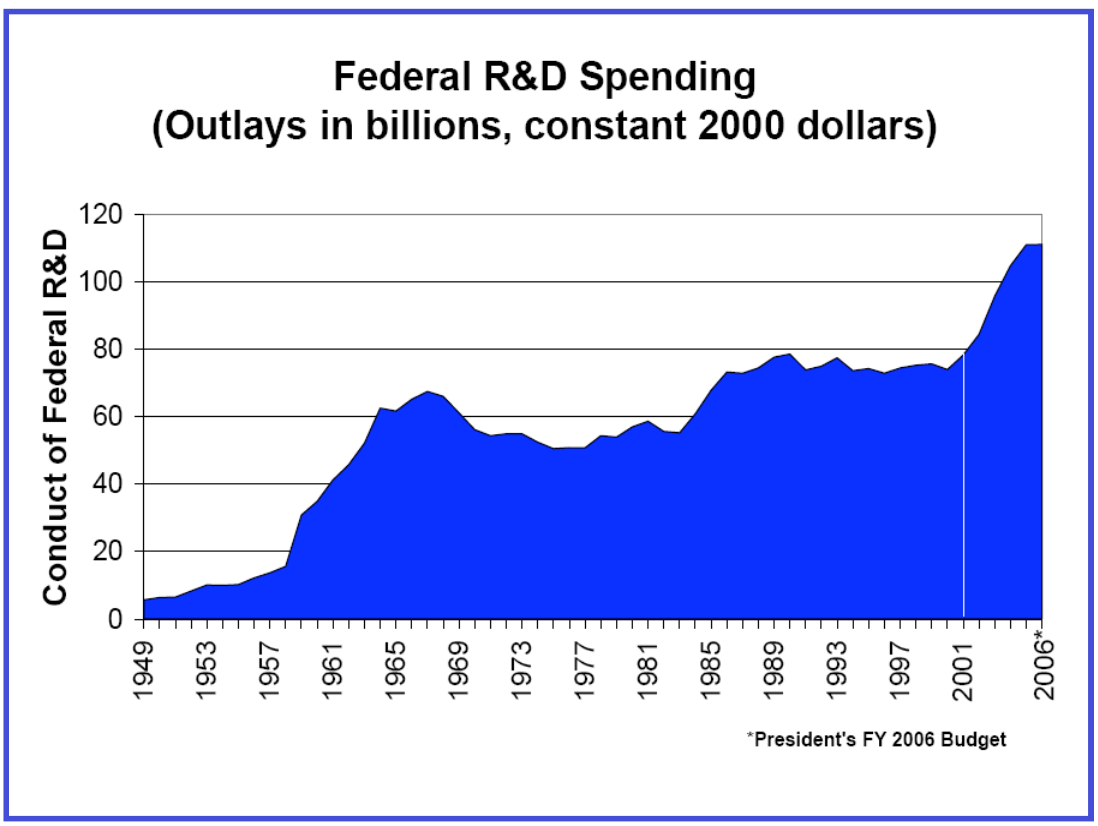
2005 AAAS S&T Policy Forum Keynote Address
Washington, D.C.
April 21, 2005

John Marburger
Director, Office of Science and Technology Policy
Executive Office of the President

Thanks to the AAAS once again for organizing this annual event. While budgets are not the only thing on the agenda, the timing of this forum makes it clear that the top issue is the President's proposal to Congress for R&D spending in the forthcoming fiscal year. So I was surprised when I looked back at my remarks at three previous forums to find that I said relatively little about the details of President Bush's proposals, and more about the factors that lay behind them. Today I am going to focus squarely on budgets and the measures of the strength of American science and technology.

The sequence of R&D budgets during President Bush's Administration very clearly shows a strong commitment to science and technology. Anyone looking at the graph below can see that R&D growth in this Administration is exceeded only by the buildup of federal funding in the post-Sputnik era of the early 1960's. This remarkable record has been parsed half to death by commentators, but its underlying message is unmistakable: This President and the Congresses that have worked with him regard strong federal R&D spending as essential to the health, security, and prosperity of the nation.



Part of my talk today is about this record and part is about the rapidly changing context for R&D and what we need to do to make sense of it – to "benchmark" it, if you will. But first, the FY 2006 Budget and its history.

