Part I:
Overview

Highlights

President Obama's proposed budget for fiscal year (FY) 2014 makes major investments in advanced manufacturing and clean energy, continues to propose increases for the three physical science agencies targeted in the America COMPETES Act, and seeks general increases in basic and applied nondefense research. In addition, the budget advances an initiative to substantially reorganize the federal science, technology, engineering, and math (STEM) education portfolio. Overall federal investment in research and development (R&D) would increase slightly from FY 2012 levels, but nondefense R&D would reach an all-time high – in part due to the budget's proposal to roll discretionary spending back to pre-sequestration levels. The success or failure of this proposal would have major implications for the Administration's investment plans.

- **The proposed federal R&D portfolio in FY 2014 is $144.1 billion, an increase of 1.1 percent or $1.5 billion over FY 2012 levels** (see Chapter 1 and Table II-1). Defense R&D spending would decrease by $4.3 billion (5.5 percent), but this would be more than offset by a $5.9 billion (9.2 percent) increase in nondefense R&D. In total dollars, agencies with the biggest increases include the Department of Energy (DOE; $1.9 billion increase to $12.7 billion total), the National Science Foundation (NSF; $534 million increase to $6.2 billion total); the Department of Homeland Security (DHS; $893 million increase to $1.4 billion total); and the National Institutes of Health (NIH; $478 million increase to $30.5 billion total). The Department of Commerce would receive an enormous increase of $1.4 billion to $2.7 billion total; however, $1.2 billion of this proposal consists of one-time mandatory funding for advanced manufacturing and technology initiatives at the National Institute for Standards and Technology (NIST). Even without these mandatory proposals, however, research agencies within Commerce would still receive large increases.

- **Total federal support of research (basic and applied) would increase 6.9 percent to $69.7 billion** (see Table II-1). In real-dollar terms, this would be nearly the largest single-year research investment in history (see Chapter 2).

- **Federal development spending, however, would decrease 6.3 percent to $71.4 billion** (see Table II-1). This decrease is largely due to cuts to weapons development activities at the Department of Defense (DOD), which would decline by $5.4 billion or 8.8 percent. Nondefense development would increase by $520 million, or 6.9 percent.

- **The three President's Plan for Science and Innovation agencies would receive increases, but would fall well short of the doubling pace established in the America COMPETES Act.** NSF would receive a total budget increase of 7.3 percent to $7.6 billion, NIST would see a total budget increase of 23.6 percent to $928.3 million, and DOE's Office of Science budget would increase 4.4 percent to $5.2 billion.

- **Clean energy is a clear R&D priority in the FY 2013 budget.** DOE's energy programs would receive a 48.6 percent increase in R&D funding ($1 billion) to a total of $3.1 billion, primarily due to gains in efficiency and renewables, and at the Advanced Research Projects Agency-Energy (ARPA-E). The budget would also establish a new Energy Security Trust to fund research on low-carbon vehicles.

- **The National Institutes of Health (NIH) would receive a flat R&D budget after a very modest increase last year** (see Table II-9 and Chapter 7)**.** NIH's R&D budget of $30.1 billion would represent a more than 2 percent decline when factoring in inflation.

- **DOD basic research would grow while most other DOD R&D accounts would decline dramatically** (see Table II-2 and Chapter 5). Basic research would reach $2.2 billion, while applied research would be trimmed by 2.2 percent or $103 million. DARPA R&D would increase by 1.8 percent to $2.9 billion.

- **The U.S. Department of Agriculture's (USDA) R&D investment would rise by 8.2%** (see Table II-13 and Chapter 10)**.** The Agriculture and Food Research Initiative (AFRI), USDA's extramural research program, would see its budget increase by 45.1 percent to $383 million, while intramural research at the Agricultural Research Service would also increase.

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Federal R&D in the FY 2014 Budget: An Introduction

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Introduction

The President released his fiscal year (FY) 2014 budget request on April 10, 2013, a full two months late in response to ongoing debates and delays with the prior year's appropriations, which were not finalized by Congress until late March. Amid a slow but steady economic recovery and continuing concerns over deficits and debt, the Administration's stated priorities for this budget reprise the common themes from past years: manufacturing and innovation for job creation, deficit reduction, infrastructure investment, and tax fairness. Notably, the budget proposes a roll back of sequestration and a return to pre-sequester discretionary spending caps of $1.057 trillion under the Budget Control Act. That proposal puts the President's budget $91 billion above the post-sequester spending level embraced by the House, setting the parties on yet another collision course over spending priorities this summer (see Chapter 3). Within this context, it does propose a mix of spending cuts and revenue increases to begin to close the deficit – though it would never produce a balanced budget over the next decade – while also seeking targeted increases in research, science, innovation, and STEM education.

