicly available budget submissions regarding high-risk, high-reward research, but NSF did not report whether it had set a percentage funding goal.

**NIST.** NIST set a goal to fund high-risk, high-reward research, but did not report this in its annual budget submissions. With respect to setting a goal, NIST reported that it had set a percentage funding goal to fund high-risk, high-reward research. NIST determined that several programs in its research portfolio represented high-risk, high-reward research and

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<sup>7</sup>NSF submitted letters to the Speaker of the House and the House Minority Leader and to the Majority and Minority Leaders of the Senate in fiscal years 2009 and 2010.



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aggregated these programs' proposed budgets to develop its percentage funding goal. With respect to spending toward its goal, NIST has not reported its prior year spending but reported planned spending in each fiscal year in which it reported. With respect to the manner of reporting, NIST did not report this information along with its other budget documents but instead submitted it in separate letters to authorizing congressional committees, without publicly releasing them.<sup>8</sup> For fiscal years 2009 and 2010, NIST did not mention high-risk, high-reward research in updates to its 3-year programmatic plans.

**Definition of high-risk, high-reward research.** The COMPETES Act provided some elements that the agencies could use to determine what basic research constituted high-risk, high-reward research; however, agency officials told us that high-risk, high-reward research was difficult to define and that they were not certain how these criteria applied to their programs. Because each agency perceived ambiguities in how high-risk, high-reward applied to the research they oversee, each agency made its own determination on how to apply these criteria. Consequently, the agencies have not reported their funding for this research consistently, and Congress has not received the information it sought regarding this research. As a result, it is more difficult for Congress to monitor spending for high-risk, high-reward research by individual agencies or track the effectiveness of these investments. In addition to the act, the directors of OMB and OSTP specified in an August 2009 memo that agencies conducting science research should explain, in their fiscal year 2011 budget submissions, how they will support high-risk, high-reward research, although this memorandum did not specify that agencies should set a percentage goal.<sup>9</sup> In this memo, the directors of OMB and OSTP further stated that to explain how federal science and technology investments contribute to increased economic productivity and progress, new energy technologies, improved health outcomes, and other national goals, federal agencies should cooperate with them to develop datasets better documenting federal science and technology investments. The

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<sup>8</sup>NIST submitted these letters to the Chair and the Minority Leader of the House Committee on Science and Technology and the Senate Committee on Commerce, Science, and Transportation. NIST officials told us that, although the information was not publicly released on its Web site or with its budget documents, that they were publicly available if specifically requested.

<sup>9</sup>See Executive Office of the President, Office of Management and Budget, Office of Science and Technology Policy, *Science and Technology Priorities for the FY 2011 Budget* (Washington, D.C., Aug. 4, 2009).

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memo also states that these data should be open to the public in accessible, useful formats. Officials from DOE, NSF, and NIST told us that they consulted with OMB concerning high-risk, high-reward research. However, although each agency has expertise with evaluating basic research, they have not consulted with each other or with OMB and OSTP to develop a more consistent definition of this research. As we have previously reported, coordination among agencies can be difficult, as it requires staff working across agency lines to define and articulate the common federal outcome or purpose they are seeking to achieve that is consistent with their respective agency goals and mission.<sup>10</sup> We have also reported that collaboration among federal agencies can be enhanced by establishing mechanisms to operate across organization boundaries, such as by developing a common definition of what constitutes high-risk, high-reward research. Furthermore, we have reported that collaboration can provide more public value than agencies could otherwise provide alone.<sup>11</sup>

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## While It Is Too Early to Evaluate Programs' Effectiveness, Agencies Are Taking Steps to Oversee Project Implementation and Using Different Approaches to Assess Progress toward Long-Term Outcomes

It is too early to evaluate the four agencies' new or expanded programs and activities in meeting the goals of the act. All four of the agencies are taking steps to oversee the implementation of various projects and using different approaches to collect data for assessing progress toward achieving long-term outcomes.

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<sup>10</sup>GAO, *Managing for Results: Barriers to Interagency Coordination*, [GAO/GGD-00-106](#) (Washington, D.C.: Mar. 29, 2000).

<sup>11</sup>GAO, *Results-Oriented Government: Practices That Can Help Enhance and Sustain Collaboration among Federal Agencies*, [GAO-06-15](#) (Washington, D.C.: Oct. 21, 2005).

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## Evaluating Effectiveness of Federal Research and STEM Education Programs in General Can Be Difficult

Because the new programs authorized under the COMPETES Act have only recently obligated the money provided to them, it is too early to assess their effectiveness. Four of the newly authorized programs received appropriated funds and were implemented—DOE’s ARPA-E, NIST’s Technology Innovation Program, the Department of Education’s Teachers for a Competitive Tomorrow, and NSF’s Science Master’s Degree Program;<sup>12</sup> the other 20 newly authorized programs were not funded. DOE’s ARPA-E began receiving funding in fiscal year 2009 through the American Recovery and Reinvestment Act of 2009 (ARRA).<sup>13</sup> ARPA-E makes up the largest portion of new programs funded under the COMPETES Act. From April 2009 to July 2010, it completed three rounds of funding, awarding a total of \$349 million to 117 transformative energy projects—research into technologies with the potential to change how the U.S. generates, stores, and utilizes energy—in 18 states. With regard to NIST’s Technology Innovation Program, it began receiving funding in fiscal year 2008. In the program’s 2008 Annual Report, NIST reported that it spent the initial year staffing the program, identifying critical needs areas, and issuing implementing regulations required by the act.<sup>14</sup> NIST announced the first project awards in January 2009, and to date has awarded a total of \$113.5 million to 29 projects in civil infrastructure and manufacturing.<sup>15</sup> The Department of Education’s Teachers for a Competitive Tomorrow program began obligating funding in fiscal year 2008. The program has awarded \$6 million to 8 grant recipients since it began. NSF’s Science Master’s Program received its initial appropriations in fiscal year 2009 through ARRA. The program awarded 21 grants in fiscal year 2010, totaling \$14.6 million. Collectively, these new programs have awarded about \$483 million in funding to a total of 174 projects.