This year's budget is under considerable pressure. It maintains a strong focus on winning the war against terrorism while seriously moderating the growth in overall spending. Consequently, the FY 2006 proposal is the tightest in nearly two decades.

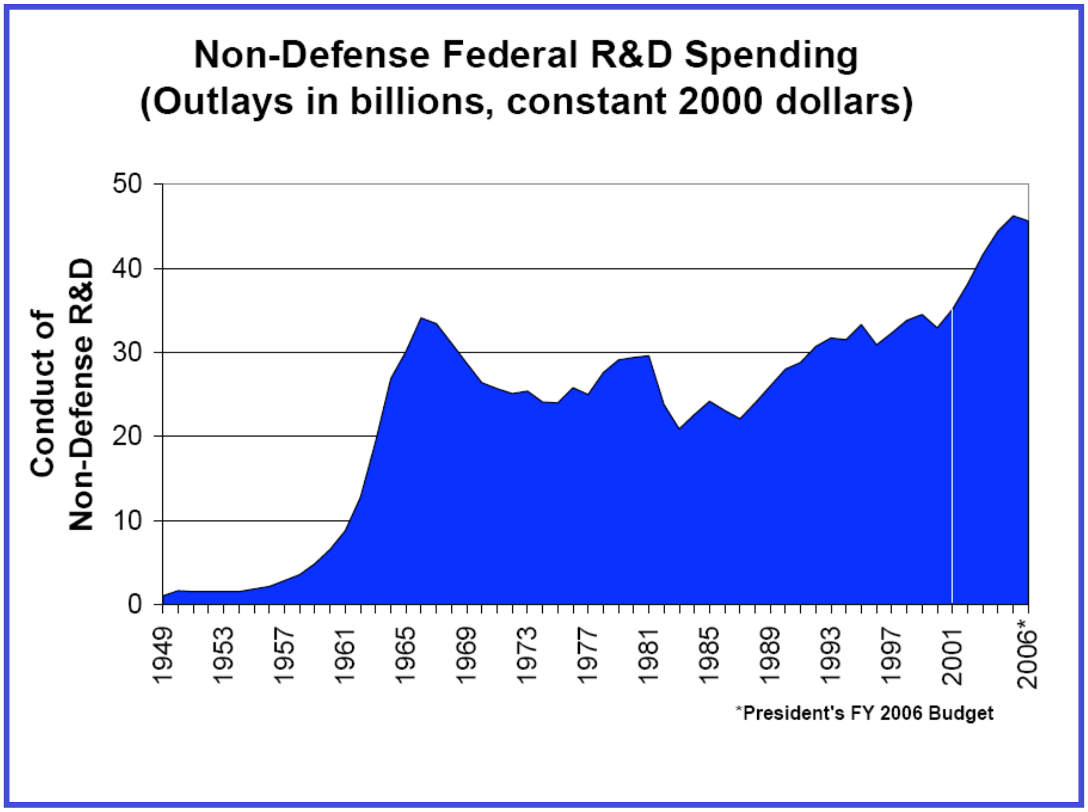
Despite these pressures, Federal R&D funding is actually *increased* in the President's request. And the Administration has maintained high levels of support for the priority areas of nanotechnology, information technology, climate change science and energy technology – including the hydrogen initiative – and space exploration. In a budget that would cut the total of "non-security" discretionary spending by one percent from the 2005 allocated amount, total "non-security" R&D spending is spared.

What this means is that the FY 2006 proposal preserves the substantial increases in R&D spending made during the first term of this Administration. The U.S. research and development enterprise is currently working from a new historically high base as it enters an era of rapidly changing conditions in global technical activity. Let me remind you of the actual numbers.

The President's FY 2006 Budget increases total R&D investment by $733 million to a new high of $132.3 billion, which is 45% greater than FY 2001's $91.3 billion. The Budget allocates 13.6 percent of total discretionary outlays to R&D - the highest level in 37 years. Non-defense R&D accounts for 5.6 percent of total discretionary outlays, an amount significantly greater than the 5.0 percent average over the past three decades.