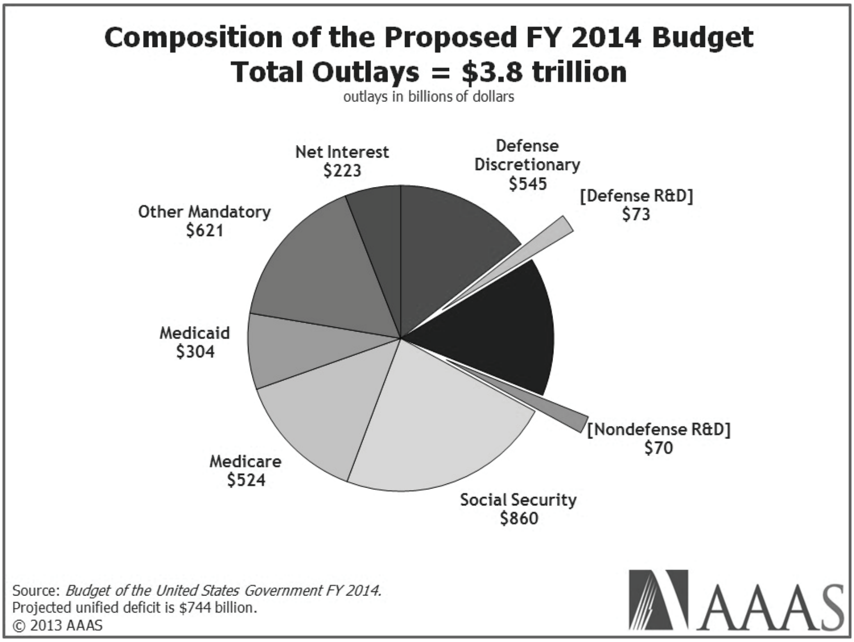
The FY 2014 Budget: The Basics

President Obama's $3.8 trillion FY 2014 budget request estimates a $744 billion deficit next year. At the time of this writing, accurate FY 2013 figures are not available, but the FY 2014 projected deficit would decline by almost one-third from the FY 2012 deficit of $1.1 trillion, and will likely represent a decline from FY 2013, per the Congressional Budget Office's (CBO) most recent estimates. CBO has alternatively estimated that the

President's budget would produce a $675 billion deficit in FY 2014. The deficit reduction would come from a mix of policy changes, including some limitations on tax benefits for high-income earners and closures of loopholes, and some targeted spending cuts, especially in health spending, Social Security, and other entitlements.

This $3.8 trillion budget is divided into mandatory spending – which consists largely of entitlements like Social Security and Medicare, as well as interest payments on the national debt – and discretionary spending, which consists of defense spending and most other nondefense functions the government fulfills, including nearly all research and development (R&D) expenditures (see Figure 1). Discretionary spending is subject to the annual appropriations process, while mandatory spending is not. In FY 2014, the Administration estimates that discretionary spending would account for only 30.9 percent of the total budget; accounting for the lower discretionary spending caps currently in place, this percentage would drop even lower, further continuing the long-term decline of discretionary spending relative to mandatory spending over the past few decades. For comparison, discretionary spending was 40 percent of the budget in 1990, 46.8 percent in 1980, and 61.5 percent in 1970 (see Table I-3).

Figure 1. The Proposed FY 2014 Budget



Discretionary outlays would decrease by 3.4 percent overall from FY 2012, but would likely represent an increase above FY 2013 outlays given the proposal to raise the spending cap. The decline from FY 2012 is entirely driven by defense cuts, while nondefense would grow moderately (see Table I-2). Further, many – though not all – science agencies would outpace the general growth in nondefense discretionary spending under the President's request. Indeed, nondefense R&D spending would actually increase under the President's budget by 9.2 percent above FY 2012, though this increase would be 5.2 percent when adjusting for inflation. Compared to FY 2013 post-sequestration, this would represent a substantial double-digit boost.

Looking ahead to future years, the Administration expects discretionary outlays to continue declining beyond FY 2014, with a $200 billion reduction over the next decade. The Administration also projects that discretionary spending will continue to shrink as a share of the total budget – down to 27.5 percent in FY 2018 – as entitlements and other forms of mandatory spending continue to grow. If the post-sequestration spending caps remain in place, these figures would decline further.