For programs expanded by the act, it is too early to tell how effective these programs have been, and agency officials told us that it is also

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<sup>12</sup>This program was authorized by section 7034 of the act as the “Professional Science Master’s Degree Program.” In addition to changing the name of the program, while the program was originally authorized to be funded through NSF’s research and related activities account, NSF funded the program through its education and human resource funding beginning in fiscal year 2010, according to information from NSF.

<sup>13</sup>Pub. L. No. 111-5, 123 Stat. 115 (Feb. 17, 2009).

<sup>14</sup>See section 3012(b), amending the National Institute of Standards and Technology Act (15 U.S.C. 271 et seq.).

<sup>15</sup>NIST issued a third funding solicitation in April 2010, through which it plans to award up to an additional \$25 million in funding to projects anticipated to begin in January 2011.

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difficult to distinguish the incremental activities funded under the COMPETES Act. For example, DOE Office of Science budget officials told us it could not easily identify the effectiveness of the projects that were specifically expanded across its six research programs resulting from the incremental increases in program funding provided based on authorizations in the act. These officials noted that in some cases, projects were expanded from their original research focus but not in ways that would allow the officials to attribute the specific results to the incremental funding.

Moreover, we and others have also found that evaluating the effectiveness of federal basic research and STEM education programs such as those authorized by the act can be inherently difficult.<sup>16</sup> We have long recognized the difficulties of developing useful results-oriented performance measures for federal research programs, and that the uncertain nature of research outcomes over time can make it challenging to set specific and measurable goals that demonstrate the results of these programs.<sup>17</sup> Some of the challenges we and others have identified in evaluating the effectiveness of basic research programs include:

- results may take a long time;
- unpredictability of the pace of research makes it hard to annually measure outcomes; and

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<sup>16</sup>For example, see GAO, *Performance Budgeting: PART Focuses Attention on Program Performance, but More Can Be Done to Engage Congress*, [GAO-06-28](#) (Washington, D.C.: Oct. 28, 2005); GAO, *Higher Education: Federal Science, Technology, Engineering, and Mathematics Programs and Related Trends*, [GAO-06-114](#) (Washington, D.C.: Oct. 12, 2005); U.S. Department of Education, *Report of the Academic Competitiveness Council* (Washington, D.C., 2007); Committee on Science, Engineering, and Public Policy, *Evaluating Federal Research Programs: Research and the Government Performance and Results Act* (Washington, D.C.: Feb. 1999); and Office of Management and Budget, “Program Assessment Rating Tool Guidance No. 2008-01, Appendix C: Research and Development Program Investment Criteria,” (January 2008)

<sup>17</sup>See, e.g. GAO, *Performance Budgeting: PART Focuses Attention on Program Performance, but More Can Be Done to Engage Congress*, [GAO-06-28](#) (Washington, D.C.: Oct. 28, 2005); GAO, *Pipeline Safety: Systematic Process Needed to Evaluate Outcomes of Research and Development Program*, [GAO-03-746](#) (Washington, D.C.: June 2003); and GAO, *Highway Research: Systematic Selection and Evaluation Processes Needed for Research Program*, [GAO-02-573](#) (Washington, D.C.: May 2002).

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- research may not achieve its intended results but can lead to unexpected discoveries that provide potentially more interesting and valuable results.

Challenges we and others have identified in evaluating the effectiveness of STEM education programs include

- linking results from an individual program with agency wide or government-wide goals;
- limited evidence collected by agencies that provides a basis for drawing conclusions about the effectiveness of these programs; and
- ambiguities in identifying careers which are not traditionally classified as STEM, which can create challenges in tracking long-term career outcomes.<sup>18</sup>

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### Agencies Are Taking Steps to Oversee Project Implementation and Using Different Approaches to Assess Progress Toward Long-Term Outcomes

The agencies are collecting various types of project data to monitor progress toward cost, schedule, and program outputs. For example, for the construction projects we visited, agency officials told us they are using the earned value management system,<sup>19</sup> which tracks progress toward cost and schedule milestones. These projects include NSF's Ocean Observatories Initiative and NIST's construction of the new Precision Measurement Laboratory at its Boulder, CO, facility. (For more information regarding these projects, see Enclosure I). ARPA-E officials reported that they are overseeing the performance of their research projects in a number of ways, including requiring award recipients to submit periodic progress reports, regularly visiting project sites, and conducting annual reviews of project performance. These officials told us that the award agreements for each project includes a set of negotiated technical milestones and that each project will be annually assessed to determine whether it should proceed or be modified or terminated.

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<sup>18</sup>Traditional classifications of commonly tracked STEM-related careers may not include graduates who use their degrees to pursue other STEM-related careers, such as managers at technology companies or patent lawyers.

<sup>19</sup>An earned value management system has the ability to combine measurements of scope, schedule, and cost in a single integrated system. If implemented appropriately, this system can provide objective reports of project status, produce early warning signs of impending schedule slippages and cost overruns, and provide unbiased estimates of anticipated costs at completion.

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The agencies are also collecting various output data as indicators of program performance. For example, according to NIST documents, NIST's Technology Innovation Program plans to evaluate project performance through several short-term output metrics, such as the number of patent applications, journal publications, and amount of additional follow-on investment. However, NIST documents indicated that these measures are time lagged, and that the agency does not expect results to be generated until at least 3 years of project research are complete.

For the STEM education programs, the Department of Education's Teachers for a Competitive Tomorrow program is collecting performance information and annual reports from each of its grant recipients to evaluate the extent to which they are succeeding in meeting the purposes of the program. Data to be collected include the number of student teachers participating in the program, their majors, demographics, and data on employment placement, and graduates continuing to teach in the STEM fields, particularly in schools determined to have the highest need.

