I’m pleased to be here with this auspicious group of leaders from engineering, science, and technical societies. I’m a strong believer in the importance of engineers speaking out more actively on public policy issues, so I am especially thrilled to see such a large group here for the Engineering R&D Symposium.

The topic for the next two days of discussion is the budget for Fiscal Year 2004, which President Bush proposed to Congress in early February. It is exciting for all of us to see that the President had recommended the highest level of federal funding for R&D in history. It is particularly rewarding for the members of the President’s Council of Advisors on Science and Technology to see that he has recommended a higher level of resources for the physical sciences, because the No. 1 Recommendation PCAST made in our report “Assessing the U.S. R&D Investment” was to improve funding levels for physical sciences and engineering.

The agenda for this symposium includes many experts who will provide detail on various types of R&D of funding, so I would like to focus my own comments on setting the context for the upcoming discussions. When it comes to the federal R&D picture, PCAST has two important over-arching areas of concern that I would like to emphasize this morning: First, the need to achieve better balance and coordination of federal R&D investments, keeping in mind the broader national objectives they serve and the increasingly global nature of the environment in which we function. And second, the importance of strengthening the pool of science and engineering talent that is essential if we are to stay at the forefront of discovery.

These concerns emerged from a lengthy study process by a PCAST panel, which I chaired. We reviewed the federal government’s pattern of R&D expenditures, listened to a wide variety of experts, and commissioned a RAND study. The panel presented its findings and recommendations to the full PCAST group, and then its report was presented by the co-chairs of PCAST to the President last October.
(FEDERAL & INDUSTRY R&D)
As we looked back over the pattern of past federal research funding, we discovered some trends that concerned us. The government got involved in investing in R&D in order to maintain military superiority, but R&D has now developed into a critically important driver of economic productivity, which can be measured by the Gross Domestic Product. As a percentage of the Gross Domestic Product, industry investment slumped, then recovered. Federal investment slumped, and then slumped some more. In fact, federal research support shrank by almost two-thirds between 1987 and 1999.

(SOURCE OF US RESEARCH FUNDS)
A second, related trend over the past 40 years was a significant shift in who conducts what portion of our national research and development enterprise. Essentially, the federal government and private industry have switched places. The federal government, which was the source of about two thirds of R&D back in the early sixties, now drives less than 30 percent, while industry, which conducted about a third of our national R&D 40 years ago, now does almost 70 percent of it. However, this is not a quid pro quo exchange. It represents a shift of emphasis away from basic research toward development.

(2 BAR GRAPHS)
The lefthand set of bars on these two graphs make it clear that industry is by far and away both the largest source and the largest performer of the development portion of R&D. On the righthand side of both graphs, you can see that the federal government provides most of the funding for fundamental, frontier research, and universities are the largest performer. It is easy to understand why this is true. Frontier research is where science meets the unknown. It is difficult to know when and where new discoveries will appear and what they might be. Even when new discoveries have appeared, it can take decades before they are put to practical use. And what’s more, the practical, profit-making uses may turn out to be in a completely different field than the original fundamental research.

(FEYNMAN PHOTO)
When physicist Richard Feynman introduced the new field of nanotechnology to the American Physical Society in 1959 in a lecture entitled “There is Plenty of Room at the Bottom,” I doubt that anyone there in their wildest imaginations envisioned the products that are emerging today as a result. They include, for example, stain-resistant pants, self-cleaning windows, women’s cosmetics, and running boards for vans. By the same token, I doubt that General Motors, Eddie Bauer or Revlon Cosmetics in their wildest imaginations ever though of investing in the frontier research that generated the nanotechnology from which they are now profiting.
In the dog-eat-dog competition of today’s global marketplace, it is difficult for private industry to justify spending on frontier research when the bottom-line profit is likely to be some years away and may turn out to benefit somebody else. The National Research Council’s publication *Trends in Federal Support of Research and Graduate Education*, indicates, for example, that the computer and semi-conductor industries allocate less than 5 percent of their research expenditures to frontier research. So a very important concern for PCAST was increasing the federally funded fundamental, frontier research that underlies the development of new products.

The good news is that this has begun during the past several years. This graph shows the past 20 years of total federal R&D expenditures, expressed as actual dollars and then calibrated to current 2003 dollars. After a time of relative flat-lining and even a dip, we are now seeing a significant increase in federal support. And I believe the first thing we need to do in addressing Congress is to thank them for their increased support.