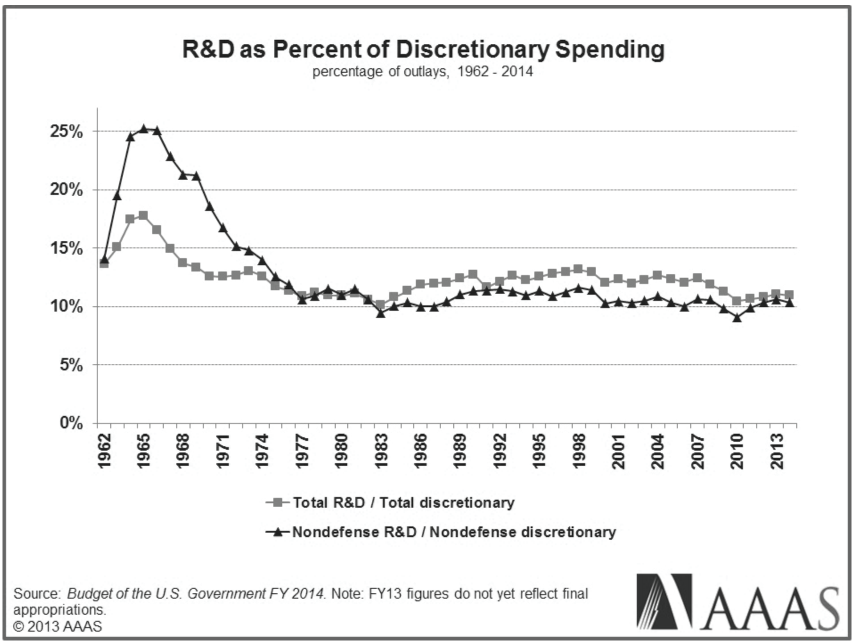
R&D in the Federal Budget

Although the President's budget presentation each year contains a section devoted to R&D and several tables summarizing proposed and historical R&D expenditures, it is important to recognize that **there is no overall R&D budget** and no special treatment for R&D within the budget. R&D budgets are folded into the budgets of more than two dozen federal departments and independent agencies as shown in Table I-1, and, expenditures for R&D programs are frequently included as part of regular budget items and accounts. For instance, a particular science program may have a $200 million budget, of which $125 million might go towards the performance of R&D, while the remaining $75 million might go towards overhead, workforce development, security, and other non-R&D functions; there may be little or no distinction made between the two activities in the budget materials.

Federal R&D outlays would represent 3.8 percent of the total $3.8 trillion budget for FY 2014, and 11.5 percent of total discretionary outlays. R&D funding has hewn surprisingly close to overall discretionary spending over the years, hovering between 11 and 13 percent of total discretionary spending for over 30 years, since the end of the space race (see Figure

2). Such a relatively stable trend is a rather remarkable outcome over so many years, given a complex and decentralized appropriations process in which R&D funding results from the combination of hundreds of different budget decisions that are only aggregated after the fact. However, when disaggregated into defense and nondefense spending, the trend is not quite so static, as the rise of advanced technology in weaponry has caused defense R&D to claim a somewhat larger share of the overall defense budget. Following some years of modest decline, nondefense R&D as a share of the nondefense discretionary budget has recovered somewhat in recent years.

Figure 2. R&D and Discretionary Spending



Overall, **the FY 2014 budget would invest $144.1 billion in R&D**. In nominal dollars, this represents an increase of 1.1 percent above FY 2012; however, inflation is expected to reach 4.0 percent between FY 2012 and FY 2014, which means a real-dollar decline for total R&D of 2.9 percent.

This top line figure can only tell so much about the proposed federal R&D enterprise, as becomes apparent when disaggregating the proposed funding into **defense** and **nondefense,** and further **by character.** Indeed, the

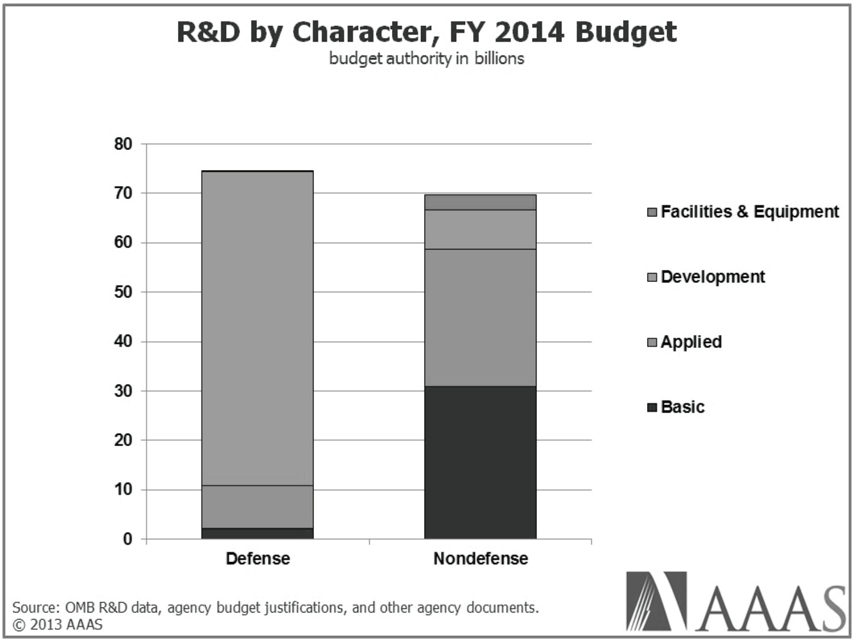
President's budget proposes a **marked shift from defense to nondefense R&D,** and relatedly, **from development activities to basic and applied research.**