Also, the agencies are using different approaches to evaluate effectiveness and progress towards long-term outcomes. The research agencies we reviewed—DOE's Office of Science, NSF, and NIST—each used peer review to various degrees to qualitatively assess the effectiveness of their research programs and evaluate progress towards long-term outcomes. For example, DOE's Office of Science, which generally funds basic scientific research, periodically reviews each of its six research programs once every 3 years using panels comprised of expert reviewers from academia, DOE's national laboratories, other federal agencies, and the private sector. DOE also uses other peer-review mechanisms to manage its research portfolio. NSF conducts similar activities, such as panels comprised of expert reviewers, which it uses to assess the quality of research and its effectiveness in meeting NSF's goals. These reviews assess the quality of the processes used to solicit and review project proposals and the resulting quality of the program's research portfolio. In evaluating progress toward long-term outcomes, the experts review a range of program information to qualitatively assess progress on a scale from poor to excellent. Also, ARPA-E is currently developing its strategic plan, which will include long-term goals and measures that it will use to evaluate its program outcomes. For STEM education programs, we also found that the NSF and Education are taking steps to evaluate the long-term effectiveness of their funded projects. As part of its broader initiative to pilot and reviewed new approaches to the evaluation of its programs, NSF developed goals and metrics for activities in its education portfolio to reflect its increased expectations for evaluation of its funded projects.

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NSF documents represent that these metrics will be used to assess the programs and provide information for improving the programs and opportunities to move in new directions. For example, for its Robert Noyce Teacher Scholarship Program, NSF is negotiating a contract to conduct longitudinal studies of program graduates as their careers progress, effect of program on recruitment to teacher preparation programs, and comparative studies to examine practices that are most related to keeping teachers in high-need areas. NSF is also collaborating with the President's Office of Science and Technology Policy and other federal agencies on the STAR METRICS project.<sup>20</sup> This project is working to improve collaboration between federal agencies and those in the research community to better document the evidence needed to describe and assess the impacts of the federal investments in science research and education. To evaluate the effectiveness of Education's Teachers for a Competitive Tomorrow program in meeting long-term program outcomes, program documents indicate that the agency will evaluate recipient's annual reports and data collected on a range of performance measures to assess the extent to which the program is succeeding in increasing the percentage of highly qualified STEM teachers in high-need areas, increasing the number of students enrolled in STEM programs, and data on teacher placement and retention rates, among other aspects.

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## Conclusions

The COMPETES Act seeks to address many factors contributing to scientific and educational achievements in the United States, such as sustained investments in scientific research and education. While it is too soon to tell how effective the research and educational investments authorized by the act will be in improving the science and technology outcomes laid out in the act, agencies have made progress collecting data and monitoring the outputs of the programs they oversee to prepare for such an evaluation in the future.

While it is difficult to precisely define high-risk, high-reward research, agencies could improve their reporting of these activities, which would aid in improving congressional oversight. Toward this end, the law provided a sense of the Congress that agencies should provide key information which not all agencies provided. In particular, none of the agencies reported a

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<sup>20</sup>STAR METRICS stands for Science and Technology in America's Reinvestment—Measuring the Effect of Research on Innovation, Competitiveness and Science. The project is intended to monitor the impact of federal science investments on employment, knowledge generation, and health outcomes.

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percentage funding goal for high-risk, high-reward research with their annual budget requests. Although the COMPETES Act allows agencies to report that they have not set a goal—as DOE chose to do to comply with the reporting requirement—Congress provided that agencies should set a goal. Such information could be useful in evaluating whether agencies aim to pursue the appropriate balance of such research as part of their overall research budget. However, because agencies did not provide it, Congress did not have this information readily available for review during its consideration of the overall budget. Although OMB and OSTP suggested that the agencies should cooperate with them to develop datasets better documenting federal science and technology investments, such cooperation or coordination among the agencies has not taken place to date to consistently define this research. Officials with each of the agencies we reviewed also voiced difficulty regarding defining high-risk, high-reward research meaningfully and consistently. As a result, agencies used differing methods to define high-risk, high-reward research—with one agency, NIST, identifying the budgets of entire programs, and other agencies, such as NSF and DOE, focusing on specific research proposals. Congress needs consistent information to effectively oversee the degree to which high-risk, high-reward research is being conducted within the programs and investments it authorized with the America COMPETES Act. We recognize that coordination can be difficult, but if agencies work together to refine their approaches and provide this information to Congress, Congress could in turn, better determine if this approach meets its needs or if further clarification is needed. While it may have been difficult to set goals for high-risk, high-reward research immediately after enactment of the COMPETES Act, full implementation makes agencies' goal setting and complete reporting important for Congressional monitoring and oversight.

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## Recommendations for Executive Action

To better inform Congress regarding spending priorities for high-risk, high-reward basic research, we recommend that the Secretary of Commerce (by directing the Director of the National Institute of Standards and Technology), the Secretary of Energy, and the Acting Director of the National Science Foundation each take the following two actions:

- establish a percentage goal to fund high-risk, high-reward research, and in setting a goal, cooperate and coordinate with other agencies funded under the COMPETES Act that perform basic scientific research—as well as OMB and OSTP—to more clearly define and identify these research activities, and



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- report this information as part of their annual budget submissions to Congress—which are available to the public—as provided by the act.

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## Agency Comments and Our Evaluation

We provided a copy of our draft report to the Director of the Office of Science and Technology Policy; the Secretaries of Commerce, Education, and Energy; and the Acting Director of the National Science Foundation. OSTP, the Department of Commerce, DOE, and NSF provided written comments, which are reprinted in Enclosures II, III, IV, and V of this report, respectively.<sup>21</sup>

OSTP provided written comments noting that it found the report to be accurate, concise, and complete in its assessment of the America COMPETES Act and is supportive of high-risk, high-reward research, but was concerned about aspects of the Act's reporting provisions, particularly regarding setting numerical targets for high-risk, high-reward research. We understand OSTP's concern, but we continue to believe that, unless agencies attempt to fulfill the sense of the Congress and the act's reporting provision, Congress cannot receive the views of agencies regarding this concern; consequently, we did not change our recommendation. OSTP's comments and our evaluation of them are attached as Enclosure II. Commerce provided written comments concurring with our findings and recommendations. Commerce's comments are attached as Enclosure III. DOE provided written comments stating that the agency disagreed with some of our findings, conclusions, and recommendations. In particular, the agency disagreed with our characterization of some activities of its Office of Science and with our recommendation that DOE establish a percentage goal for high-risk, high-reward research, as Congress provided they should. We incorporated DOE's comments as appropriate by changing the text to clarify our findings, such as including more information about DOE's efforts in promoting high-risk, high-reward research. However, we continue to believe that each agency charged with the reporting provision should attempt to fulfill it by using its own definition; consequently, we did not change our recommendations. DOE's comments and our evaluation of them are attached as Enclosure IV. NSF provided written comments agreeing with the second recommendation to report to Congress, but expressing concerns about some elements in our draft report and the first

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<sup>21</sup> Agency comments refer to the draft report as GAO-10-1040R. That report number has since changed to GAO-11-127R.

