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Welcome Remarks
ESD Symposium
Wong Auditorium, Tang Center
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Good morning. I am delighted to welcome you to MIT.

And, since I think engineering systems is a topic of great importance, I am happy to be able to greet such a full house!

Actually, I've thought a lot about systems engineering since the Monday morning three weeks ago when I turned on my computer and it began to download 12,600 messages!

I first heard the term "systems engineering" when I was a graduate student, at a seminar about the Vanguard missile—the United States' first, ill-fated attempt to counter Sputnik by putting a grapefruit-sized satellite into space. But an embarrassing sequence of Vanguards started to climb and then blew up. Khrushchev thought it was very funny. Now, the fact is that it had been assembled from excellent components that had been designed without any knowledge of the components with which they would interface. Heat, electrical fields, etc., played havoc with it. The fix was to engineer the system. I found this very interesting...and then proceeded on to a career in engineering science.

MIT established the Engineering Systems Division in our School of Engineering in 1998. The creation of the Division reflected our growing awareness of the rising social and intellectual importance of complex engineered systems.

A large number of faculty members in the School of Engineering and in other Schools at MIT were already engaged in research on engineering systems...and we had launched some very important educational initiatives at both the master's and doctoral levels. The new Division was intended to provide a focus for these varied activities, giving them greater administrative and programmatic coherence and stimulating further development.

The Division's progress has been due in no small measure to the energetic leadership of Dan Roos, who has been its Director since its founding. I believe Dan will talk about ESD in more detail later this morning. Last year, he was joined by a Co-Director—Daniel Hastings. They have made a very effective team.

MIT, of course, is famous for its role in establishing "engineering science," which revolutionized engineering in the post World War II era.

In my view, a truly pivotal moment in MIT's history was when Karl Compton realized that in the future we would not be great in engineering if we did not also have great science. This started the institution on a path that could later lead to the engineering science revolution. And it has been one of our strengths that basic scientific research and deep scholarship exist side by side and in mutual respect with highly applied work and engineering.

Another pivotal moment in MIT's history occurred half a century ago when the Lewis Commission, considering the nature of our educational programs, told us that to be a great engineering school in the future we would need to develop strong programs in the humanities and social sciences. Perhaps that set us on a path that has led to this day when a large swath of the engineering community has gathered to consider the evolving 21st-century view of engineering systems. For surely such systems are not based solely on physics and chemistry.

It is indisputable that today and tomorrow many engineers must conceive and direct projects of huge complexity that require a new, highly integrative view of engineering systems. Academics led the way in engineering science. I don't think we have led the way in what we now are terming "engineering systems." Rather, we have been struggling to observe the world of industry, government, and society, and asking ourselves, "What in the world should we teach our students?"

This is a valuable exercise, but it is not enough. The thinkers who have brought us together today are working hard to establish a proper intellectual framework within which to study, understand, and develop large, complex engineered systems. They have approached this problem from a variety of perspectives—historical, experiential, and analytical.

Something exciting is stirring.

It comes none too soon, for as Bill Wulf has so eloquently warned us, we work every day with systems whose complexity is so great that we cannot possibly know all their possible end states. How do we provide assurance about the safety, reliability, and resilience of such systems? In other words, how can we practice engineering?

The worlds of biology and neuroscience are suddenly rediscovering the full glory and immense complexity of even the simplest of living systems. The engineer and the computer scientist are suddenly as indispensable to research in the life sciences as the most brilliant reductionist biologist. The language is about circuits, networks, and pathways.

And it has been fascinating to participate in various discussions of the role of science and biology—of research and development—in homeland security, or more generally in antiterrorism. I think of this as the Mother of All Systems Problems. Designing systematic strategies to protect against terrorism has about as much in common with our experience of protecting ourselves from the Soviet threat of just a few years ago as it does with strategizing against 18th-century British troops marching toward us in orderly file.

Or what about engineering systems for today's globalized industries? We have such little understanding of that that bright, passionate people who protest vigorously or even violently against globalization cannot explain what they are protesting against. Yet we all know that globalization—industrially, economically, culturally, and socially—is as inevitable as death and taxes. We'd better learn how to think about it and how to operate it in a way that benefits humankind.

Or look at what IBM's vice president for research, Paul Horn, is thinking about these days. He is observing a company and an industry that produce the ultimate fruit of the engineering science revolution—that is, computers—morphing into a new services sector—financial services, manufacturing services, McDonald's hamburger services—and he is asking, "Is there a services science that is trying to emerge? Is there a new discipline to be had?" In my view, if there is, it is a subset of what the thought leaders gathered here call the new Engineering Systems.

In any event, it has been MIT's engagement with industry that has spurred our developing approach to this topic.

We are not an ivory-tower institution. We have a long tradition of engagement with industry and government that makes engineering systems a "natural" for us.

In the 1980s and early 1990s, our attention turned to large-scale engineering in no small measure because of our engagement with industrial issues, especially productivity. Those concerns generated major multidisciplinary efforts such as the MIT Commission on Industrial Productivity—which led to *Made in America*— and the International Motor Vehicle Program—which led to *The Machine that Changed the World*.

(By the way, I have recently written a little bit about the importance of perseverance in academia. That moves me to pause to recognize how important the intellectual perseverance of Dan Roos has been to the emergence of the Engineering Systems Division at MIT, and indeed to the emergence of his embryonic field.)

Of course, today, collaboration with industry remains central to the research and educational programs within ESD. But the relevance of engineering systems extends beyond industry to the government and the public as well.

The safety of complex engineered systems remains a critical concern. You will have the privilege this morning of hearing from Institute Professor Sheila Widnall, former Secretary of the Air Force and a member of the Columbia Accident Investigation Board. The Board's findings serve as a powerful reminder of the impact that human factors can have in the operation of an engineered system.

Before I close, let me editorialize one last time. I referred to homeland security as the Mother of All Systems Problems. But there is one that is even greater, and ultimately even more important—that is the sustainable development of human societies on this system of ultimate complexity, yet likely great fragility, that we call Earth.

Like someone captive to the most recent book he has read, I must confess that I spent last week in Sweden at a meeting of our seven-year-old Alliance for Global Sustainability. But the fact remains that, at least in modern Europe, "sustainable development," ill defined though it may be, is part of the everyday work of industry and politicians. It certainly is a common element of political rhetoric, and rhetoric is a start. I am troubled that it is not even on the radar screen in the U.S., let alone on the tongues of Presidential contenders.

It is, however, a worthy area of thought for those of you who want to engineer really big systems.

I have tried to sketch out some of the reasons why I think engineering systems is such an important area of discovery, teaching, and research. But of course, the real proof will come over the course of this symposium, as you hear from a truly extraordinary array of speakers. I would like to salute the co-chairs of this symposium, Joel Moses and Tom Allen, for developing a truly outstanding program.

And I especially want to acknowledge my wonderful colleague Joel's tremendous vision for engineering systems at MIT. As Dean of Engineering, as Provost, and now in the even higher position of Professor, Joel has had a clear vision of the intellectual excitement and real-world importance of this field.

In closing, let me welcome you once again to MIT, and to what promises to be a truly remarkable symposium.