Technology Development in the 1990s: Will Government Policies Help or Hinder?

Robert M. White

The following is the text of Robert M. White's address at the second annual meeting held by the Council on Superconductivity for American Competitiveness on September 14, 1990 in Washington, DC. See "From Washington" in this issue for a report on the CSAC meeting.

Technology policy has never been more important because foreign competition and accelerated technological change are driving a dramatic transformation of the world's economic order. The competitive and technological arena of the next century will bear little resemblance to the one in which the United States has been the world's undisputed leader. Today, we face unprecedented challenges in shaping our commercial system for an environment in which new technology, foreign competition, and rapidly changing global markets will transform every product, service, and job in the United States.

Ironically, over the past three decades, the United States began to lose its leading competitive position in many high-technology industries at the very pinnacle of its technological dominance. We still lead the world in generating new knowledge and creating new technology. But that alone gives us an insufficient competitive edge.

We all know that the statistics show the United States losing market share in virtually every industry segment. They reflect U.S. weakness in converting new technology into world class products, and they also show the rapidly growing strength of our advanced industrial competitors.

The president is keenly aware of the formidable challenges before the nation and that America's technological leadership and economic future are at stake. However, the president believes that government cannot create competitive industries. The government's job is to strengthen the nation's technology infrastructure and improve the climate for investment and innovation. Industry must do the rest.

The Council on Superconductivity asked that I discuss technology development in the 1990s and whether government policies will help or hinder. Well, that certainly depends on the kind of policies.

There is growing recognition that many of our traditional business and technology policies and practices aren't as effective as they once were. They were designed to optimize our performance in an environment in which technology advanced slowly, foreign competition was weak or nonexistent, markets were domestic, consumer desires stable, the workplace demanded few highly skilled people, and labor was plentiful. None of these conditions exist today. Therefore, I do not believe that fine-tuning yesterday's policies and practices will significantly improve our competitive lot.

When unprecedented change is afoot, outcomes uncertain, and the economic stakes high, spirited debate and differences of opinion are to be expected. However, if business and government do not find new ways to navigate the "sea-change" in which we find ourselves, it's going to be continued rough sailing.

The government's leverage in improving the competitiveness of our firms is actually far less than many would like to believe. I think this misconception is the root cause of the frustration and polarization that often surrounds the debate over the roles of government and industry. Industry should not look for government to take the initiative in areas involving business risk.

There are four fundamental assumptions that guide policymakers: (1) The free market alone should determine commercial success—"market pull" not "government push." (2) The forces of the market are inexorable—attempts to subvert these forces won't work. (3) Only industry possesses the means to manage the complex process of developing and commercializing technology. Government intervention in that process is no substitute for the aggressive effort of a strong, competitive private sector. (4) And industrial strength is best forged through the intense heat of global competition.

Where the government does have some leverage, this administration has advocated progressive policies to improve U.S. competitiveness.

By some estimates, our cost of capital is 2-3 times that of our foreign competitors, so the president has proposed a capital gains tax reduction, a permanent R&E tax credit, and a plan to increase savings. The president reaffirmed his commitment to these policies in his televised address to the nation three days ago.

The Council on Competitiveness, chaired by Vice President Quayle, has begun a concentrated effort to reform our cumbersome and expensive product liability system, which many feel stifles innovation.

President Bush is committed to ensuring that trade is free and fair through mechanisms such as the GATT trade negotiations, and he also reduced unnecessary export controls to open overseas market opportunities for U.S. firms.

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However, the real leverage in improving our global trade position rests with the private sector. A recent report noted that eliminating all foreign trade barriers would reduce the U.S. trade deficit by only 10%. Major improvements on the trade front depend on aggressive action on the part of U.S. firms to make more competitive products, export them, and to displace the imports that flood our country.

The National Cooperative Research Act of 1984 removed the major antitrust uncertainties related to cooperative R&D—a very helpful policy! President Bush has proposed legislation to extend this act's provisions to cover joint production ventures as well.

This administration is committed to in-

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creasing government support for basic research and for generic technologies in the precompetitive stage of development.

The Commerce Department's new Advanced Technology Program will focus on the early to mid-stage development of precompetitive technologies that have substantial long-term commercial potential and underlie a wide range of potential applications.

The U.S. innovation machine, further primed with record breaking federal R&D investments, continues to produce an unrelenting flow of new technology. It is solely up to the private sector to turn that technology into world class products and services. If U.S. industry does not apply enough of it or use it fast enough, our competitors will; they certainly have done so in the past.

Superconductivity

President Bush is committed to the commercialization of superconductivity. He said, "Our goal as a nation is to lead the world in superconductivity R&D and in translating this new technology into products." He recognizes that those first to commercialize superconductivity could well gain an insurmountable advantage in the world marketplace. So, he is backing up that commitment by building on the strong foundation established by the previous administration.