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recommendation. In particular, NSF expressed concern about our findings on their reporting of high-risk, high-reward research, and about our recommendation that NSF set a percentage goal for funding high-risk, high-reward research. We changed the text to clarify our findings regarding NSF's reporting of its high-risk, high-reward research, but we continue to recommend that the agencies, which are the most informed about the research they fund, fulfill the sense of the Congress and the reporting provision. NSF's comments and our evaluation of them are attached as Enclosure V. Education and DOE also provided technical comments, which we incorporated where appropriate.

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We are sending copies of this report to the appropriate congressional committees; Secretaries of Commerce, Education, and Energy; the Director of the National Institute of Standards and Technology; the Acting Director of the National Science Foundation; and other interested parties. In addition, this report will be available at no charge on the GAO Web site at <http://www.gao.gov>.

If you or your staff members have any questions about this report, please contact me at (202) 512-3841 or [ruscof@gao.gov](mailto:ruscof@gao.gov). Contact points for our Offices of Congressional Relations and Public Affairs may be found on the last page of this report. Key contributors to this report were Jon Ludwigson (Assistant Director), Lee Carroll, Jonathan Kucskar, Michael Meleady, Alison O'Neill, and Laina Poon. In addition, Casey Brown and Virginia Vanderlinde also made important contributions.



Frank W. Rusco  
Director, Natural Resources  
and Environment

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# Enclosure I: Objectives, Scope, and Methodology

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The COMPETES Act required GAO to evaluate, within three years following its enactment, the effectiveness of authorized programs. In response to this requirement, our reporting objectives for this review were to examine (1) the extent to which the agencies have obligated funds for new or expanded programs and activities, and (2) the effectiveness of the new or expanded programs and activities in meeting the goals of the act.

To assess the extent to which agencies have obligated funds for new and expanded programs under the act, we reviewed the relevant provisions of the act, program documents, budget information, and interviewed agency officials. We defined new programs as those programs authorized by the act to receive their initial appropriations beginning in fiscal year 2008. We defined expanded programs to mean existing programs that the act authorized to receive increased appropriations from fiscal year 2008 to fiscal year 2010. We evaluated the reliability of the data provided by agencies on their budgetary obligations by corroborating this data with other published sources. Because financial obligations for fiscal year 2010 were not final, we relied on the agencies' estimates for that fiscal year.

To evaluate the effectiveness of these programs, we reviewed a judgmental sample of seven scientific research and education projects that illustrate authorized programs within the four agencies that received funding. We selected the sample to include projects within both new and existing programs. We focused on those that were implemented in 2008 or 2009 because they were more likely to be established enough for us to evaluate their effectiveness. We also looked for a range of project characteristics, such as award size, project scale, location, focus (scientific research or STEM education), and agency. See Table 2 for a summary of the projects we reviewed. To review the mechanisms agencies are using to measure these projects' effectiveness, we analyzed documents, interviewed officials, and visited these projects' sites.<sup>1</sup> In addition, to expand our understanding of methods for evaluating the effectiveness of scientific research and STEM education programs, we interviewed officials responsible for research at Stanford, Harvard, the University of Washington, and Google to learn how they evaluate research and education efforts.

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<sup>1</sup>We conducted site visits at all of the projects we reviewed with the exception of one project, representing the Department of Education's Teachers for a Competitive Tomorrow program. For this program, we reviewed documents and communicated with program officials remotely.

**Table 2: Summary Information for Projects We Reviewed under the COMPETES Act**

(In millions)

<b>Project</b>	<b>Approximate cost</b>	<b>Project Duration</b>
Robert Noyce, San Jose State U.	\$0.5	Spring 2004 to Fall 2009
NSF, Ocean Observatory Institute (OOI)	126	September 2009 to September 2014
DOE, ARPA-E, Foro Energy Thermodynamic drilling	18	Early 2009 to mid-2012
DOE, ARPA-E, Stanford Large Energy Reductions	6	April 2010 to April 2012
NIST, Bldg 1 Expansion (Precision Measurement Laboratory), Boulder, CO	102	FY 2007- FY 2012
NIST, Scientific and Technical Research Services, Boulder, CO Labs	100	ongoing
Department of Education, Teachers for a Competitive Tomorrow, William Paterson University, NJ	1	FY 2008- FY 2013

Source: GAO analysis.

We conducted this performance audit from March 2010 through July 2010, in accordance with generally accepted government auditing standards. Those standards require that we plan and perform the audit to obtain sufficient, appropriate evidence to provide a reasonable basis for our findings and conclusions based on our audit objectives. We believe that the evidence obtained provides a reasonable basis for our findings and conclusions based on our audit objectives.

# Enclosure II: Comments from the Office of Science and Technology Policy

Note: GAO comments supplementing those in the report text appear at the end of this enclosure. Agency comments refer to the draft report as GAO-10-1040R. That report number has since changed to GAO-11-127R.

EXECUTIVE OFFICE OF THE PRESIDENT  
OFFICE OF SCIENCE AND TECHNOLOGY POLICY  
WASHINGTON, D.C. 20502

Response to GAO Report GAO-10-1040R

September 23, 2010

Dear Sir or Madam,

Thank you for the opportunity to review the draft report, "America COMPETES Act: It is Too Early to Evaluate Programs' Long-Term Effectiveness, but Agencies Could Improve Reporting of Research Priorities." (GAO-10-1040R)

Overall, we find the report to be accurate, concise, and complete in its assessment of the America COMPETES Act of 2007. We agree with the GAO's assessment of the new or expanded programs and activities authorized in the Act, namely that it is too early to assess the effectiveness of these programs but that agencies are taking steps to evaluate these programs' ongoing impacts using different approaches.

