Fifty Years of Global Technology

George Sadowsky
New York University and the Internet Society
4 August 1997, Islamabad, Pakistan

Mr. President, distinguished guests, ladies and gentlemen:

It is an honor to be with you today to talk about a subject as important to modern society and development as technological progress. As my colleague Dr. Kolb has already described, during the last 50 years the scientific community has provided enormous amounts of new information about the nature of our world. As a society we have been using it to fashion technology to create a different and hopefully a better world.

Scientific knowledge may be neutral in its implications, but how it is implemented in specific technologies is clearly not neutral. Scientific discovery can lead to technical developments that seem clearly benign, such as nuclear power and the use of nuclear isotopes in medicine, or to opposite results, such as the creation of weapons of mass destruction. This example highlights the crucial responsibility of scientists to inform policy makers about the social choices that are enabled by technology, and the equally crucial responsibility of those who govern to make informed and responsible choices.

The last 50 years have often been characterized as the information revolution, although they are much, much more than that. Information technology has been one of the most visible and one of the most broadly distributed of all technologies. It is important in its own right and also because it has the potential to accelerate dramatically the rate of diffusion of knowledge about all sciences and technologies throughout the world.

Components of this technology include the stored program digital computer whose efficiency has improved by 30% per year during almost 50 years; software technology, used to create the complex sets of instructions for performing computer tasks; optical fiber technology for meeting exploding demand for communications services; and packet switched networks as the basis for the development of modern data communication architectures.

The Internet, which achieved public visibility only just recently, currently connects almost 20,000,000 computers, has a historical growth rate close to 100% per year, and is emerging as the first world-wide global information infrastructure. The invention of Xerography and fax technology have provided a means of quickly copying and sharing information with almost anyone, almost anywhere.

These are all elements of the digital revolution, characterized by both content and communication becoming digital in nature. This trend is captured in the saying, "what cannot be digitized is in danger of being marginalized."

In medicine and health, our knowledge of human biochemistry and physiology has enabled greater control of our reproductive destiny through the birth control pill and other methods of contraception. Nuclear physics has provided the basis for non-invasive diagnosis and treatment of disease using CAT scanning, MRI imaging, and accelerator beam methods for non-invasive treatment of internal tumors. A combination of prosthetic and medical technologies has allowed many parts of the human body to be reconstructed or replaced . Bionic man, with replaceable parts, is increasingly a reality.

Advances in understanding our most basic biological foundations have led to technology — the ability to cut, paste, and replicate DNA — forming the biological tool kit needed to map the entire human genome. We can now identify individuals by the "fingerprint" of their DNA and we can trick bacteria into manufacturing useful drugs for us.

In 1947, there was significant concern that a rapidly growing world population would soon not be able to feed itself. Such concerns missed almost entirely the green revolution, a combination of technologies that enabled development of crops specifically engineered to thrive in inhospitable environments.

In the area of power technology, the exploitation of nuclear fission has been somewhat limited by safety and environmental concerns, but the technology may gain more prominence in the future as the scarcity and environmental side effects of traditional fossil fuels grow. Power from nuclear fusion, although not yet achieved, offers one of the few good long term sources of sustainable power that we will surely eventually need. Solar power and new battery technology continue to evolve toward providing large scale economically efficient power. The fuel cell has provided power for large parts of the space research program.

In transportation, the jet engine and the development of commercial jet aviation have shrunk the world and allowed people of different cultures and nations to meet, mix and understand each other better.

Satellite technology is now routinely used for providing high bandwidth communication. Satellite based photography is providing detailed information about the earth's surface resources and land use, an accurate system of global positioning, and the ability to create accurate maps of the earth and to provide detailed defense surveillance information. The use of satellites for global television broadcasting has shrunk the world and heightened our awareness of our interdependence as people and nations.

The laser has enabled very high bandwidth communication, high precision surgical procedures, and is an essential element for the realization of power from nuclear fusion. Atomic clocks have sharpened our ability to measure time with error rates less than 2 parts in one billion. New knowledge about the physical and chemical properties of materials lets us design new classes of composite materials with unique combinations of properties.

Perhaps the most important technology of the last 50 years has been transistor technology. Using photolithography techniques, we can now manufacture electronic circuits with millions of transistors per square centimeter. Without the transistor, we would have, among other things:

- no inexpensive or reliable computers,
- no space program,
- no reliable mass global air transport.
- no practical digital telephony, cellular telephones, or high speed data communications.
- no consumer electronics market such as we have today,
- almost no affordable non-invasive medical diagnostic tools, and
- no way to measure or catalog the biological structures we are exploring today.

The history of the transistor illustrates the importance of the support for science in the development of technology. First, transistor technology depends upon the theory of quantum mechanics developed in Europe between the two world wars, when Europe was the center of research productivity in the sciences and its universities gave strong support to scientific research. Second, the transistor was invented in 1947 by a team at Bell Laboratories, one of a small number of premier industrial laboratories then in the United States. Such laboratories exist in diminished form today because of the pressures for a more immediate return on investment — a sad reflection on the current short-sighted attitudes toward scientific research and one that is quite likely to damage research productivity.

In an increasingly technical world, having a critical mass of scientific and technical knowledge and capacity grows in importance for achieving and maintaining economic competitiveness. Sometimes having technology can be a matter of national survival — for example, if radar had been developed by Nazi Germany in the late 1930's rather than by Britain, this might be a very different meeting today, if it occurred at all.

During the last two hundred years, the economies of the countries now characterized as developed have undergone profound shifts from being agriculturally based to industrially based to service and knowledge based. In the United States for example, which is self-sufficient in agriculture, less than 4% of the labor force is employed in that sector. Similarly, only a little more than 10% of the labor force works in manufacturing. The message to developing countries is that investment in human capital is a very important — if not the most important — investment that can now be made in aspiring toward a more developed status.

Fortunately for all nations, intelligence and creativity appear to be distributed at birth without regard for national boundaries. However, to be useful these traits must be identified, encouraged and developed actively. Educational opportunities need to be widespread, robust in quality, and available to all without undue hardship to realize this potential. The development of science and technology cannot succeed unless society's values and actions reflect a high priority given to it.

Likewise, science and technology are not limited by national boundaries, and will migrate to the most fertile environments to be free to investigate and create new knowledge and technology. Nations wishing to benefit from science and technology need to invest in the educational, industrial and research infrastructures that encourage and support them. Paraphrasing the earlier saying, "those countries that do not adapt to a world increasingly based upon knowledge and technology are in danger of being marginalized."

Sir Charles Babbage, the intellectual father of computing, once said that he would gladly give up the remainder of his life if he could be allowed to live for 3 days 500 years from then and be provided with a scientific guide to explain the discoveries made since his death. So might we all at times, and the ultimate scientific and technical advance might allow us to do that without incurring Babbage's proposed sacrifice.

The futurists of 1947 predicted such outcomes as personal airplanes for mass commuting to and from work, and limitless energy through atomic power. They also predicted that the world of the future would need at most 20 large scale digital computers. Their crystal ball was murky; will ours be any better?

The next 50 years should continue to reward us with very substantial advances in science and technology, many of which we cannot even imagine today. On both a global and a national level, the stakes are high. Those countries that invest in and nurture the development of science and technology, and also invest in the educational infrastructure needed to support such investment, will be in the best position to capture substantial long run economic and social returns. I am sure that we all look forward to Pakistan achieving this goal.

Thank you very much.