SAND 5243549

Engineering As a Life

Commencement Address, University of Florida College of Engineering
5 May 2006

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Introduction

Thank you Dr. Abernathy, Dean Khargonekar, Distinguished Guests, Graduates of the College of Engineering 2006, Ladies and Gentlemen.

First of all, I want to tell you what a great personal pleasure it is to be with you for your special night. I have always had a deep attachment to this university and especially the College of Engineering, for it was here that my professional life began. My original home is not very far from here—in fact, less than 40 miles—but my heart is even closer. Graduating as a Gator Engineer allowed me to begin a journey that at the time I had little insight into and only now can see with any reasonable clarity. My hope tonight is to talk about the change that you are likely to see as you begin your journey and as you weave together what will become your story. If you have any uncertainty about that or where the future will lead you, I can assure that it is likely no more than my own at that time, and likely no more than most of the distinguished guests on this stage at the same point in their careers. For it is this uncertainty that provides the excitement and challenge in life, and that challenge gives rise to opportunity. Opportunity allows success, and success brings fulfillment.

Not so long ago, I had the opportunity for discussions with a noted historian who described life in this country a century ago. It was

certainly a sharp contrast with today: high rates of infant mortality, pandemic diseases, limited opportunity to vote for some people, concentration of wealth, and a country that had not yet established a global presence. I have always been a student of history and would recommend it to anyone—but I take a century ago as something I studied, not something I experienced. Four decades ago, however, when I was in your position, is a strong and personal recollection. Imagine: no Internet, computers the size of trucks that ate paper cards and occasionally provided an intelligible and practical output, no microelectronics, square roots and trig functions taken from tables or maybe from the ubiquitous slide rule, few women in engineering classrooms, a prevailing image of industrial America in three-piece suits, where conformance was the career guidance of choice, a nation with great social and economic divides, and the very real threat of nuclear annihilation as an accepted part of every citizen's life. Yet I would submit that in the next four decades—your decades—the contrast with today will be even more striking.

Let me then talk about what an engineer might reasonably expect.

I. Challenging the stereotypes

From what we are led to believe, when the average person thinks about an engineer he pictures a guy in a white shirt with a pocket protector, a guy with a calculator in his hand, maybe a little unkempt, a little distracted. A guy who spends his day in front of a computer. A guy devoted to his work because he has no life outside of work, or—if he does—he spends it in the company of other engineers, talking about math and science and maybe, if you're lucky, cars or even golf.

Engineers are sometimes portrayed as geeks or nerds, as people whose socks don't match. They are accused of being poor communicators, needing interpersonal skills—the guys who had no dates in high school.

Even our more charitable critics—like wives and husbands—tend to regard us as primarily practical people, people who fix things and build things.

Engineers are many times not seen as leaders, but rather as anonymous cogs in the company machine. Sometimes people view engineers as forever consigned to sort out how to accomplish things but not the important role of deciding what things need to be accomplished.

Well, I'm here to tell you these stereotypes are wrong. The truth is that engineers are engaged in prominent roles in every business, at every university, everywhere in politics, and at every level of leadership. If I could convince you of only one thing it is that engineering is a call to lead and it is the ticket not only to the front of the train but to decide where the tracks will go. Yet I must personally admit that my socks match, my ties generally complement my suits, and any ability I have to converse in things of art and literature are largely the result of a talented and devoted wife.

Engineering is not the domain of any single race or gender. It is not constrained to follow a path prescribed by legacy or institutional edict. It is the path less taken, but it is the path on which much of the world's hope for the future depends.

Engineers share a love for invention, design, and discovery. We hold the keys to innovation and creativity. We are respected members of society. We are participants, not spectators.

We are patriots. We participate in and support our military forces. We respond to national disasters and many other areas of human need.

Many will carry in their mind a strong distinction between the scientist and the engineer. I would argue that the distinction is very blurred. Time and the strong integration of our technology have left that view behind. I personally spend no time giving that distinction

any credibility. It is rather two facets of the same gem that has as its core the search and profound respect for the truth, the excitement of discovery, and the satisfaction of making a difference in the lives of people. Engineering is science in action, but science yet.

