It is a great pleasure and privilege to be here with you at the Engineering Deans Council Annual Public Policy Colloquium. I am an engineer, and have been both a school chair and a dean of engineering along the way. So I have walked in your shoes, and I have a special appreciation for the perspective that you as engineering deans can bring to the public policy process.

What are some key public policy issues that engineering deans need to be concerned about? A few that find their way to my list include:

- Need to balance the federal government’s R&D portfolio, with improved funding for engineering and physical sciences.
- Concern about the growth of engineering graduates in India, China and the European Union to levels that exceed those of the U.S.
- Increasing competition by other nations in the innovation space.
- Falling levels of applications to U.S. engineering programs from international students.
- Reductions in funding from state sources for public universities.
- The need to accommodate rapid increases in technological breakthroughs in interdisciplinary fields.
- Low rates of retention of engineering students in comparison to students in other fields.
- Low rates of participation by minorities and women in engineering.
- The slow rate of change of engineering education to respond to new circumstances.

This is an imposing list and represents what I believe is a serious threat to the vitality of engineering in the United States. Some of the issues are beyond the ability of those of us in this room to address and we will need help if we are to find solutions. Others are issues are more within the control of the leaders of engineering education like yourselves, and will require your leadership if they are to be resolved.

I am fortunate to serve as president of a university that graduates more engineers than any other institution in the nation, and I feel a great responsibility for their future. So I very much share your concerns about the challenges ahead. This concern has motivated me to participate in a number of activities that are focused on technological policy issues, so that I might in some small way work with engineering professionals like yourselves to improve the odds for engineering in the United States for the future.

These experiences have convinced me that we engineers and engineering educators need to come out of our shells and become more active as participants and leaders in the broader world around us. That calls for change that must come from outside academia, but also change that has to come from within.

Engineers have always built the essential foundation for society’s operation and created the technology that has allowed it to prosper. And we can be pleased and proud of the significant
role engineers have played in making our nation a world economic and technology leader for many long years. However, as we all know, what worked in the past, will not necessarily work in the future, and I would like to spend a little time this morning thinking with you about our role as engineering educators in the 21st century.

If we look back over the past two decades, it is easy to identify two major trends that converged to shape the world in which we now live. The first is the explosion of technology. Many of the technological devices we use daily and take for granted did not even exist just 20 years ago. The computer of 20 years ago featured a nine-inch text-only display, had no hard drive, and cost more than $4,000. Cell phones were large and bulky, and none of them did text messaging or took digital pictures. In fact, there were no digital cameras. There were no BlackBerries or other wireless devices. There was no commercial Internet, and nanotechnology had yet to be discovered by BusinessWeek.

Technology is not the only thing that changed rapidly during the past two decades. Twenty years ago the Berlin Wall was still standing, and the world was dominated by two political power blocks – the communist world of the East, anchored by the Soviet Union, and the democratic world of the West, anchored by the United States. Then the Cold War ended in late 1991, and the Soviet Union broke into its component republics. The political barriers that had separated the world rapidly dissolved and trade barriers between many nations came down.

At the same time, the proliferation of telecommunications technology and the development of the commercial Internet opened new avenues of inexpensive, real-time communication. Emerging nations like India and China began developing technology-based economies. These nations, together with Japan and the European Union are looking to compete with the United States in fields where engineering and technology form the backbone, and they are making inroads.

This combination of political and technological forces has created a global economy that is increasingly driven by innovation. The surging economies in places like China and India are propelled to some extent by the disparities in wages compared to the United States and Europe, but they also reflect the development of skilled technological workforces in these nations. They are investing in education programs in science and technology, and according to the National Science Foundation, China, India, and the European Union each now graduate more engineers than the United States.

In this highly competitive economy of the 21st century, it would be both arrogant and unrealistic for the United States to think that we will continue to dominate the innovation process as we have in the past. We must learn to compete in an environment in which we produce only one of every four or five major inventions and where the largest markets for technological products will lie in Asia.

Craig Barrett, the CEO of Intel, says it this way: “The U.S. is not graduating the volume of scientists and engineers; we do not have a lock on the infrastructure; we do not have a lock on the new ideas; and we are either flat-lining, or in real dollars cutting back, our investments in physical science and engineering. The only crisis the U.S. thinks it has today is the war on terrorism. It’s not.”
We can see his words reflected in federal research funding and in our own enrollments. Over the past decade the National Research Council, PCAST, and AAAS have documented the problems in federal funding for R&D in engineering. The federally funded research portfolio has also become unbalanced, with the lion’s share of the funding increases focused on health and life sciences while funding increases for engineering and the physical sciences languished.