We find the assessment of agencies' responses to Section 1008 of the Act to be accurate. Our concerns are mostly with the Act's requirements rather than how agencies are meeting them. We note that the America COMPETES Act defines 'basic research' by reference to OMB Circular A-11, but does not define either the terms 'high risk' or 'high reward.' It is our experience that there is enough background understanding of these concepts for OMB and OSTP to encourage agencies to support more HRHR research (as in the August 2009 memo referenced in the report), but without an explicit definition it is extremely difficult for agencies to set specific numerical targets for such research and to identify annually the percentages of agencies' basic research portfolios devoted to such research. We do not see the need for a government-wide definition; we believe it is appropriate for agencies to use differing methods to define HRHR research according to agency missions, time horizons, and program designs. Therefore, while OSTP is supportive of encouraging agencies to support HRHR research (as noted in the report), OSTP does not support specific numerical targets for HRHR research, nor does OSTP support establishing an explicit, government-wide definition for HRHR research. OSTP is also concerned that setting a numerical target for HRHR research may have the unintended consequence of segregating risk and reward in a small segment of an agency's research portfolio, making the non-HRHR portion of an agency's research portfolio less transformative, less risky, and potentially less rewarding.

We are pleased with the report's recognition of OSTP, OMB, and agency efforts to develop datasets on federal science and technology investments. We wish to make clear that these datasets are not intended to document high-risk, high-reward research as a separate category, but instead to document federal science and technology investments and their contributions to

See comment 1.

See comment 2.

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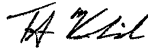
**Enclosure II: Comments from the Office of  
Science and Technology Policy**

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achieving key national goals such as economic growth and improved health outcomes. We are pleased with the report's recognition of STAR METRICS as one example of these efforts.

Again, thank you for the opportunity to provide comments on the draft report and for your continued interest in scientific and technological innovation.

Sincerely,



Tom Kalil  
Deputy Director for Policy  
Office of Science and Technology Policy

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The following are GAO's comments on the Office of Science and  
Technology Policy's (OSTP) letter dated September 23, 2010.

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## GAO Comments

1. We agree with OSTP that there can be meaningful distinctions in how agencies and programs interpret the definition of high-risk, high-reward. However, we believe that, given that Congress provided that the agencies funded under the America COMPETES Act should provide information on high-risk, high-reward research, it is important for each agency charged with the reporting requirement to attempt to fulfill it, at least initially, by using its own definition. In this way, Congress can both receive the views of agencies regarding the definition and consider whether to alter the reporting requirement or provide further direction to the agencies regarding the definition. We did not revise our report in response to this comment.
2. While we acknowledge these concerns, unless agencies attempt to fulfill the sense of the Congress, Congress will not receive the views of agencies regarding this concern. We did not revise the report in response to this comment.

# Enclosure III: Comments from the Department of Commerce

Note: Agency comments refer to the draft report as GAO-10-1040R. That report number has since changed to GAO-11-127R.



**UNITED STATES DEPARTMENT OF COMMERCE**  
The Secretary of Commerce  
Washington, D.C. 20230

September 27, 2010

Mr. Franklin Rusco  
Director  
Natural Resources and Environment  
United States Government Accountability Office  
Washington, D.C. 20548

Dear Mr. Rusco:

Thank you for the opportunity to comment on the draft report from the U.S. Government Accountability Office (GAO) entitled *America COMPETES Act: It Is Too Early to Evaluate Programs Long-term Effectiveness, but Agencies Could Improve Reporting of Research Priorities* (GAO-10-1040R).

We concur with the report's recommendations that the National Institute of Standards and Technology (NIST) sets a goal for funding high-risk, high-reward research and that NIST includes information on high-risk, high-reward research in its annual budget requests to Congress, as the law requires. The Department of Commerce has no comments to the report.

We look forward to receiving your final report. Should you have any questions regarding this response, please contact Rachel Kinney at (301) 957-8707.

Sincerely,

A handwritten signature in black ink that reads "Gary Locke".

Gary Locke



# Enclosure IV: Comments from the Department of Energy

Note: GAO comments supplementing those in the report text appear at the end of this enclosure. Agency comments refer to the draft report as GAO-10-1040R. That report number has since changed to GAO-11-127R.



Department of Energy  
Office of Science  
Washington, DC 20585  
September 30, 2010

Mr. Franklin Rusco  
Director, Natural Resources and Environment  
Government Accountability Office  
441 G Street, NW  
Washington, DC 20548

Dear Mr. Rusco,

Thank you for the opportunity to comment on the draft Government Accountability Office (GAO) report entitled "America COMPETES Act: It Is Too Early to Evaluate Programs Long-term Effectiveness, but Agencies Could Improve Reporting of Research Priorities" (GAO-10-1040R). We have reviewed the draft report and provide general comments below. The comments provided here have been coordinated with other relevant offices of the Department of Energy (DOE).

The GAO was charged by the America COMPETES Act to assess and evaluate the effectiveness of a representative sample of the new or expanded programs and activities, and report on those findings. We recognize that conducting a review of the agencies and activities authorized in the America COMPETES Act is an enormous undertaking, and in particular we appreciate the time the GAO took to review one of the Department's new programs, the Advanced Research Projects Agency—Energy (ARPA-E). Given that ARPA-E does not fund basic scientific research, DOE's comments on this report do not apply to the ARPA-E sections of this report.

We find, however, that the draft report is not well balanced between reporting on the assessment of the additional programs that have been established or expanded as a result of the America COMPETES Act and the evaluation of the effectiveness of those programs, and implementation of other specific activities. In particular, the report's focus on the agencies' implementation of the Section 1008 Sense of Congress regarding support for high-risk, high-reward basic research appears at the expense of providing meaningful details and discussion on agencies' programs and evaluation efforts. We would also like to note for the record, that while the GAO reviewed two of the ARPA-E programs, it decided to not assess a single DOE Office of Science program in depth as part of their review.