The defense and nondefense division is fairly straightforward. Defense only includes two components: the Department of Defense (DOD) R&D budget and defense-related R&D funded by the DOE, primarily through the National Nuclear Security Administration (NNSA). The DOD R&D portfolio is nearly 20 times that of the DOE defense R&D portfolio, and so generally speaking, as the DOD budget goes, so goes the defense R&D budget. Nondefense R&D is, everything else, including health, space, energy, agriculture, environment, and social science research. Another wrinkle comes when examining the R&D budget by character, or by kind of investment. There are five of these: basic research, applied research, development, R&D facilities construction, and capital equipment for R&D (see Appendix 3 for definitions). AAAS tables combine R&D facilities construction and capital equipment, often described together as simply "R&D facilities" or "R&D plant." Adding basic and applied research together produces a figure for "research" or "total research," while the two research categories plus development compose "conduct of R&D." Adding R&D facilities construction and capital equipment yields "total R&D."

Defense and nondefense R&D have very different characters, as shown in Figure 3. More than 80 percent of defense R&D consists of development activities, due to the development costs associated with high-tech weapons, vehicles, and other systems pursued by DOD. In addition, development activities consume more than a third of DOE's atomic defense R&D budget. The combined defense research budget is also quite large at over $10 billion, larger than any two other agencies' combined research budgets except for the massive NIH.

On the other hand, nondefense R&D is very much focused on research, which accounts for more than 80 percent of that budget; it is also split fairly evenly between basic and applied research. Lastly, nondefense agencies spend several times more than defense agencies for R&D facilities and capital equipment, for laboratories, telescopes, satellites, particle accelerators, and other items. Altogether, because of these differences, development accounts for more than half of the federal R&D budget, while basic research is only one-fifth.

Figure 3. Character of Defense and Nondefense R&D



The figures shown in Tables I-5 and II-1 represent agencies' best efforts to classify basic and applied research, development, and R&D facilities within their R&D portfolios. The data reported here are imprecise and reflect the agencies' judgments as to how their R&D fits into the definitions for character of work. To summarize the major points:

Total federal investment in research would rise 6.9 percent to $69.7 billion. Several agencies would see increases in research funding under the President's budget over FY 2012, especially the Departments of Energy, Commerce, Interior, and Homeland Security (DHS), and NSF; additionally, patient outcomes research funded by the Patient-Centered Outcomes Research Trust Fund is scheduled for a substantial increase. The overall increase in research funding is almost entirely for nondefense activities, as DOD research funding would decline by $298 million or 3.5 percent below FY 2012.

The overall increase for applied research funding would be twice as large as basic research. Nondefense applied research would jump by $3.2 billion, or 12.9 percent, while defense applied research would decline slightly. Basic research would increase across both defense and nondefense accounts, for a total increase of $1.4 billion or 4.3 percent; factoring in an inflation rate of 4 percent, basic research would remain flat from FY 2012 in real dollars. Of the nondefense agencies that have a particular emphasis on basic research – NIH, DOE's Office of Science, and NSF – only the latter two would see significant increases.

Development funding would be slashed substantially by 6.3 percent, or $4.8 billion, largely due to continuing cuts to DOD's weapons development activities. This trend, which has been occurring for a few years, is not surprising, given the wind-down in overseas military operations (see Chapter 5 for more on DOD). Nondefense development activities would receive a large relative increase of 6.9 percent, or $520 million. The Departments of Homeland Security, Commerce, and Energy would be the primary beneficiaries of this increase, while NASA – the largest funder of nondefense technology development – would be cut.

R&D facilities funding would receive a major increase of 48 percent, or $957 million, to reach $3 billion. This is in large part due to DHS funding for construction of the National Bio- and Agro-defense Facility in Manhattan, KS (see Chapter 11).

Administration Priorities in the R&D Budget

The President highlighted the role of science and innovation in economic growth during the State of the Union, when he stated "Today, our scientists are mapping the human brain to unlock the answers to Alzheimer's; developing drugs to regenerate damaged organs; devising new material to make batteries ten times more powerful. Now is not the time to gut these job-creating investments in science and innovation. Now is the time to reach a level of research and development not seen since the height of the space race." The Administration's proposed investments and associated strategies generally attempt to make good on this rhetoric, focusing on select priorities similar to those seen in recent budgets, with a particular emphasis on nondefense research.

Science for Innovation and Discovery. The enactment of policies to both advance the borders of knowledge and drive an innovative economy – particularly in advanced manufacturing – has become a lead strategy for the Administration. The budget proposes $2.9 billion for advanced manufacturing, spotlighted by the one-time billion-dollar mandatory proposal for a manufacturing network at the National Institute of Standards and Technology (NIST). Elsewhere, DOE's advanced manufacturing program to help domestic firms become more energy efficient and more effective at producing next-generation energy technology would more than double. Key manufacturing-related initiatives at NSF would also receive substantial boosts.