But the hot beds of discovery and invention are now in the spaces between the traditional academic disciplines, and this convergence of knowledge across the disciplines requires that they all move forward together. Advances in biomedical research, for example, are based on fundamental discoveries not just in biology, but also in chemistry and physics, and in electrical and mechanical engineering. Yet these other disciplines have seen little, if any, increase in federal support over the past decade. These circumstances are well documented in reports published by PCAST, the NRC, AAAS, and the Council on Competitiveness.

Congress recently expressed its intent to begin to correct the imbalance by expanding the budget for the National Science Foundation. Unfortunately the federal budget deficit has thwarted that commitment. But even if they had provided the funding, setting things to right is not that neat and tidy. Research in engineering and the physical sciences is spread across several federal agencies, and in some disciplines, agencies like the Department of Energy provide more funding than NSF. There is no single federal agency that can serve as a “fly-wheel” to provide balance and make sure all disciplines are in a position to contribute fully to the growing interdisciplinary mix. As a result we need to work strategically towards common goals that can garner broad based support.

We are also seeing other nations increasingly compete with us in research investment. The United States spends more money than any other nation on R&D, but our expenditures are heavily focused on defense-related activities while other nations focus a much larger portion of their R&D activities on basic, long-term knowledge discovery. PCAST has recently been looking at issues surrounding nanotechnology, for example, and data show that while the United States has rapidly increased our federal investment from only about $100 million in 1997 to almost $1 billion last year, Western Europe and Japan have pretty much kept pace with us. China, Israel, Australia, Canada, Eastern Europe, Singapore, South Korea, and Taiwan are also making significant investments in nanotechnology research.

The problems of research funding are closely linked to the problems of human capital. We struggle to recruit U.S. students into the pursuit of advanced studies in engineering in part because of a lack of fellowship and research assistant support. For example, in the 1970s we had the National Defense Education Act that provided scholarships and fellowships for students who undertook studies in engineering and science. That program was phased out many years ago. In 1995, the DOE was supporting more than 1,000 fellowships and dissertation awards, but with pressures on their budget, that number has shrunk to around a hundred.

The latest data from NSF shows a slight increase in engineering doctorates in 2003 after we hit a low of just over 5,000 in 2002, but we are still well below the peak of over 6,100 back in 1997. Part of the problem is when federal research funds decline in a particular field, graduate
enrollment and doctoral degree recipients experience a parallel decline. At the bachelor’s degree level, we are hovering around 60,000 degrees a year, down from almost 77,000 in 1986.

Over the past several decades, the United States was able offset the declining enrollment of our own engineering graduate students with an increasing number of international students. But following the 9-11 terrorist attacks, it became more difficult for students to obtain visas. And at the same time, competition for the best and brightest international students increased. Other countries are increasingly offering quality degree programs in engineering with strong financial incentives. ASEE’s *Prism* magazine reported in its last issue that there was a 36% decline in applications from international students to U.S. engineering programs. Some of this can be attributed to the issues associated with foreign students entering this country. Fortunately there is evidence that efforts to resolve them are turning things around. But don’t be surprised that it is also related to increased competition from universities around the world, and this is not going to go away.

As a nation we have been known for innovation and a willingness to develop and implement products and services that are at the cutting edge. We have used our ability to innovate to keep our economy robust so that it provides good wages and a high standard of living. It is not surprising that other nations are moving to build economies in the innovation space, and we cannot fault them for working to improve their own standard of living. But that means we need to focus more deliberately on being ahead of the game and insuring we will have our fair share of the economic returns in the future.

“Innovation” has become a buzzword these days, and it is often used interchangeably with a word “invention.” But they are not the same thing. Invention can be done by the lone genius working in a university or a private laboratory. Innovation is a much more social activity that emerges at the intersection of science and technology with business and the marketplace. Innovation done right requires a setting that is conducive to what is a social activity among different disciplines.

Innovation begins with research that generates breakthroughs in science and technology, opening new fields of endeavor. But scientific discoveries and new technology by themselves are not enough in this new, interconnected global economy. Innovation requires that we not only discover new knowledge and technology, but also that we anticipate ways to put it to work within a complex legal, political, social, and economic landscape. Our competitive edge will lie in the application of leading-edge technology in creative ways to solve the problems and serve the needs of society. Engineering should be a leader in this effort, but it needs to appreciate the broader issues that frame innovation if it is to lead.