The example of leadership by engineers is long and distinguished:

President Herbert Hoover, President Jimmy Carter, Admiral Hyman Rickover, Alfred Hitchcock, Lee Iacocca, Cowboys Coach Tom Landry, Jack Welch of General Electric, Neil Armstrong, first man on the moon.

II We have much to be proud of

Much can be said about the progress of civilization in the last century, but little can be said without acknowledging the pivotal role of engineering and the technological explosion that has resulted. Through engineering we electrified both urban and rural America. We developed automobiles and airplanes that made distance no longer an inhibitor to commerce or individual opportunity. We have clean water in virtually every household. We communicate instantly, live and work in comfortable, controlled environments. We explore planets. We enjoy energy at our fingertips. We can access more information in a minute than was produced over the prior 3000 years. We can arguably live more comfortably, likely more safely, and certainly longer. Few professions have this unquestioned impact on history. Few deserve the same respect and pride that engineering has earned. I hope you feel it and share it.

The pace of expansion of knowledge and technology has truly been staggering. In my own field it is still hard to believe that we went from the discovery of a new elementary particle of the atom—the neutron—to the production of electricity from nuclear power generation in two decades. In the space of two or three generations we went from the first powered human flight to the exploration of the moon and space. In an even shorter time we saw the

deployment of personal computers evolve into connectivity, commerce, and collaboration across the entire globe. This revolution is redefining the workplace and the workforce, allowing massive globalization of industry, 7 by 24 product development and support, and a fuzziness about boundaries of nations and companies.

At the same time, all these technologies can have a dark side. It is never certain that all these things will lead to a better quality of life, or more security for our citizens, or more opportunity for the deprived. It is we as engineers who can help assure that the world is a better place because of what we do and, sometimes more importantly, because of who we are.

You might think that the golden age has come and gone. I would argue that it certainly has not. It is just getting started. We are on the brink of another very rapid period of profound technological and social change.

III Let me talk about engineering as we have come to know it

Back in the 1950s and 1960s, most engineers were thinking big, not small. That was the time of big cars, big jets, and big atomic bombs. We were building skyscrapers, bridges, dams, and the interstate highway system.

But in the 1950s and 1960s some researchers started making things small. The invention of the transistor in 1947 and the first integrated circuit in 1959 launched an era of electronics miniaturization. This provided a whole new way of thinking about engineered systems and how to achieve functions from the inside out.

Some interesting evolutions occurred. In the 1950s a new automobile could be developed in about 24 months. As the world got more complicated with safety and emissions standards, that time grew to almost 5 years. With the pressure for quality and

international competition, the industry has gotten that time back down to about 2 years, but the competitive pressures are indicating that a norm of 18 months will be necessary to stay on top of the market.

In an area close to my own experience, we developed a nuclear deterrent to assure our nation's security in a nuclear-armed world. This had a special priority and focus during the Cold War standoff with the Soviet Union. To develop that capability, the United States performed over 1000 nuclear tests and relied on them to assure the safety and reliability of our stockpile. Today it is likely that we may never perform another test.

In general, though, there was one prevailing philosophy: design it, make it, shake it, break it, and repeat until done. As the last century closed, it became clear that this general approach would need rethinking.

And this rethinking comes at a time when the need in the world is clear and urgent.

The challenges and the call for technology solutions are intense. We desperately need to find secure, stable supplies of energy at a price that can sustain our economy. We have no apparent solution to the rising cost and impact of health care, which grows at two or three times the rate of the economy. The United States and especially Western Europe have an aging population that does not provide stability for our future workforce and social programs. We live in a world where modem civilization and freedom are under constant attack and where global strategic confrontation is always a threat over the horizon.

This country faces a true dilemma. We produce less than 10% of the world's engineers. A few decades ago, the United States produced roughly as many doctorates in Science and Engineering as the rest of the world combined. Today we produce about one-half as many as the other industrialized nations. And of course a

sizeable number of our graduates are from other countries and have the intent to return to their native homes.

In short, Science and Engineering has not been a national priority. It has not been the focus of our education systems or of our social priorities. This must change. Some have argued that we have experienced a "silent sputnik." Some may recall that fateful day in 1957 when the world heard the first signal from space—beep-beep-beep—and the ominous thought that not only had an adversary outstripped us by putting objects in space orbit, but also had nuclear warheads that when launched could destroy us at will.