Looking specifically at the six agencies where the bulk of R&D funding is located, we can see increases for the past two years. Just by way of explanation, Congress has still not passed a budget for the current fiscal year, and these agencies are operating under a resolution that simply continues spending at 2002 levels. So we have to we have to go back to 2002 to get hard numbers for comparison purposes. Here you can see the result of the effort to double the budget of the National Institutes of Heath, which is set to conclude this year. You can see the beginnings of a new initiative to increase the budget of the National Science Foundation, and the opportunities presented by the new Department of Homeland Security, for which $1 billion in R&D has been proposed for 2004. However, you can also see that the science and technology budget for the Department of Defense has been cut back even below its 2002 level.

As you can see on the lefthand bar representing defense, funding is shifting away from science and technology research toward the development of the missile defense system. This is significant for engineering research, which gets close to 40 percent of its federal funding from the Department of Defense. Any increase for engineering in NSF would be offset at least partially by the cuts in the Department of Defense.
(AREAS OF EMPHASIS)
That is a view of funding by agency. Another way to approach it is by several areas of emphasis reflected in the President’s budget proposal that you can see listed here. These reflect another development that PCAST has recommended and that we are pleased to see. There has traditionally been a lot of “stove-piping” in addressing federal R&D, with responsibility for appropriations divided among 10 different Congressional subcommittees and expenditures made by numerous federal agencies, each of which tends to spend those funds according to their own internal missions. But much of today’s research is interdisciplinary in nature, which requires a greater level of coordination and cooperation among federal agencies, and cross-cutting, interdisciplinary initiatives like these are a good move in the right direction.

(BAR GRAPH: CHANGE)
Part of my responsibilities in this talk is to touch specifically on the physical sciences, and that is an important concern, because the physical sciences provide a foundation for many other disciplines. The FY 2003 budget marked the final year in a five-year push to double the budget of the National Institutes of Health. And as you can see here, that increase for NIH came at the expense of some of the physical science and engineering disciplines. However, advances in biomedicine are driven by fundamental research in chemistry and physics, and in chemical and mechanical engineering, which provide insight into the operation of living systems. Mapping the human genome, for example, was based on fundamental breakthroughs in physics and chemistry. If we neglect these physical sciences, we will hamper what we can achieve in biomedical research.

The same is true for information technology and computer science, which experienced strong growth in federal funding in the timeframe of this chart and continues to receive a significant share. Yet today’s semi-conductors emerged from federally funded frontier research in quantum mechanics during the 1940s, and the Internet grew out of ARPA and NSF funding in the 60s and 70s.

(CHANGES IN FIELD SHARES)
This trend existed even before the doubling of the NIH budget, although that exacerbated things. As you can see here, it goes back a number of years. PCAST has recommended that beginning with FY 2004, the R&D budget for the physical sciences and engineering be adjusted upward to bring these disciplines into parity with the life sciences. Congress has passed and the President signed legislation calling for a 15 percent increase in the budget of the National Science Foundation for each of the next three years. The 2004 budget includes a positive move in this direction, with an overall increase of 9 percent for NSF compared to what was proposed for 2003, and a 13 percent increase of $100 million for the physical sciences within NSF. This would lift the
NSF budget for mathematics and the physical sciences to more than $1 billion for the first time. However, the R&D budget for NSF is less that a fifth of that of NIH, so a similar percentage-based increase will generate fewer dollars for NSF.

(SLIDE: ENGINEERING ENROLLMENT)
The second overarching concern for PCAST is the need to strengthen and expand the talent pool. It will not matter how much money is proposed or appropriated for R&D if we do not have the scientists and engineers to do the work. Five years out of college, engineering is one of the top 10 professions for earnings. So, if the workforce marketplace operated in a purely rational fashion, you would expect high school graduates to flock in droves to engineering schools. But they don’t. During the 1990s, a declining number of students at both the undergraduate and graduate levels sought degrees in engineering, and the same is pretty much true for the physical sciences, math, and computer science.

(PERCENT OF 24-YEAR-OLDS)
PCAST co-chair Floyd Kvamme spoke at Georgia Tech last November, and he noted that science, engineering and technology are “stealth” professions compared to professions like law, medicine, and education, which have a higher level of visibility in the media and in the community. Children grow up knowing what doctors, dentists, lawyers, and teachers do. But the person walking down the street past the buildings where science and engineering research is taking place has no idea what is going on inside. We are going to have to find ways to change that and reverse the slide.

(S&E DOCTORATES)
At the graduate level, the number of Ph.D.s awarded in the sciences peaked in 1998, then declined 3.6 percent in 1999. The number of Ph.D.s in engineering peaked earlier, in 1996, and had declined by more than 15 percent by 1999. The largest enrollment increase in the past two decades has been in international students. By the latter 1990s, almost half of the Ph.D. students in engineering, computer science, and math at American universities were from other countries. But, as you can see here, even the increase in international students has begun to taper off.

