Unedited Version

Maintaining America's Science and Technology Leadership

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Let me start by thanking Dr. Harry Armen, the President of the American Society of Mechanical Engineers, for inviting me today this symposium. Dr. Armen was an ASME fellow in my office where he helped developed the Technology Reinvestment Act of 1993.

I would like to cover three basic points today.

First, I would like to discuss some disturbing indications that we can no longer take our supremacy in scientific excellence and technological innovation for granted. Other nations such as India and Taiwan are on a fast track to overtake the United States in scientific discovery and innovation; I will cite examples of these countries from my visits there over the past two years.

Second, I will highlight what I think are poor decisions in the proposed Fiscal Year 2006 budget for science and technology, which could further weaken our economic and scientific posture.

Third, I will outline what I believe are the needed policies and investments to put us back on path of scientific preeminence which this nation has enjoyed since World War II.

It goes without saying one of the basic policies of our nation's economic security must be to maintain a sustained investment in science and technology. There is no dispute that science, and the technology that flows from it, are duly recognized as the principal engine of our economic growth. Nor is there any contention of the fact that America's present strength, prosperity, and global preeminence depend directly on fundamental research. The scientific record of the past half century constitutes overwhelming proof. At the present time, we lead the world in such areas as nanoscience, genomics and proteomics, and advanced scientific computing.

But lately, I have become concerned that we are beginning to slip in our world leadership role in science.

Let me start out with some troubling trends across the R&D spectrum spotlighted in a recent report prepared by the Council on Competitiveness entitled, "The Knowledge Economy: Is the United States Losing its Competitive Edge?"

In the area of education, we are now finding that undergraduate science and engineering degrees within the U.S. are being awarded less frequently than other countries. The ratio of our first university degrees in science and engineering now stand at 5.7 per 100 college age population. Taiwan and South Korea now award 11 per 100 or roughly two times what we produce.

The U.S. share of worldwide undergraduate S&E degrees awarded annually has dropped.

In 2000, Asian universities accounted for almost 1.2 million of the world's S&E degrees, and European universities (including Russian and Eastern Europe) accounted for about 850,000 S&E degrees, while North American universities accounted for only about 500,000 degrees.

As for doctoral degrees, the U.S. has a smaller share than both Asia and Europe. In fact, in 2000, about 89,000 of the approximately 114,000 degrees earned worldwide were earned outside the United States. To make matters worse, the trend is now for students to pursue Ph.D.'s in their home country. The number of Asian students pursing Ph.D.'s in the U.S. has dropped by 19 percent while it has doubled in their own countries.

These trends indicate to me that our science and engineering workforce is aging while that overseas is young and vibrant. In fact, more than half of those with science and engineering degrees in our workforce are now over 40.

I believe this is why we are now seeing the movement of corporate R&D centers from the U.S. to overseas locations. I will return to this topic.

Let me mention another troubling fact in the area of R&D investment.

CHART # 1 R & D

Right now the U.S. invests about 2.7 percent of its GDP in R&D – that is pretty good and it puts us as number 5 in the world, yet still behind Korea and Japan who invest over 3 percent.

However, the issue is not to look at the static picture, as you scientists know – it is the *rate* of change. From 1995 through 2001, the U.S. increased its R&D investments by 34 percent, while the world's fastest growing economies such as China, Korea, and Taiwan, boosted their R&D investments by a whopping 140 percent.

During that same time frame, China's R&D per GDP jumped from 0.6 to 1.2 percent -- still well behind the U.S. -- but doubled in slightly more than a half-dozen years at a 7 percent annual growth rate.

CHART # 2 Federal Investment

While we are on benchmarks per GDP, federal funding of basic research in engineering and physical sciences has experienced little to no growth for the past three decades. In fact, as a percentage of GDP, federal investment in the physical sciences has declined by 50 percent over the past 30 years, from 0.1 percent per GDP to today's 0.05 percent.

What do these disturbing trends indicate?