In February this year, it was my pleasure to meet with leaders of congress and the President to be part of announcement of a new government priority to support this essential change. It is right, it is important, and it is urgent.

IV What about the future?

As we look forward, then, what will engineering become and what will it mean?

I would propose there are some very real and likely roles for technology. Imagine in the near future:

- Small microdevices inserted into the body, powered by glucose from the bloodstream. They monitor, report, alert, and alter the body's response mechanisms to avoid heart attacks and strokes.
- Natural disasters that are predicted, their effects evaluated, and protective measures initiated to protect the population and the country's infrastructure.
- Solid-state devices for lighting, resulting in a 10% reduction in the our total energy demand, leaving incandescent bulbs to be seen only in museums.

- Microbes tailored by computer genetic alteration to provide for rapid bioconversion of organic materials to produce energy from renewable crops and waste materials.
- Our nation's soldiers and defenders with instant access to information that assures complete situational awareness, computer-augmented development of tactics and actions, and a range of options to maximize effects and minimize any collateral damage.
- A wide range of energy options, like renewable energy and expanded nuclear power, that can reduce tensions from energy dependence and limit the impact on our climate.
- Computing done through quantum effects that increase information density and processing a million-fold.
- An information-rich, computer-enhanced learning environment that transforms education into an experience to gain deeper understanding of more and more complex interrelated subjects.

What then is the role of the engineer?

Let me list a few things:

We will work faster. We will move from current design approaches—which take us from ideas to prototypes to products in months—to new approaches that will take us only hours.

We will work smarter. We will no longer rely on traditional "make, shake, break, and repeat" to realize products. The design environment will incorporate imbedded modeling and simulation that allows a complete range of effects and environments to be addressed with complete confidence. A decade ago we broke the so-called sound barrier of computing—one trillion operations per second. Today we have just crossed one-hundred trillion, and a thousand trillion is just around the comer. Soon our ability to think, to discover, and to create will be not just supercharged but

hypercharged by the power to see, feel, and hear beyond all the experience of human history.

We will work with others more seamlessly. An unlimited array of individuals and knowledge will be instantly available to allow the most creative and innovative ideas to be developed, covering the widest possible range of technologies and applications.

We will work more deeply. We will work at the level of the very structure of atoms and molecules to develop new materials and devices that provide any desired function at any desired size scale.

We will learn more. Learning will never stop, understanding will ever increase—more and more about more and more.

And we as engineers will lead more. The world will look to us more for the hope of the future.

So, let me finish with that last thought.

V. A call to leadership

One of the pleasures of my current position is the opportunity to talk to recent engineering graduates that have joined our company. Recently I asked some of them what they wished they had known when they graduated that they now know after a year or so of work.

Many said they wished they had better understood the need for continuous learning, especially to the depth and breadth necessary to be a functioning engineer.

Many said they wished they knew how interdependent they would become with others and how important the ability to team with and learn from others would be.

And many, as you might expect, said they did not appreciate how much work would be required to excel.

The first two are necessary elements in the transformation to fully embrace the future. The latter is a necessary consequence of undertaking a profession as important as engineering.

In closing, I would like to add my own wish—one that I did not realize when I was in your position—and that is the enormous need and clear call to engineers for leadership.

- Leading ideas
- Leading people
- Leading organizations
- Leading society
- Leading nations.

So, take satisfaction in the accomplishments of others; enrich them in any way you can.

Have confidence in yourself and your ability to impact important things. Take pride in what you do, in who you are, and in the path you have chosen.

The nation and world need engineers. They need you—your values, your truths, and your creativity.

If this nation is your home, then I hope you will find a role to truly impact the future of this country toward a better, more prosperous tomorrow.

If this country is not your home and you intend to reside elsewhere, then I hope you will take what you have learned here to your country of choice. Take the values that this country stands for, the hope for a better world, and the power of a free people; take it and make a difference.

As engineers you have much to offer. As such, much is expected from you. You can truly create a different tomorrow. It will happen if you care. It will happen if you choose to lead.

It has been my pleasure to address you tonight. It has been my honor to share the same profession. Thank you.