The report makes several generalized statements about the agencies' actions that suggest much broader deficiencies in the agencies' responsiveness to the requirements of the America COMPETES Act than the content of the GAO review and report substantively addresses. For example, the report summary states, "[h]owever, unless the agencies improve their reporting of their research activities, it will be difficult for Congress to conduct meaningful oversight." This generalized statement, without the appropriate context, appears to apply to all of the research activities of the agencies covered under the America COMPETES Act. If the intention is really

See comment 1.

See comment 2.

See comment 3.

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Enclosure IV: Comments from the Department of Energy

referring only to the reporting requirements specific to the Sense of Congress in Section 1008 of the Act, the language in the report needs to be much more specific so that this statement is not taken out of context. This is also an issue with the title of the report. The only reporting issue directly addressed in the report refers to Section 1008, but the title implies the issue is much broader. Several statements in the report also attempt to aggregate information that a subset of the reviewed agencies provided (e.g. statements that use phrases such as “one agency...” or “three of the agencies...”). We believe this approach does not provide the appropriate transparency about the information that the Department actually provided and those statements should be further clarified.

See comment 4.

With regard to Section 1008, the draft report’s discussion of agencies’ support of high-risk, high-reward basic research, including establishing a common definition and how such research is identified, does not acknowledge or take into consideration the associated challenges that have been well identified in studies conducted by the scientific community over the past decade through Federal advisory committees<sup>1</sup>, the National Academy of Sciences<sup>2</sup>, and the American Academy of Arts and Sciences<sup>3</sup>. These studies have described the many challenges with defining what is “high-risk” and what constitutes “high-reward,” recognizing that different organizations will associate different operational meaning to these phrases. These studies also recognized that agencies’ support for high-risk, high-reward basic research is not merely a funding issue, but is also a cultural issue—both inside agencies and within the scientific communities. In that context, the draft report over-simplifies the Department’s (and other agencies’) challenges with establishing a common definition and with quantifying such research, and these complexities should be considered in the report’s recommendations.

See comment 5.

The draft report’s discussion on the agencies implementation of Section 1008 does not acknowledge the Department’s significant efforts to address the intent of Section 1008, which is to “strive to support and promote innovation in the United States through high-risk, high-reward basic research projects.” The Department has a long history of supporting high-risk, high-reward basic research, particularly in the Office of Science. The need for fundamental scientific and technological breakthroughs to accomplish DOE mission goals requires that the Office of Science support high-risk, high-reward research ideas that challenge current thinking yet are scientifically sound. The Office of Science considers a significant proportion of its supported research as high-risk, high-reward. Because this basic research is integrated within program portfolios and projects, it is not possible to quantitatively separate the funding contributions of particular experiments or theoretical studies that are high-risk, high-reward in a manner that is credible and auditable. The report’s discussion of whether agencies have established a percentage funding goal needs better discussion in the context of what agencies are doing to support and promote high-risk, high-reward basic research.

<sup>1</sup> (a) Noonan, N. E., *Report of the Advisory Committee for the GPRA Performance Assessment: FY 2004* (Washington, DC: NSF, 2004); (b) National Science Board, *Report on Enhancing Support of Transformative Research at the National Science Foundation* (Washington, DC: NSB, 2007), and references therein.

<sup>2</sup> Committee on Prospering the Global Economy of the 21st Century: An Agenda for American Science and Technology. Committee on Science, Engineering, and Public Policy, *Rising Above the Gathering Storm: Energizing and Employing American for a Brighter Economic Future* (Washington, DC: National Academies Press, 2006)

<sup>3</sup> Committee on Alternative Models for the Federal Funding of Science, *Advancing Research in Science and Engineering: Investing in Early-Career Scientists and High-Risk, High-Reward Research*, (Cambridge, MA: American Academy of Arts and Sciences, 2008)

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**Enclosure IV: Comments from the Department  
of Energy**

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See comment 6.

The GAO's recommendation for the development of a "consistent" definition needs further clarification. What is considered "high-risk" and "high-reward" depends largely on the scientific or technical field and the stage of research (whether basic or applied research, or technology development and deployment). A definition that is "consistent" within an agency or among the agencies implies the establishment of a one-size-fits-all definition, which may limit the Department's ability to promote high-risk, high-reward research in a way that is most impactful to its diverse mission areas. The Office of Science and ARPA-E both provided the definition each office applies to its respective programs (basic research vs. applied research and technology development) to explain how a one-size-fits-all definition would not be practical within the Department.

Thank you, again, for the opportunity to provide comment on this draft. We look forward to receiving your final report.

Sincerely,



Patricia M. Dehmer  
Deputy Director for Science Programs  
DOE Office of Science

Enclosure

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The following are GAO's comments on the Department of Energy's (DOE) letter dated September 30, 2010.

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## GAO Comments

1. As noted in our report, we found that it is too early to judge the effectiveness of spending under the act and that the areas funded under the COMPETES Act, namely R&D and STEM education programs, take significant time to produce outcomes. This view was shared by the DOE staff and funding recipients we met with during our work. We also determined that agency reporting of high-risk, high-reward research could be useful for evaluating the effectiveness of basic scientific research programs authorized under the act. We did not revise the report in response to DOE's comment.
2. As we noted in the draft report, although we defined expanded programs to mean existing programs that the act authorized to receive increased appropriations from fiscal year 2008 to fiscal year 2010, our review of specific projects focused on those that were implemented in 2008 or 2009 because they were more likely to be established enough for us to evaluate their effectiveness. DOE Office of Science projects were only funded under the authorization of the act for fiscal year 2010; prior years had been authorized under prior legislation. We made no change in response to DOE's comment.
3. We agree that the summary language could have been misconstrued to refer to research activities more broadly when we were specifically referring to high-risk, high-reward research. We revised the report title and summary statements to better clarify this distinction in response to DOE's comment.
4. We acknowledge the challenges faced by agencies in defining high-risk, high-reward research and have noted this in the report. Further, we acknowledge that there can be different opinions on what these terms can mean in a basic research context. In response to this comment, we added language to make this point more clear. However, because Congress is instrumental in funding such research, and because Congress provided that agencies should report this information, we believe it is essential that agencies work directly with Congress to resolve these issues. DOE made an effort to begin this dialogue, and complied with the reporting requirement, by reporting that it would not set the goal that it was the sense of the Congress that they should set. We believe that unless Congress repeals the reporting requirement, agencies should make an effort to provide the information on the goal, together with their definition of high-risk,

high-reward research. In this way, agencies could constructively engage in an important dialog with the relevant congressional committees and research agencies, along with OSTP and OMB—each of which has sought to have agencies work to develop such information. Given each party’s expertise, such a dialog and exchange of views could, over time, facilitate policy decisions, including the appropriate level of funding for such research at the individual agencies and across government. We maintain that reporting this information across the agencies funded under the COMPETES Act could result in better oversight and consequently have not revised the report in response to DOE’s comment.