It means that other nations are on a fast track to overtake the United States in scientific discovery and innovation. The rapidly developing Asian economies are forging ahead, nearly matching their R&D investments with their GDP growth rates, while the United States is lagging behind.

Previously, these countries once sent their students abroad to learn in the U.S., but today they are able to educate them at home. As a result, they have an expanding workforce of undergraduate engineers to staff manufacturing facilities, as well as a growing increase in intellectual property because of a flourishing number of graduate degreed scientists. Lagging international interest in U.S. graduate study is not recovering from record lows. Last year applications dropped another five percent.

Let me close this part of my discussion with some observations from my recent science and technology trips to India, China and Taiwan.

The most impressive finding from these trips relates to the growing skilled workforce I mentioned earlier.

In India, the President of Infosys, the first great Indian software company, told me that last year they received 1.2 million applications, they gave a standardized test to 300,000, interviewed 30,000 and hired 10,000 – and they expect to repeat that again this year. This is the highly trained workforce we must now compete against that I just mentioned.

Another finding is that U.S. and foreign high technology companies are now building their newest R&D centers in these developing nations to tap into their intellectual capital and highly skilled workforce.

Today, General Electric’s largest R&D center is in Bangalore, employing 2300 Ph.D.’s in all areas of research from trains to cat scanners . In fact, these researchers now instructing production plants in Indiana what process controls to use.

Intel has just built a design center in Bangalore with 2000 engineers, soon to expand to 5,000 which will design chips that are produced in my state at their Albuquerque Intel plant.

So the paradigm of the U.S. producing cutting edge R&D which is then manufactured in lesser developed countries has been turned on its head.

The point I want to emphasize is that U.S. companies are not waiting for foreign students with visas to come here -- they are simply building R&D centers there where the intellectual capital is and bypassing the U.S. visa issue.

Let me close this first section with an observation on Taiwan and how other nation's approach cutting edge fields such as nanoscience.

When I visited Taiwan in November of 2003, we visited their Hsinchu Science Park. This science park was founded in the early 1980's to create a region where cutting edge semiconductor manufacturing could team with suppliers, universities and national laboratories in a synergistic environment. Today, the science park has an over 325 microelectronics and optoelectronics companies generating $22 billion in gross revenues. Firms locating there are not taxed for the first five years of operation; their employees can sell their stock at their book value not market value thus avoiding capital gains. That science park model is now being adopted in throughout Asia in China, Singapore and India.

The park is bounded by two universities with active doctoral research programs for a steady stream of new talent and ideas, and in between the universities and the industries are six national laboratories to transition talent and ideas from the lab bench to product.

While we in the in the U.S. pride ourselves on nanoscience, Hsinchu has had one nanoscience center operating since 1994. This facility concentrates on taking fundamental university research into product application. Taiwan has just completed a second nanoscience building next to the first, which is over 300,000 square feet. By comparison the Nanoscience facility being built in my state by the DOE Office of Science will only be 96,000 square feet in size. The new Taiwan facility is 3 times the size of ours.

More importantly is what these centers do – they train over 800 graduate students a year, preparing them for careers in the science park. The nanoscience center works also closely with the science park industries. In 2003, the center performed over 10,000 custom foundry services for semiconductor firms in the park while performing over 134 projects with the two universities located at Hsinchu.

In other words, in Taiwan it is not so much the basic research in nanoscience that matters but how it gets used to create new jobs and new industries. In that regard, I believe Taiwan is ahead of the U.S. by locating their nanoscience centers in the heart of Hsinchu science park, the U.S. has no comparable industrial policy of linking innovation to job growth.

The next question is what we are currently doing to reverse the situation – because by the time the majority of our policy makers read the handwriting on the wall, their backs will be up against it, and it maybe too late to correct.

Let me cite what I mean by that last statement. Edward Cody in the Washington Post recently noted in an article entitled "China's Quiet Rise Cast a Wide Shadow" that while the U.S. has become preoccupied with the war in Iraq, China's rapidly growing economy is forging strong economic ties in throughout Asia that will ultimately translate into its ability to overtake economic and diplomatic relationships long dominated by the United States.