I know from experience that engineering deans naturally have a tendency to be focused on helping their faculty attract research awards, recruiting the best students and raising private funds. But the message I want to leave with you today is that your lives have just gotten more complicated. If we are going to address the imposing challenges we face, we need to get help. And to get that help, we need to pay attention to the issues the public and our elected officials are concerned about as well.
This Colloquium provides you with an important opportunity to speak out, and I congratulate you on your plans to open dialogue with Congress and local elected officials. But if you want to influence Congress and other politicians, you will need to be informed on the larger challenges they are facing. Do your homework and read up on the good policy work that has been done in the past few years. Reports by PCAST, the National Research Council, NSF, the NAE, AAAS and the U.S. Council on Competitiveness among others support the positions you need to make. Knowing and citing this work gives you third party validation, and strengthens your arguments. It helps you establish a policy context while demonstrating that you appreciate the issues beyond the purely technological and academic world.

Finally, if we want to gain support for our positions, we will need to show that we are willing to change to prepare a future that will be drastically different than today’s setting. For too long engineering education has changed only after external events forced our hand. The goal of the Engineer of 2020 Initiative of the National Academy of Engineering is to sort out the issues and opportunities that lie ahead, so that engineering education can anticipate the future and produce the curricula and processes that will allow us to graduate engineers who are prepared for the environment in 2020.

This initiative has been underway for three years. The report for Phase I is now available through the National Academy of Engineering, and it addresses the circumstances that are likely to be important for engineering in 2020. It also goes a step further by identifying aspirations for engineering and engineers so that the profession will be able to re-establish a place of respect in our society and be able to attract our share of the best and brightest students.

In reviewing the context for 2020, the Phase I report comments that basics, like access to fresh water, energy, medical care, and housing, will be at core of the problems we will face, particularly as we add 2 billion more people to the world during the next 20 years. Even as these issues grow, we are fortunate that new breakthrough technologies coming from fields like nanotechnology and biotechnology will offer entirely new approaches to tackle our challenges. However, if we are to make the transition to a new toolkit, it will take a significant effort on the part of engineering and engineering education to ensure that engineers are up to the task and on par with those from other nations.

Engineers will need to be educated as innovators, which means giving students more direct exposure to cross-disciplinary topics and the workings of an entrepreneurial economy. Engineering students will also need to have the opportunity to study abroad and learn to appreciate the cultures of other nations so they can function readily within the global economy. Finally we will need to enhance positive interactions between our students and faculty in academia and the engineering profession and industry.

From personal experience I know that changing engineering education is not easy, but the effort is needed and important. Beyond the traditional curriculum we should take advantage of the fact that many changes can be made working outside the traditional classroom/laboratory environment. Thus, we need to develop leadership education that engineering students can find in their professional society activities, through study abroad, and by participation in undergraduate research and honors programs. This challenge will likely call on you to become
more involved in your university outside of your college role, so you can shape university initiatives to include engineering students and faculty.

Can we accomplish these ambitious goals? Admittedly, it will not be easy, and the question is being addressed in Phase II of the Engineer of 2020 Initiative. We held a summit last summer in Washington D.C. with some of the best minds in engineering and engineering education to address the issues. Many good ideas were presented and these are being documented in a report that will be forthcoming in late spring. The NAE is now undertaking a strategically designed effort to bring as many engineering educators and members from industry and engineering practice as possible into a dialog on the challenges that lie ahead. But for this to be effective, it will require more creative input from folks like you. No one has a lock on all of the good ideas, and the more we have the better.

At the level of the NAE we are trying to pull engineering education forward, but we need your help to push at the other end by encouraging and undertaking thoughtful change in your own colleges, schools, and departments. I would argue that while the issues that face us are large, now is the time for thinking big, working together to set goals for where we want to be, and taking actions that one by one will get us there.

I close with a quotation from Harold R. McAlindon, who is a business consultant and author. He said, “The world leaders in innovation will also be world leaders in everything else.” If we in engineering can be more innovative in developing new ideas and technology and applying them in creative ways to solve the problems and serve the needs of society, we will help our nation compete and shape a healthy, prosperous future for ourselves and for generations to come. I have indicated important areas where you can contribute. Get involved, get informed, build a common strategy and get to work! We need your help!