Beyond manufacturing, several technology areas and programs would receive increases, especially those focused on applied research or use-inspired basic research, such as NASA's Space Technology Directorate or the Energy Frontier Research Centers program at DOE. The budget also seeks to increase investment in the Networking and Information Technology R&D program (see Chapter 22) and cybersecurity programs across government. The three agencies targeted for doubled funding by the America COMPETES Act – NSF, NIST labs, and DOE's Office of Science – would receive R&D increases totaling 18 percent combined above FY 2012. Such an increase, while still falling short of the COMPETES targets, would nevertheless help return the agencies to an aggressive growth trajectory. However, not all science agencies would see an increase. Neither NASA nor NIH would keep pace with inflation, though select elements of each agency would grow. The National Nanotechnology Initiative would also see a notable decline.

Clean Energy. Equally as important to the Administration is clean energy, with $7.9 billion devoted to clean energy technology research, development, demonstration and deployment. Two flagship offices for these efforts are DOE's Office of Energy Efficiency and Renewable Energy and the Advanced Research Projects Agency-Energy (ARPA-E), both of which would receive robust R&D funding increases (see Chapter 8). Elsewhere, NSF would devote $372 million to clean energy technology, and DOD, while experiencing a funding cut, would likely continue to strengthen its role as a potential test-bed for advanced energy technologies in partnership with other agencies.

Education. The Administration would boost funding for science, technology, engineering, and math (STEM) education programs, but would drastically reorganize the federal STEM education system, consolidating resources in NSF, the Department of Education, and the Smithsonian (see Chapter 4 for more information).

Environment and Natural Resources. The four agencies most responsible for environmental R&D – the Environmental Protection Agency (EPA), the U.S. Geological Survey (USGS), the National Oceanic and Atmospheric Administration (NOAA), and the Forest Service – would generally fare well under the President's request. Although EPA research would decline, NOAA and USGS would receive substantial funding increases, reflecting the Administration's continued emphasis on land use, climate, ecosystems research, and other areas (see the disciplinary chapters for much more on these topics). Only USGS, however, has experienced even flat real-dollar funding for R&D over the past decade, as both EPA and NOAA have seen declining R&D budgets in recent years. Outside these agencies, the NSF also funds significant environmental research, especially in the Geosciences Directorate, and many key NSF environmental research offices would receive R&D boosts. The U.S. Department of Agriculture (USDA) would also receive funding boosts in multiple areas, especially competitive extramural research, somewhat offsetting long-term agency R&D decline (see Chapters 10 and 27). Lastly, funding for the U.S. Global Change Research Program, an interagency effort, would receive a 6 percent boost, with by far its largest funding amount coming from NASA (see Chapter 15).

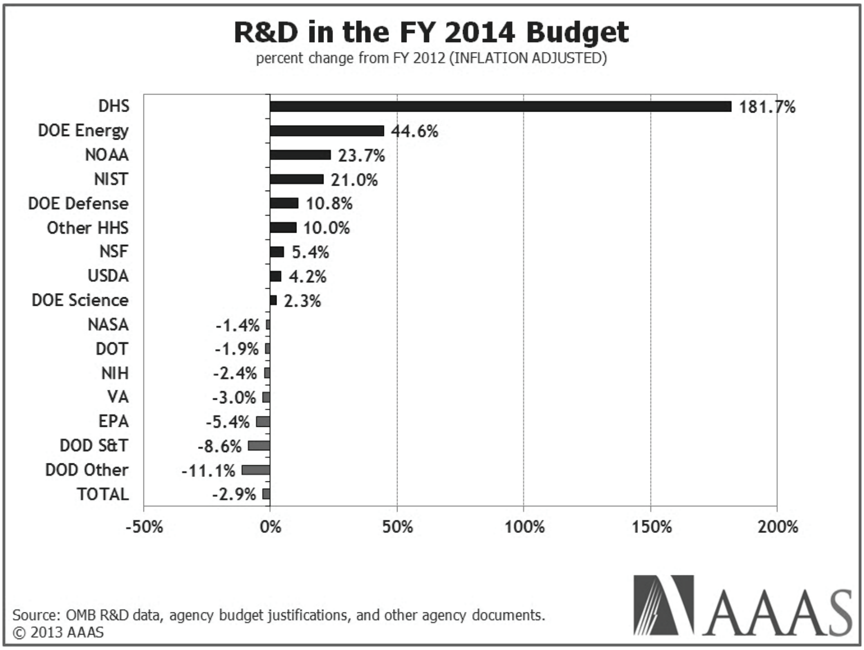
A Return to Pre-Sequester Discretionary Spending. While not quite an R&D priority per se, the President's proposal to return discretionary spending to pre-sequestration levels – effectively increasing the discretionary budget by roughly $91 billion above current law – would no doubt have substantial implications for R&D performance. This is especially so given the steady share of the discretionary budget devoted to R&D historically. Many of the President's R&D proposals would not work unless this discretionary budget cap is revised.