Some commentators have noticed that I have responded to concerns about the modest current growth rate in non-defense R&D by pointing to the enormous growth since FY01. I do that because this investment has a real impact on the technically intensive sector of the American economy. The significance of such historic growth, however, is not acknowledged in widely publicized advocacy analyses of the health of the U.S. science and engineering enterprise. I will say more about those analyses in a moment, but let me point out now that they depend heavily on the NSF Science and Engineering Indicators for 2004, which are nearly all based on data collected through FY 2001. These indicators measure the effect of the prior decade where R&D spending was indeed flat. They do not reflect the stimulus of the substantial correction in R&D budgets that actually occurred in the first term of the Bush Administration.

Commentators also point to the large component of development expenditures – the "D" in R&D – in the R&D run-up of 2001-05. In 1995 an important National Research Council committee chaired by Frank Press concluded that a more accurate measure of the investment in "the creation of new knowledge and the development of new technologies" would omit the "D" component. That report is the origin of the budget category of *Federal Science and Technology* (FS&T) first implemented in its present form in President Bush's 2002 budget proposal, but estimating its value back to 2000. It too increased substantially – 30.4% – during the Great Advance from FY01 to FY05. This category has a short history, but I believe similar information is conveyed in the non-defense component of R&D shown below. While I am uneasy about disregarding the "D" category altogether when we assess the portfolio of federal investments needed to keep our technology-based economy strong, I agree that FS&T is a better measure of long term S&T investments.



The FY 2006 request for the FS&T budget is $61 billion, a 1 percent reduction from the FY 2005 enacted level. This is a good place for me to point out that Presidential requests and prior year enacted budgets are not comparable because the enacted budgets include many congressionally directed programs (so-called "earmarks") that are not contained in the President's request. Enacted-to-enacted comparisons are valid, enacted-to-requested are not. The slight FS&T budget decrease is entirely attributable to this mismatch. Earmarks in this portion of the budget exceed $2 billion. I would like to find a way to integrate Congressional program direction with the Executive branch planning and prioritization to optimize the use of federal funds for research.

Despite the strong recommendation of the 1995 Press committee, the old categories of Basic and Applied Research continue to haunt some advocacy assessments of national S&T strength. In my opinion, this leads to seriously misleading conclusions. Hear these words from the Press report: "The committee's definition of FS&T deliberately blurs any distinction between basic and applied science or between science and technology. A complex relationship has evolved between basic and applied science and technology. In most instances, the linear sequential view of innovation is simplistic and misleading. Basic and applied science and technology are treated here as one inter-related enterprise, as they are conducted in the science and engineering schools of our universities and in federal laboratories." Ten years later the "complex relationship" has evolved to significantly new modes of research that are even more difficult to sort out among the old categories. The "Basic Research" category is nevertheless still tracked somehow by OMB, and it increased 26.2% during the Great Advance and stands at $26.6 billion in the FY06 request, very slightly down from the $26.9 billion enacted level the prior year, the reduction once again due entirely to accounting for earmarks.

I want to underscore the significance of the recent history of R&D funding. Dan Sarewitz, a familiar science policy figure now at Arizona State University has pointed out that "Science policy discourse has been in the grip of a number of myths that seem utterly insensitive to the reality of [the] budgetary history. The first is that the nation's commitment to basic research is weak, and that basic science has been under continual assault by politicians who don't understand its value." Roger Pielke, jr., Director of the Center for Science and Technology Policy Research at the University of Colorado, expressed some of my own frustration when he wrote recently that "Few seem to be aware that over the past decade S&T has experienced a second golden age, at least as measured by federal funding, which has increased dramatically in recent years at a pace not seen since the 1960s."

We may still legitimately ask whether even these historically large amounts of R&D funding are right for the times. Questions like this are invariably raised in an international context. Are we funding all the R&D we need to defend ourselves, improve and sustain our quality of life, and compete with other nations in a globalized high-technology economy? I do not know of any reliable way to answer this question short of developing a massive econometric model for the world's economies and workforces, and exercising it with various scenarios. Two decades ago such a project would have seemed impossible. Today with modern information technology and the Internet I can imagine how it might be done. But we do not have such models now.