Congress also moved a short time later by creating the National Commission on Superconductivity and by enacting the National Superconductivity and Competitiveness Act of 1988. That act called for the development of the National Action Plan on Superconductivity Research and Development, which was issued in December 1989.

The action plan identified three areas of opportunity for federal leadership in superconductivity: coordination, technical, and policy. The government is pressing forward on all three fronts.

Last year the federal government spent almost twice as much as U.S. industry on superconductivity. President Bush's 1991 budget had in it $215 million for superconductivity research. Superconductivity efforts are under way at the Departments of Energy, Defense, Commerce, Transportation, and Interior; the National Science Foundation; NASA; and other agencies. The Federal Coordinating Council on Science, Engineering, and Technology (FCCSET) established a Subcommittee on Superconductivity early on and it compiled a guide to *Federal Research Programs in Superconductivity.*

These examples show that the government is doing its part to support the development and commercialization of superconductivity. Industry is mobilizing as well. The initial excitement about superconductivity is now giving way to the steady hard work needed to bring its promise to fruition.

From 1987 to 1988, industry spending on superconductivity R&D increased 61%. More scientists and engineers are entering the field. Superconductivity consortia are beginning to crop up in Texas, New York, Massachusetts, and Pennsylvania. And industry is optimistic that products based on high-temperature superconductivity will hit the market within five years.

Enabling Technologies Demand Strategic Partnerships

Superconductivity is one of an emerging class of enabling technologies that have become a virtually important factor in international competitiveness. These technologies are giving birth to a technological renaissance more sweeping in its consequences than the Industrial Revolution. They are the wealth generators of the next century. They are the building blocks with which many different industries will create new products and processes and significantly improve existing ones.

> U.S. industry cannot competitively commercialize technologies using traditional investment and technology management methods.

The world market for enabling technologies may reach $1 trillion by the year 2000. Ultimately they will determine the future of many U.S. industrial sectors and the balance of world economic and military power. They are the battleground of technological competition. If current trends continue, however, the United States could lag behind Japan in most enabling technologies and trail Europe in several of them by the year 2000.

Enabling technologies present unprecedented challenges that flow from their unconventional investment and management dynamics. It is becoming increasingly clear that U.S. industry cannot competitively commercialize these technologies using traditional investment and technology management methods. Traditional methods don't work for several reasons.

First, it is prohibitively expensive for even a large firm to develop and commercialize an enabling technology like superconductivity. The potential benefits from an enabling technology easily transcend the product portfolio of most, if not all, U.S. firms. Thus, confronting high costs, long lead-times, and limited applications, most individual firms cannot reach the economies of scale needed to justify the investments or carry the negative cash flow until the technology matures.

Second, enabling technologies are multidisciplinary and complex. And few would disagree that speed to market is often the decisive competitive edge. Yet, to bring products and processes based upon enabling technologies to the marketplace quickly enough to achieve a competitive position requires simultaneous advances and tightly coordinated efforts in R&D, design, manufacturing, and marketing. Many scientific and technology disciplines, many industries, and large financial resources must be mobilized. An integrated effort is required even if the functions and technical disciplines reside in different organizations. This requires large-scale technology management skills. Industry must learn to routinely organize and manage the commercial equivalent of an Apollo or Polaris program or a Manhattan project.

The government cannot play the systems management role in commercial enabling technologies that it plays in defense and space projects. It is only one of the many potential customers for enabling technologies. Also, the government would have to select—from perhaps hundreds or thousands of firms—the few that would participate in technology ventures. This is inappropriate unless the government is the sole customer and assumes all the risk such as it does in defense or space. In commercial ventures, industry must select the technologies and the participants to pursue them. The market will always determine which firms were right.

Compared to some of our industrial competitors, U.S. industry is not well organized to fund and manage the development and commercialization of enabling technologies. Today, competition often means going up against diversified, vertically integrated industrial-financial giants—such as Japan's industrial groups. This model of industrial organization confers strategic advantage when it comes to exploiting enabling technologies. R&D costs can be spread over a large product base, reducing the financial exposure and risk in

technology ventures. Such organizations are well positioned to capture the significant economies of scope or multiple applications of enabling technologies. Inter-industry and inter-firm cooperative relationships allow the introduction of new materials and components simultaneously in many different applications and markets.

Firms whose products depend on enabling technologies must find new and better ways to manage, on an effective scale, this nation's unparalleled technological, entrepreneurial, and manufacturing assets. Producers, together with their users and suppliers, should consider organizing themselves into flexible, cross-industry confederations that are consistent with sound antitrust principles.

At Commerce we intend to convene representatives of industry and their upstream and downstream partners in technology forums. In these forums, industry, acting on its own, may choose to develop consensus on its technological needs. Industry may also consider appropriate cooperative activities to better organize and manage its technical, financial and manufacturing resources.