By Budget Function

Most of the federal government's R&D is mission oriented; that is, it is intended to serve the public interest goals and objectives of the agency that provides the funds, such as agricultural research in the USDA. Only NSF has a primary mission to support general science and engineering research and education across a range of disciplines. For the remaining 96 percent of the federal R&D portfolio, R&D investments are a means to achieve government ends within a defined subject area.

To illustrate these national missions, the federal government divides the budget into 20 "functions," each with an assigned function number.[1] The President's budget and the congressional budget resolution divide the total budget into these functional categories, which serve as non-binding guides for appropriators in allocating funds to agencies and programs (see Appendix 1 for a full summary). The actual funding amounts contained in each function can vary widely. Virtually all R&D funding is contained in about half of these budget functions; the other functions contain little or no R&D (see Table I-4). Viewing the R&D portfolio by function can help reveal the nation's funding priorities in different areas over time, and allows for international comparisons with other nations' spending on R&D by objective.

Figure 4. R&D in the FY 2014 Budget Request



1 AAAS separates the general science, space, and technology function (function 250) into its subfunctions of General Science (251) and Space (252). AAAS also counts Department of Veterans Affairs R&D programs in the health (550) function instead of veterans' affairs (700).

The Administration's priorities described above show up clearly in the federal R&D portfolio by mission. These priority missions would all receive fairly large to very large increases, while R&D for most other national missions would gain modestly or decrease. The Commerce mission, associated particularly with innovation and manufacturing, would receive by far the largest relative increase, though most of this increase is due to the large one-time mandatory proposal at NIST described above. The Energy mission would also see a large increase, primarily due to investments in clean energy and efficiency R&D. Justice is the third major gainer, though this is almost entirely due to increases at DHS for biodefense facility construction. In the second tier come General Science, Agriculture, and Environment, where the R&D gains would not be as large but still strong.

However, the budget functions can also show where investment is lacking. In the FY 2014 R&D request, the Space, Health, and Transportation functions would not keep pace with inflation. To some extent, the functional changes described so far represent continuations of long-term trends: over the past decade, R&D funding within the Commerce, Energy, Transportation, and General Science functions have grown substantially, while the Environment, Agriculture, Space, and Health functions, as well as Defense, have all seen relative declines. In some cases, as in agriculture and environment, these declines appear quite substantial, though this year's request would partially offset them.

Lastly, one Administration priority, Homeland Security, does not have a standalone function assigned to it (it is contained in Justice at present), but is tracked in the budget through agency reporting. **Federal homeland security-related R&D would increase by 18 percent to $5.5 billion in FY 2013** (see Table I-6). This is due to DHS growth, but also increasing contributions to the Homeland Security mission by DOE, USDA, and the Department of Commerce.

Federal R&D by Performer

Although the government maintains several hundred laboratories around the country, only about one quarter of federally supported R&D is actually carried out in these intramural labs (see Figure 5). The largest share of federal R&D is in fact carried out by industrial firms under contract – largely defense firms – which accounted for 39.1 percent of federally funded R&D performed in FY 2011. The federal R&D performed by colleges and universities in FY

2011 was slightly less than federal intramural R&D, at 22.2 percent. Other nonprofit institutions – such as research institutes and hospitals – performed the smallest portion, at 5.7 percent, and 7.8 percent of the federal R&D portfolio was performed by nearly 40 FFRDCs,[2] or federally funded R&D centers (national labs), which are operated by contractors.

Each federal funding agency has its own mix of performers, depending on the agency's mission, character of work, and historical relationships with performers. For instance, the majority of DOD's R&D portfolio is performed by private industrial weapons developers, while DOE's R&D portfolio is significantly dedicated to its national laboratories, and the NIH and NSF portfolios primarily fund research at colleges and universities.

Altogether, including research funded internally, through other private sources, and through government contract, private industry performed 68.5 percent of the nation's total R&D in FY 2011, the most recent year for which data is available. U.S. academic institutions performed a further 15.2 percent, while federal laboratories, nonprofit institutions, and FFRDCs performed the remainder.[3] The industry share in FY 2011 represented a slight decline from earlier years, while the university share represented a slight increase.