So, let me move to my second point and that relates to the budget for next year that we are currently debating in Congress.

In order to make room for huge tax cuts and address the record budget deficits they have helped create, the Administration now proposes major cuts in the research our country depends on to maintain technical leadership.

The most representative measure of R&D funding, and the measure which best captures its economic and broader societal benefits is the so-called "Federal Science and Technology" budget developed by the National Academy of Sciences. It encompasses nearly all of federal basic research, more than 80 percent of federal applied research, and about half of civilian development. It does not include Defense Department development, testing and evaluation.

Next year's proposed federal science and technology budget suffers a three percent decrease in real buying power -- a reduction of $877 million to $60.2 billion. Among other things, it provides a death sentence for the Advanced Technology Program, and slashes funding for K-12 science and math education.

The National Science Foundation is woefully under funded. The Administration's request next year for NSF is $2.91 billion, or 34 percent below the FY2006 level authorized. NSF's education programs continue to be devastated – down another 24 percent from last year. If the Administration believes in closing the gap in science and math performance between our students and the rest of the world that I just mentioned, how is that possible when proposing cuts to math and science education programs?

At the Department of Energy, the Federal Science and Technology budget would drop by $278 million, or 5 percent. The science programs in the Department of Energy that support much of the nation's premier work in physics and materials science is cut 6 percent in real spending. Renewable energy research is cut 9 percent in constant dollars and energy efficiency 5 percent. All other energy programs -- nuclear, fossil, transmission and distribution -- decline by 9 percent. In fact, the entire petroleum and natural gas R&D account has been zeroed out at a time when the price of oil is climbing past $50 per barrel. Even worse, budget constraints have force the Office of Science to cancel several long lead time big physics projects at the Fermi lab, and to slash U.S. fusion research by 40 percent due to commitments to the International Thermonuclear Experimental Reactor – when a site has not even been selected.

Buried within the Department of Defense budget are cuts to investments in science and technology that will substantially determine our war-fighting capabilities ten to fifteen years from now. Defense research, both basic and applied, are starved, and when inflation is factored in, we will end up buying less research than we did before. The Federal Science and Technology budget at the Department of Defense would drop by $905 million, or 14 percent. The majority of the growth in the defense and homeland security R&D accounts on not long term – they are short term systems deployments.

The question I pose is what can or should we be doing?

The first thing you can always do for research is increase it's funding – but for how much, what research, and for how long? That is a hard question for the Congress to answer in programmatic detail, but it seems realistic to me that we should develop a 5 year funding profile that grows our long-term basic sciences in the federal science and technology budget by 5 percent per year. For fiscal year 2006, that would be mean increasing the federal science and technology account by $3 billion bringing it up to $63 billion. In 2007, it would rise to $66 billion, and so on. That is not the entire federal R&D budget which is now about $133 billion, but it is the R&D sweet spot where basic research spurs future innovation and strengthens our science and technology workforce.

If we increase the resources for science and technology then how can we insure that this research directly translates to innovation and economic growth?

30 Years ago Taiwan looked to our silicon valley as a model for Hsinchu. I believe the opposite is now true - we need to look to Taiwan and Hsinchu for an answer for innovation and economic growth.

It is in Hsinchu we see that there are symbiotic relationships between universities, national laboratories and industries which develop close working relationships with emerging technologies such as nanoscience. One area that I am particularly concerned about is lighting. When you come back from Taiwan, Japan or Korea you see we are about to loose a field that Thomas Edison started over 100 years ago to the emerging field of solid state lighting, which is 10 times more efficient that a light bulb. It baffles me why we, unlike Taiwan, cannot closely link our nanoscience user facilities to our solid state lighting industry so it can utilize the fruits of this cutting edge research to remain globally competitive. Indeed, I am strongly advocating such a thrust area for the nanoscience center being built in New Mexico.

Let me close with some other areas where we can make some improvements that are not directly related to increasing science funding.