5. We agree that DOE’s Office of Science, and its predecessors, have a long history in supporting basic research that has contributed to significant scientific and other accomplishments. It is because of this history and experience that we believe DOE could provide more specific information on its funding for high-risk, high-reward research. In particular, DOE could serve as an example by drawing on its best resources to lay out what it considers to be the most appropriate basis for determining high-risk, high-reward research; set a goal that fits the needs of the agency and the scientific community; and constructively engage in a dialog with Congress over those matters. We believe that reporting this information to Congress is an iterative process that can be improved over time; for this process to take place, agencies need to take the first steps to report such information. We revised the report to include more information about DOE’s efforts in the area of high-risk, high-reward research.
6. We agree that there can be meaningful distinctions in how agencies and programs interpret the definition of high-risk, high-reward research. However, we believe that it is important for each agency covered under the reporting requirement to attempt to report by using its own definition. In this way, Congress can both receive the views of agencies regarding their definitions and consider whether to alter the reporting requirement or provide further direction to the agencies regarding the definition. We did not revise the report in response to DOE’s comment.

# Enclosure V: Comments from the National Science Foundation

Note: GAO comments supplementing those in the report text appear at the end of this enclosure. Agency comments refer to the draft report as GAO-10-1040R. That report number has since changed to GAO-11-127R.

NATIONAL SCIENCE FOUNDATION  
4201 WILSON BOULEVARD  
ARLINGTON, VIRGINIA 22230



OFFICE OF THE  
DIRECTOR

September 27, 2010

Mr. Franklin Rusco  
Director, Natural Resources and Environment  
United States Government Accountability Office  
Washington, DC 20548

Dear Mr. Rusco:

The National Science Foundation (NSF) appreciates the opportunity to comment on the draft report *America COMPETES Act: It is Too Early to Evaluate Programs Long-term Effectiveness, but Agencies Could Improve Reporting of Research Priorities (GAO-10-1040R)*.

NSF has a long history of supporting research with far-reaching impacts on the U.S. economy and the well-being of Americans. NSF endorses the underlying goal of Section 1008 of the America COMPETES Act (ACA) that agencies fund groundbreaking research that accelerates innovation. NSF is strongly committed and continually strives to promote innovation by supporting transformative research. "Promoting transformational, multidisciplinary research" is in fact the first investment priority listed under NSF's strategic goal "Discovery." Funding research that will lead to new discoveries and scientific and engineering breakthroughs is intrinsic to NSF's mission. NSF does endorse the draft report's recommendation to inform Congress on an annual basis about activities that are potentially transformative.

While NSF appreciates the effort and interest of GAO staff to understand NSF's research activities—especially those associated with potentially transformative research, several aspects of the report warrant further tuning.

**NSF reporting on high-risk/high-reward research to Congress.** This section (starting on page 8) contains seemingly contradictory information and does not capture fully NSF reporting activities. NSF has submitted during the past three years reports to Congress. The GAO draft correctly notes that letters were sent to Congressional leaders in 2008 and 2009. However, the draft report does not note that NSF also included in its 2010 Congressional budget request a report on high-risk/high-reward activities which captured similar information as that included in the earlier reports to Congress; the report in the NSF FY 2010 budget submission is available to the public. The section's first sentence misstates NSF reporting actions; beginning the section with the second sentence would avoid confusion caused by the first sentence.

**NSF and setting a percentage goal for high-risk/high-reward research.** In the same section of the draft report, it states that "NSF maintains that there is no formula that could establish an appropriate percentage..." As noted in the exit conference and in subsequently provided documentation, NSF had considered the concept of a dedicated allocation for high-risk/high-reward research. NSF asked the

See comment 1.

See comment 2.

Advisory Committee on Government Performance Assessment (AC/GPA) in two separate years to address this concept. The conclusions reached in both years were similar. The 2004 AC/GPA report stated that, "No obvious formula exists to guide NSF as to the fraction of the portfolio that should be 'high risk.'"<sup>1</sup> NSF's position to avoid creating an arbitrary metric draws from the committees' findings and is shared by external experts and advisors.

Rather than allocate an arbitrary percentage of the research budget to high-risk/high-reward research projects, NSF believes that the most effective way to advance transformative research is to create an environment that is conducive to funding potentially transformative research.

During the past decade, NSF has undertaken specific steps to build that environment in the context of the structures, programs and policies to foster transformative research and innovation:

- Formed an agency-wide working group to recommend policies, mechanisms, and practices to advance transformative research;
- Revised NSF's merit review criteria to include language that explicitly alerts reviewers to consider whether proposals are potentially transformative;
- Established a new funding mechanism focused on early-stage, untested, potentially transformative research (EAGER);
- Created training materials on the subject for incoming NSF program officers;
- Surveyed investigators about how welcoming NSF is to potentially transformative research proposals;
- Developed a dedicated section on transformative research on the NSF website;
- Requested outside advisors' feedback about NSF's potentially transformative research activities; and
- Conducts numerous outreach activities annually which include information for the research community about potentially transformative research and associated award opportunities.

See comment 3.