It is well to keep in mind how primitive the framework is that we use to evaluate policies and assess strength in science and technology. In the absence of models that link inputs like federal R&D investments to outputs like Gross Domestic Product per capita, we collect annual data and fit straight lines to it to forecast future conditions. We try to interpret the data by taking various ratios, plotting the results in different ways – on semi-log graphs, for example – and then talking about the results based on our intuitions about what it all means. Some of the results of this approach are useful for advocacy. They wake us up to changes so rapid they have to be important somehow – the rate of production of engineering degrees in China, for example, or rates of publication in technical journals, or government investments in different fields.

But let us not kid ourselves that these "benchmarks" contain information useful for policy-making. Take the commonly quoted plot of federally funded R&D per unit of GDP. It has been going down in the U.S. for decades even as R&D funding has been going up. It has been going down on the average for OECD nations for decades, and everywhere for the same reason: industry is doing more R&D all the time, and that is almost certainly related to why the GDP is going up so steadily in these countries. It is not bad for industry to be funding more research relative to the government, especially given the evolution that Frank Press's committee talked about a decade ago: basic and applied work are strongly merged in many important fields, and industrial R&D is adding significantly to the intellectual property base that supports important national objectives. The only major economy in which this ratio is going up (slowly) is Japan's where nearly all of the R&D investment had been in the private sector, and Japan is finally adopting policies more similar to other developed nations.

Because of huge differences in how R&D is funded in different countries, it is better to compare the sum of public and private funding per GDP. I do not see any deep rationale for this ratio, especially in comparing economies of vastly different size, but it is the measure used by the OECD and other sources. (There is a good discussion of this ratio in the 2004 NSF Science and Engineering Indicators report.) This measure is much more stable than the ratio of government R&D alone to GDP and is used as a planning target within the European Union. The EU would like its members to spend 3% of GDP on R&D, but world-wide only two countries with large economies even come close: the U.S. with 2.7% and Japan with 3.3%, in both cases rising. In the U.S. private funding is twice government funding. Japan's ratio is converging to this, but U.S. government funding for R&D still exceeds Japan's in absolute terms by a factor of three.

The misuse of ratios in widely publicized advocacy benchmarks seems to have misled some journalists and commentators. I read an article recently that claimed "the U.S. scientific enterprise is riddled with evidence that Americans have lost sight of the value of non-applied, curiosity-driven research." Apart from the point that current ideas about research metrics tend to blur the distinction between pure and applied research, this statement is sharply contradicted by the recent history of funding in the Basic Research category. Total Basic Research expenditures during the past five years exceed those of the prior five years by 33% in constant dollars.

Although it is not useful for international comparisons, it is worth keeping in mind that the government portion of R&D has been a practically constant fraction of the U.S. domestic discretionary budget for decades. That is, more money goes to science in direct proportion to the money "on the table" during any budget year. The ratio is even more stable, at about 11%, if defense spending is excluded. This fact is like Moore's law – there is no necessity for non-defense science to receive about 11% of the non-defense discretionary budget year after year for decades, but it is happening, and it is a reasonable bet that it will continue to happen. This undermines arguments about particular influences on the top-line federal research budget to such an extent that Daniel Sarewitz has asked whether science policy even matters. Of course it does because it is not just the top line that matters. Science policy plays itself out in the establishment and implementation of priorities within the available budgets. In times like the present when the discretionary budget is constrained, it is normal to find decreases as well as increases within the overall science portion of the budget.

The FY 2006 R&D request highlights priority areas including some, like nanotechnology, that are often mentioned in international comparisons. The U.S. National Nanotechnology Initiative is a well organized interdisciplinary program that has received much attention from Congress as well as the Administration, and benefits from a current investment of more than $1 billion across more than a dozen agencies. This budget has doubled within the past five years. During the past six months, the President's Council of Advisors on Science and Technology has looked in depth at the strength of the U.S. nanotechnology effort relative to other nations. PCAST found that while the public sector investment (which includes not only Federal expenditures but also state funding) in the U.S. is approximately equal to the investments by Europe and Asia, the U.S. leads the world in nanotechnology as measured by a number of different metrics, such as the number of scientific papers published and the number of patents filed. The PCAST report can be found through the OSTP website.