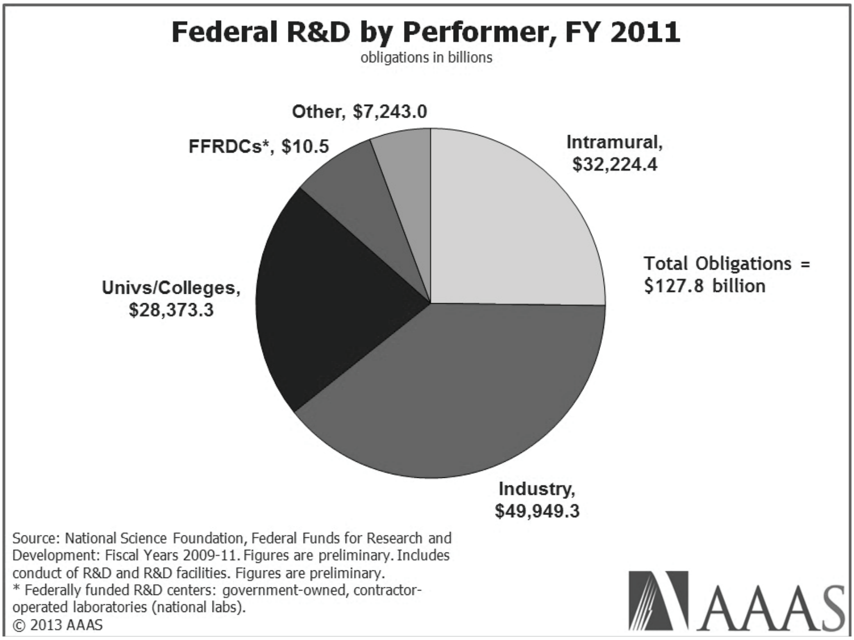
Setting Priorities for Federal R&D Investments

Priorities for R&D programs generally depend on the priorities of the agencies in which they are located and the missions of those agencies. From the standpoint of serving the nation's interests, at least in the short term, this makes good sense, since these R&D programs are not ends in themselves but the means to the ends that their sponsoring agencies serve. From the standpoint of the long-term health of the research enterprise, however, it can cause problems. The mission orientation of R&D programs makes it difficult for policymakers to assess the overall health of the research enterprise, to coordinate programs among different agencies, to achieve long-term planning goals across agencies, and to address issues of balance among various scientific and engineering fields and disciplines.

2 A full list is available on the NSF website (http://www.nsf.gov/statistics/nsf10305/content.cfm?pub_id=3966&id=6).

3 National Science Foundation, *National Patterns of R&D Resources: 2011* (http://www.nsf.gov/statistics/natlpatterns/).

Figure 5. Federal R&D Funding by Performer



The Office of Management and Budget (OMB), which has overall responsibility for preparation of the President's budget, is in a position to provide some coordination, although it is hampered by the fact that the agencies that support R&D are treated individually by its different sections in the budget review process. Some coordination is provided to agency heads by the White House Office of Science and Technology Policy (OSTP), including through a yearly science and technology priorities memo sent out by the OSTP and OMB directors. This memo typically describes the Administration's science and technology priorities two years in advance of the fiscal year to which it is addressed, so that agencies can integrate that guidance during their internal planning process.

Some R&D budget coordination also takes place under the National Science and Technology Council (NSTC), an interagency body comprised of cabinet officers and the President. NSTC has organized a number of key interagency science and technology initiatives, including the U.S. Global Change Research Program, the Networking and Information Technology R&D Program, and the National Nanotechnology Initiative. Budgets for these initiatives are shown in Table I-9.

Congressional responsibility is even more decentralized – and less coordinated – than in the executive branch. R&D programs are considered at two levels in Congress: authorizations and appropriations. Authorizing committees (such as the House Committee on Science, Space, and Technology) develop special expertise in the programs they oversee, and prepare legislation that addresses program substance, provides guidance, changes or creates programs, and sets multiyear funding ceilings; these committees do not, however, actually allocate funding through appropriations. Instead, the authority to allocate discretionary program funding, including R&D, resides in the Appropriations Committees of the House and Senate. These committees are each divided into 12 subcommittees, each one of which is responsible for a bill that controls one portion of the budget, with twelve appropriations bills in total.

In the congressional appropriations process, federal R&D is contained in 11 of the 12 appropriations bills. Table I-7 shows the distribution of R&D funding among these appropriations bills/subcommittees. It is important to remember that each subcommittee produces its appropriations bill separately from the others, and that each bill is usually signed into law separately, although in recent years several bills have had to be bundled into a single omnibus appropriations bill at the end of the congressional session.

The division of the budget into 12 appropriations, and the fact that these committees pursue their business separately and do not negotiate with one another, serves to limit any possible coordination or trade-offs between agency or mission R&D portfolios in the congressional process. For example, three R&D agencies – NSF, NASA, and the Department of Commerce – are under the jurisdiction of the Appropriations Subcommittee on Commerce, Justice, and Science. NIH appropriations reside in the Labor, Health and Human Services, and Education appropriations subcommittee. This means that money used to increase the NASA R&D budget does not come from the same pot of money as that which funds NIH, although NASA's budget increase could be directly offset with a cut in NSF's budget, since they are in the same appropriations bill. This system also means that science agencies compete with non-science agencies in the same appropriations bill.

The Role of R&D in the U.S. Innovation System

Science and technology are recognized as key drivers of economic growth, improved human health, and increasing quality of life. Economists estimate that half or more of economic growth over the past several decades is due to technical progress.[4] Thus, developing a robust science, research, and innovation ecosystem has become a major focus for most forward-thinking leaders in the developed and developing worlds alike. Such efforts necessarily include an array of measures, including support for universities, human capital development, and immigration, tax policy, and patent reform. And they also by definition include public support for R&D, both directly (through funding) and indirectly (through tax incentives).