**NSF funding of potentially transformative research.** The draft report states that in FY 2010 NSF planned to spend \$94 million on potentially transformative research, but then incorrectly equates that amount as NSF's total funding of potentially transformative research for the fiscal year and calculates NSF funding of transformative research to be less than 2% of the NSF budget. In several submissions to GAO in support of its ACA evaluation, NSF noted that the \$94 million was devoted to efforts to study NSF processes and test new ones that might aid in discovering and funding potentially transformative research (e.g., creating "shadow panels" which have the primary purpose to identify potentially transformative research proposals, "sandpits," etc.). NSF also noted that NSF funding for potentially transformative research is not limited to the \$94 million but rather spans across and is supported in NSF core research funding programs.

See comment 4.

**High-risk/high-reward vis-à-vis Potentially Transformative Research.** Within NSF, the terms "high-risk/high-reward" and "potentially transformative" research are not synonymous—although they do overlap. While the term high-risk can mean a high degree of technical difficulty or novelty, high risk associated with research activities could also include the risk of not completing the research due to external factors (weather, access to critical instrumentation, dangerous working conditions) as well as the degree of experience a researcher possesses compared to the complexity of the research. For NSF, "transformative research involves ideas, discoveries or tools that radically change our understanding of an important, existing scientific or engineering concept or educational practice or leads to the creation

<sup>1</sup> A similar statement was made by the 2005 AC/GPA when it noted "there is still no empirical way to determine what fraction of the portfolio should be the farthest out on the frontier."

Enclosure V: Comments from the National Science Foundation

of a new paradigm or field of science, engineering, or education." NSF can and does identify proposals that contain potentially transformative research ideas or concepts – across the entire spectrum of NSF-supported disciplines.

See comment 5.

**NSF and Program Evaluation.** The draft report indicates that DOE's Office of Science convenes every three years experts to review its programs. The draft report does not mention that NSF undertakes similar activities through Committees of Visitors (COVs). COVs (1) assess the quality and integrity of program operations and program-level technical and managerial matters pertaining to proposal decisions; and (2) comment on how the outputs and outcomes generated by awardees have contributed to the attainment of NSF's mission and strategic outcome goals. COV reviews are conducted at regular intervals of approximately every three years for programs and offices that recommend or award grants, cooperative agreements, and/or contracts and whose main focus is the conduct or support of NSF research and education in science and engineering. NSF relies on the judgment of external experts to maintain high standards of program management, to provide advice for continuous improvement of NSF performance, and to ensure openness to the research and education community served by NSF.

See comment 6.

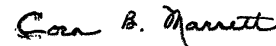
**OMB/OSTP Memorandum.** The August 2009 OMB/OSTP memorandum encourages agencies to pursue transformational solutions, and to describe funding for high-risk, high-payoff research and how to evaluate the success of techniques supporting high-risk research. The memo separately calls upon federal agencies to develop datasets to better document Federal science and technology investments that increase economic productivity and progress toward other national goals. The GAO draft report links the two points in a manner not found in the OMB/OSTP memo.

See comment 7.

**GAO proposal to establish a common high-risk/high-reward research funding percentage goal for federal agencies.** After considering the GAO recommendation regarding high-risk/high-reward research, NSF does not support setting a percentage goal for high-risk/high-reward at either an agency level or government-wide. The ability to identify *a priori* during the review stage proposals that will lead to transformative results before the research is conducted and before the scientific community can assimilate the findings is challenging and, in most cases, impossible. In addition, as noted by advisory committees to NSF, there is no basis to determine an appropriate set-aside for high-risk/high-reward research funding within the NSF context. Moreover, a common percentage goal for research-funding agencies ignores the requirements and missions unique to the individual agencies and assumes a one-size-fits-all approach.

NSF is committed to supporting highly innovative research projects that have the potential to transform the frontiers of science and engineering and spur innovation. If you have any questions regarding this response, please contact Kathryn Sullivan at 703-292-7375. We look forward to receiving your final report.

Sincerely,



Cora B. Marrett  
Acting Director



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The following are GAO's comments on the National Science Foundation's (NSF) letter dated September 27, 2010.

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## GAO Comments

1. We agree that NSF's letter reported similar information about high-risk, high-reward research in its fiscal year 2010 budget submission as it had in its letters to Congressional leaders; however, NSF's fiscal year 2010 budget submission did not report whether the agency had set a percentage goal for such research—something Congress provided they should do in the COMPETES Act. In addition, NSF did not include information about high-risk, high-reward research in its fiscal year 2009 or 2011 budget submissions. We revised the report to clarify NSF's reporting.
2. We are not recommending that agencies allocate an arbitrary percentage to high-risk, high-reward research. Rather, we are recommending that the agencies, who are the most informed about the state of the research communities they fund, fulfill the sense of the Congress and the reporting requirement—namely that they each establish a goal, perhaps as a range, and report funding toward the goal on an annual basis. The efforts to build a supportive research climate that are under way at NSF appear to be compatible with this approach. We revised the text to reflect the information on NSF's efforts to explore how to establish a percentage goal.
3. We revised the report to more accurately reflect NSF funding of potentially transformative research in response to NSF's comment.
4. Although our draft report reflected that potentially transformative research is not synonymous with high-risk, high-reward research, to further represent NSF's views, we revised the text to better clarify the distinctions.
5. We added an explanation of the role of the Committee of Visitors, which is a panel of expert reviewers at NSF, in response to NSF's comment.
6. We agree that the memorandum did not explicitly link these concepts. We found that the spirit of the memorandum encouraged agencies to improve reporting of scientific information, this reporting could include Congress' provision that agencies should report funding on high-risk, high-reward research. We revised the report to better clarify these facts in response to NSF's comment.

7. While we acknowledge these concerns, unless agencies attempt to fulfill the sense of the Congress, Congress cannot receive the views of agencies regarding these concerns. We believe that it is important for each agency charged with the reporting requirement to attempt to fulfill the sense of Congress and the reporting provision by using its own definition. In this way, Congress can both receive the views of agencies regarding the definition and consider whether to alter the reporting requirement or provide further direction. NSF also commented that a common percentage goal does not take into account the missions and requirements of each individual agency. We modified the wording of our recommendation to make clear that we are recommending that each agency establish its own goal, as Congress provided.

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