Another priority area that has received much public comment is math and science education. The President's FY 2006 proposal requests an increase of $71 million, or 28% for the K-12 Math and Science Partnership program, an initiative designed to recruit postsecondary institutions to enrich math and science curricula in school districts throughout the country. This initiative is carried forward jointly by the National Science Foundation and the Department of Education, and as the program matures, funding has shifted between the two agencies. Reductions in the proposed budget for NSF are more than matched by requested increases for the portion of the program in the Department of Education.

The President's annual budget proposal to Congress is complex but assembled in a well-defined process. It reflects priorities that are explained in the budget narrative, which is available on-line. Some commentators and journalists work hard to understand its intricacies, and I strongly recommend that anyone interested in science funding regard this document as a primary source, and read the science narrative carefully. As complex as it is, it is easier to understand the federal budget than it is to build an econometric model of the R&D enterprise.

Now I would like to return to that vision. Under the auspices of the National Science Board, the NSF Science and Engineering Indicators Program produces an outstanding series whose volumes are full of analysis as well as data. Just as I urge you to read the President's budget proposal each year, I strongly suggest that you read as much of the narrative volume of the indicators as you can. Do not simply surf the statistical volume for numbers. Read what the text says about the numbers. This is an objective, high quality document full of excellent insights.

That said, the indicators are based on a data taxonomy that is nearly three decades old. Methods for defining data in both public and private sectors are not well adapted to how R&D is actually conducted today. For example, all R&D carried out by a corporation is attributed to that corporation's main line of business. And the indicators are not linked to an overall interpretive framework that has been designed to inform policy. These problems and many more are analyzed in a very recent publication of the National Research Council titled "Measuring Research and Development Expenditures in the U.S. Economy". On page 1 the authors write "The NSF research and development expenditure data are often ill-suited for the purposes to which they have been employed. They attempt to quantify three traditional pieces of the R&D enterprise – basic research, applied research and development – when much of the engine of innovation stems from the intersection of these components, or in the details of each. … [T]he data are sometimes used to measure the output of R&D when in reality in measuring expenditures they reflect only one of the inputs to innovation and economic growth. It would be desirable to devise, test and, if possible, implement survey tools that more directly measure the economic output of R&D in terms of short-term and long-term innovation. Finally, the structure of the data collection is tied to models of the R&D performance that are increasingly unrepresentative of the whole of the R&D enterprise." The report makes a number of recommendations for improving various components of the data and enhancing their usefulness. These recommendations should receive high priority in future planning within NSF.

The growing importance of R&D within our society, however, and its strong association with national priorities, demands much more than the kind of improvements recommended in the NRC report. My perception of the field of science policy is that it is to a great extent a branch of economics, and its effective practice requires the kind of quantitative tools economic policy makers have available, including a rich variety of econometric models, and a base of academic research. Much of the available literature on science policy is being produced piecemeal by scientists who are experts in their fields, but not necessarily in the methods and literature of the relevant social science disciplines needed to define appropriate data elements and create econometric models that can be useful to policy experts.

I am suggesting that the nascent field of the social science of science policy needs to grow up, and quickly, to provide a basis for understanding the enormously complex dynamic of today's global, technology-based society. We need models that can give us insight into the likely futures of the technical workforce and its response to different possible stimuli. We need models for the impact of globalization on technical work, for the impact of yet further revolutions in information technology on the work of scientists and engineers, for the effect on federal programs of the inexorable proliferation of research centers, institutes, and laboratories and their voracious appetite for federal funds, for the effect of huge fluctuations in state support for public universities. These are not items that you can just go out and buy, because research is necessary even to frame an approach. This is a task for a new interdisciplinary field of quantitative science policy studies.

I am confident about America's near-term future in science and technology, but I share the concerns of many about the longer term. I do not fear so much that our current budgets are too small, or that our facilities are inadequate, or that our policies guiding federal research are too restrictive. But I worry constantly that our tools for making wise decisions, and bringing along the American people and their elected representatives, are not yet sharp enough to manage the complexity of our evolving relationship with the awakening globe. I want to base advocacy on the best science we can muster to map our future in the world.

This annual forum sponsored by AAAS is an ideal place to stimulate interest in the work that needs to be done, and explain the relevance of policy studies to our nation's future. I congratulate the organizers of today's event on an excellent agenda. Thank you.