In the U.S., R&D investment reached $414 billion in FY 2011, nearly two-thirds of which came from industrial firms; roughly a third came from government. Federal agencies support more than 60 percent of R&D performed in U.S. colleges and universities, most of which is basic research (see Table I-9). Not only does this help to drive discoveries that can lead to new knowledge and technological advances, which in turn can drive markets and improve quality of life, but it also serves to help educate the next-generation workforce of scientists and engineers.

It is important to remember that not all R&D is created equal: nearly 80 cents out of every dollar spent by industry for R&D goes toward near-term product development. In contrast, federal R&D – especially nondefense R&D – is far more focused on basic and applied research. While all R&D involves risk and uncertainty, the tolerance for these is lower in a competitive market, and so industry favors R&D investments that offer a surer, more predictable bet over those that might take 10 or more years to yield marketable results. Conversely, basic and applied research – the kinds of research that can yield potential greater knowledge gains, but that force the performer to cope with higher risks and greater uncertainty – are exactly those pursuits in which government is able to specialize as both funder and performer, so long as lawmakers and the public are willing to maintain support for a robust science enterprise. This is not to say that the private sector does not fund a large amount of basic and applied research, nor is it to say that government does not pursue nearer-term development

4 See, for instance, Michael Boskin and Lawrence Lau, "Generalized Solow-Neutral Technical Progress and Postwar Economic Growth," NBER Working Paper No. 8023.

activities that serve public rather than private interests. But there are clear tendencies at work that have consequences for research policy choices.

A further reason for the importance of federal R&D is the economics of knowledge spillovers. Private firms that spend money on R&D must cope with the fact that new knowledge often cannot be contained or restricted. Spillovers – essentially, the transfer of knowledge outside of the firm that created it – mean that it can be difficult for a firm to recoup all of the benefits of that knowledge, as other firms can acquire it, improve it, and use it to their benefit, in the same industry and in other industries. Because others besides the original creator can benefit from this knowledge, the **social** returns of R&D are frequently higher than the **private** returns of R&D. This presence of a broad social good, which would not enter into a private firm's market calculus, again suggests a federal role in pursuing high-risk research to generate this knowledge. There is now an enormous literature that details many of the federal R&D contributions to the modern economy, in computing, energy, biotechnology, and agriculture.[5] And the importance of this role only continues to grow as the international innovation system becomes more fragmented, small firms continue to make important contributions to innovation, the global market becomes more competitive, and public-private research partnerships become ever more important.

U.S. Investments in an International Context[6]

In absolute terms, American R&D spending in 2009 from public and private sources was twice as large as in the second-largest funder, China, which only recently surpassed Japan, adjusting for the lower costs in personnel and equipment there. The U.S. also spent more than the entire combined R&D budget of the EU, and 33.9 percent of world's R&D. This remains by far the largest share for a single nation, though it has declined steadily over the past decade as emerging R&D powers, especially South Korea, China, and others in Southeast Asia have dramatically increased their own investment levels. Either way you slice it, the United States remains the dominant R&D power in the world in terms of pure scale.

5 For instance, see Fred Block and Matthew R. Keller, eds, *State of Innovation: The U.S. Government's Role in Technology Development,* Paradigm Publishers, (2010); and Rebecca M. Henderson and Richard G. Newell, eds, *Accelerating Energy Innovation: Insights from Multiple Sectors,* University Of Chicago Press (2011).

6 Data in this section comes from NSF's *Science and Engineering Indicators.*

However, there are other ways to assess the health of the domestic R&D enterprise. When one looks at the research intensities of various economies – measured by national R&D expenditures as a share of gross domestic product (GDP) – the picture is still positive, but not quite as positive. R&D represented 2.9 percent of GDP in the United States in 2009. This places the U.S. below several other developed countries, including Japan (3.3 percent) South Korea (3.4 percent in 2008), Sweden (3.6 percent), and Taiwan (2.9 percent). On the other hand, the United States still ranked in the top 10, above most other major industrialized countries — including Germany, France, and the United Kingdom. In 2000, as part of the Lisbon Strategy, the EU set a goal of attaining an EU-wide R&D intensity of 3 percent by 2010; President Obama and others have set the same target in the U.S. However, the EU R&D investment ratio in 2009 remained at 1.9 percent, only marginally higher than when the goal was set, mainly due to the induction of 10 less research-intensive nations in 2004. Another important note is that a significant share of U.S. R&D is for defense, which can have a markedly different impact on the civilian economy and industrial competitiveness than nondefense R&D. By comparison, other world R&D powers like Germany and Japan devote only a small portion of their R&D resources to defense. Lastly, what really matters for the long-run health and competitiveness of the nation is not the static picture of the national research enterprise at this point in time, but long-term trends, backward and forward. In this view, the United States has ever-so-slowly been ceding ground to international competitors, leading some to predict that the global R&D enterprise could look very different in the coming decades.