(U.S., EUORPE, ASIA LINE GRAPH)
This decline in international PhDs does not mean that other countries are becoming less interested in science and engineering, but rather reflects the growth in quality Ph.D. programs offered by universities around the world. Europe passed the United States back in the late 80s in the number of doctorates it awards in science and engineering, and Asia is probably passing us right now, even as I am speaking.
What’s more, the international graduate students who still come here are showing an increasing tendency to return home after graduation. As other countries increase their attention to research and development, new opportunities are opening up for them in their home countries. Microsoft has 180 programmers in a research lab in Beijing, for example, and a third of them have Ph.D.s from American universities.

Which brings us to another significant consideration. American companies are beginning to export tech jobs to countries that offer a college-educated workforce at significantly lower salaries. Business Week recently reported that Bank of America has cut one-fifth of its 25,000 tech jobs. Some of those job cuts are the result of corporate downsizing in a slow economy, but a third of those jobs are moving to India, where work that costs $100 an hour in the United States can be done for $20 an hour.

Two decades ago we saw manufacturing jobs for athletic shoes, consumer electronics, and toys migrate to developing countries where labor was cheap. We are now at the front end of a similar exodus of technology jobs. Banks, insurance companies, investment brokerage firms, Internet service providers, manufacturers of chip-based technology, and large software companies, to name a few, are beginning to send routine tech tasks like number crunching, database management, computer programming, and help desk services to India, China, Russia, and Eastern Europe.

India has a workforce of more than 500,000 IT engineers with a starting salary of $5,000; China is graduating twice as many mechanical engineers as the United States. The Philippines produce 380,000 college graduates a year, and has an oversupply of accountants trained in U.S. accounting standards.

Forrester Research Inc. analyst John C. McCarthy predicts that at least 3.3 million white collar jobs and $136 billion in wages will shift from the United States to lower-cost countries by 2015. For developing countries with college graduates, this shift will be a boon. For the United States, the impact is less clear. If we can send abroad the technological work that we have been employing immigrants to do, and shift our own workers to higher-value industries and cutting-edge research and development, we may be able to realize a net gain from this shift. But that scenario requires us to do a better job of producing talented researchers in science and engineering.
One of the reasons why it is difficult to get students to pursue graduate studies is that the average annual stipend for graduate students in science and engineering is about half of the average wage of bachelor’s degree recipients, and many of our brighter students go into the workforce. When we look more closely at graduate stipends, there is a second pattern that emerges.

(QUOTE “TRENDS IN...”)

In its study called “Trends in Federal Support of Research and Graduate Education,” the National Research Council found that fields in which federal funding for university research declined during the 90s have also experienced declines in both graduate enrollments and doctoral degree recipients. For example, federal funding for university research in physics declined by 7.4 percent from 1993 to 1999. During the same time, the number of full-time graduate students in physics declined by more than 22 percent. For chemistry, federal funding declined by 2 percent and graduate students declined by more than 7 percent.

Some of this decline is obviously explained by the fact that federal research funds support graduate research assistantships, but that is neither the whole picture nor the most striking part. What is more dramatic is that in fields where federal funds are flat or declining, the sharpest decline in graduate students is among students who are self-supporting. In engineering, for example, 85 percent of the overall decline in graduate enrollment has been students who are self-supporting.

It works in the opposite direction as well. From 1993 to 1999, federal funding for research in medical science increased by 20.5 percent, and graduate school enrollment increased by 41.5 percent. Within that increase, however, the number of graduate students supported by federal funds increased by only 14 percent, while the number of self-supporting students increased by 54 percent.

Graduate students view federal funding for university research as a bellweather, and they simply do not invest their own funds in fields that are not perceived as growing.

The National Science Foundation asked for $215 million for graduate fellowships and traineeships in FY 2004, which would increase the annual stipend to $30,000 from its current level of $21,500 in the 2002 budget, and increase the number of students supported to 5,000 – 350 more than the agency asked for in the yet-to-be-passed FY 2003 budget. PCAST views these funds as critically important, and we are advocating a major program of graduate fellowships.
So as you listen to the various panels and presenters on the details of the 2004 budget proposal, and as you visit with Senators and Representatives over the next two days, I encourage you to keep in mind the three recommendations that PCAST made to President Bush last fall:

1. To improve funding levels for the physical sciences and engineering.
2. To establish a major program of fellowships to attract and support the advanced graduate studies of U.S. citizens in science and engineering.
3. And finally, we recommend a continuous assessment and analysis by the White House Office of Science and Technology Policy of the adequacy of the overall federal R&D investments in light of national interests, international competition, and human resource needs.

The proposed budget for FY 2004 moves us in a positive direction on these recommendations, and PCAST would appreciate the help and support of the associations represented here in this room to encourage Congress to support these recommendations and continue the progress.