DOE's Office of Science should expand our international R&D collaborations. On my recent trip to India, I visited their Indian Institute of Science, which is essentially their Cal Tech, with a long tradition of research excellence. I was informed that essentially all the funds for collaboration with the U.S. under a 40 year program have disappeared. The Office of Science has a wonderful opportunity to develop a program across all DOE laboratories for an open dialog and sustained exchange with the best and brightest India and other developing nation's have to offer. There ought to be dedicated program in the Office of Science for international research collaborations – much like those at the NSF. Our DOE laboratories have much to gain here by having a window into the rapidly accelerating science in countries such as India and Taiwan.

But I believe we can do better than the programs at the Office of Science and the NSF to keep a window on emerging technology driven countries. I believe that there should be a dedicated line in the President's budget for such international collaboration that is allocated to the various science agencies in the Executive Branch. This budget line should be overseen and coordinated directly out of the Office of Science and Technology Policy by the President's Science Advisor. It seems to me that there is nothing more pressing right now than scientifically engaging India and Taiwan, because as I have mentioned earlier, by the time we realize at a national level that it is a problem it may be simply too late to reverse the outsourcing of high technology jobs.

I am also introducing legislation to offer incentives to our existing science parks to expand while also constructing new ones. The rise of Taiwan's microelectronics miracle can be directly attributed to their government's role -- not in picking winners and losers -- but by building the necessary infrastructure allowing competition to flourish through their science parks. The same holds true with India's software science parks and its rise as a world powerhouse in that industry.

In the area of the R&D tax credit, I along with Senator Domenici believe that the R&D tax credits should be modified so that participants in a research consortium receive a flat 20 percent research tax credit. We should be encouraging companies to be working together to share the cost of research instead of requiring each of them to bear the full capital expenditure to which they would be entitled to get the research tax credit. I also believe we should get rid of a restriction that allows companies to only consider 65 percent of their research expenses for purposes of calculating their tax credit when the funds are paid to an outside party such as a federal laboratory, a university or a small business. I believe that we should allow a company to consider 100% or all of their expenses when contracting with a lab, university or small business to handle their research projects.

These are small additions to larger overall R&D tax credit which is reauthorized every year, but they concentrate on encouraging research innovation through our tax code.

CHART #3 High Tech Industry Output

Finally we should be encouraging at a national level foreign direct investment in the U.S. to locate manufacturing plants that would be built by U.S. or foreign firms overseas. Ideally the Department of Commerce should administer a program that acts as the Overseas Private Investment Corporation in reverse, it would lay out incentives to encourage U.S. and foreign firms to locate high tech manufacturing in the U.S. The details are complicated, but such an effort would act to collect and analyze trends in the outflow of high technology investments from the U.S. to such countries as China or India. It would develop incentives using public – private partnerships to attract new manufacturing operations in the U.S. Finally it would act the policy focal point across the U.S. Government to coordinate efforts to make the U.S. attractive for foreign high technology investment.

CHART #4 US Trade Balance

Let me close with a quote from Craig Barrett in the March 17th edition of the Financial Times. The title is “Chipmaker Chief Warns that the U.S. is in Danger of Losing Global Lead”. In that article, he says that the “challenge we face is global in nature and broader in scope than anything we have faced in the past.” He adds, “It will take a massive, coordinated U.S. research effort involving academia, industry and state and federal governments to insure that America continues to be the world leader in information technology”

While the indicators we face today may seem to be grave, I have outlined measures o correct our situation. My greatest fear is that outlined in the Washington Post article I mentioned where we become so preoccupied with other conflicts that countries with rapidly developing S&T based economies surpass us and become regional giants influencing the decisions of countries in that region who were staunch allies of the U.S. We must be alert that the indicators and shortfalls I have discussed do not translate into strategic sources of conflict later, because by the time we recognize that we as a nation have fallen behind these other countries I fear it will cost far more to remedy than addressing it head on today.

Again, let me thank you all for your time and I’d be happy to answer any questions you might have.