Commercializing Federal R&D

There are new opportunities for industry and government to work in partnership, particularly with regard to industry's access to the huge federal investment in R&D—including the substantial federal effort in superconductivity.

> Today, companies and universities can own and license the inventions they make with federal funds.

The need for speedy and concurrent development and commercialization of enabling technologies, like superconductivity, means we must quickly close the gulf between our firms, and our university and federal labs where most of the nation's basic research is performed. We can no longer tolerate the time delays and problems that typically occur when technology from federal and university labs is transferred to the private sector.

During the last 10 years, we have made enormous strides in achieving these objectives.

Today, companies and universities can own and license the inventions they make with federal funds. Government owned and operated laboratories can enter into new cooperative R&D agreements with the private sector and agree in advance on the rights to any resulting invention—new policy. Over 500 new cooperative R&D agreements between federal labs and industry have been established.

However, U.S. industry must be aggressive in taking advantage of the world's largest research pool and the unique federal lab facilities.

International Access

The United States is by no means the only nation racing to commercialize superconductivity. For example, the Japanese are aggressively pursuing R&D in this area.

The federal government has moved to ensure that our science and technology arrangements with other nations operate as two-way streets, with knowledge and technology flowing both ways. International cooperation in science and technology must be guided by the principle of symmetry: balanced contributions, shared risk, equitable benefits, and equal access to the other nation's R&D enterprises—particularly government-funded activities. These policies were codified in the 1988 Omnibus Trade and Competitiveness Act.

Also in 1988, the United States established a model for these policies when it concluded a new head of government bilateral science and technology agreement with Japan. Japan agreed to open its national R&D programs to U.S. scientists and engineers, and to adopt a new regime for the protection and equitable allocation of intellectual property rights.

This is a tremendous opportunity to get U.S. researchers into Japan's premier laboratories, including those conducting government-funded research on superconductivity. Again we need a commitment from American industry to pursue those opportunities; it has been slow to take advantage of them. There are now at least 10 Japanese scientists in U.S. facilities for every one of ours in Japan. The government can only create the opportunities—our firms must seize them.

Manufacturing and Organizational Excellence

Now let me turn briefly to an area in which U.S. industry must take the lead. Commercializing technology, including superconductivity, depends on the business and management decisions and practices of individual firms. Manufacturing is a linchpin.

I will quote a business executive from the superconductivity industry: "...a quality product with good delivery and a fair price always has a market. The future is not secured simply by implementing new trade laws. Companies must first develop themselves to be competitive in an open international market." In his statement, which appeared in *Superconductor Industry* magazine, he recognized that government does have a positive role to play. But he also said that when it comes to competitiveness—matters of productivity and quality—"the burden lies squarely on the shoulders of U.S. industry." Those are wise words.

Today, traditional manufacturing practices are giving way to a new industrial paradigm—that is, offering a wide variety of products for specialized markets at the cost of mass produced items. A premium is now placed on reliable delivery, customer convenience, high quality, the ability to quickly introduce new products, and the ability to identify and quickly seize niche markets around the world.

A small cadre of leading edge U.S. firms has demonstrated the superiority of these methods over traditional practices. But for the most part, U.S. industry has been slow to adopt modern manufacturing and management practices, even though the competitive climate demands it. Changes are required to successfully compete in today's fiercely contested global markets. This snail's pace of change must be accelerated, but I realize that is a significant undertaking. I believe there is a fundamental cause for this inertia.

Our factories and other workplaces have long been designed around management principles that prevent organizational flexibility and change. Harvard's Michael Porter describes it well, so I will quote him: "Change is an unnatural act, particularly in successful companies; powerful forces are at work to avoid and defeat it. Past approaches become institutionalized in standard operating procedures and management controls. Training emphasizes the one correct way to do anything; the construction of specialized, dedicated facilities solidifies past practice into expensive brick and mortar..."

Such systems were simply not designed to react quickly, if at all, to rapidly changing conditions. Flexibility, perpetual innovation, continuous improvement—all forms of continuous change—constantly disrupt this kind of system, so change is avoided.

Converting to the new industrial paradigm is wrenching and disruptive for the entire enterprise—from the very top on down to the factory floor. It's hard to abandon a traditional "way of business life" in

favor of one that is radically different.

Traditional management principles have made many organizations so inflexible that, to adapt to the speed up of technical change, innovation is often performed "off line." A separate innovative culture has emerged from the formal, inflexible organizational structure. It is isolated in "skunk works" within the firm, or removed from the firm altogether in the form of spinoffs and entrepreneurs.

This places too much new technology in the hands of small firms that lack the resources to take it to the market rapidly in sufficient scale and scope. And, production and marketing strength is then left with the firms that tend to resist new technology.

If we don't close this gap, more small resource-poor entrepreneurial firms will be snapped up by our competitors, and our resource-rich firms will suffer as their products are made obsolete by fast movers with next generation technology. We must find ways to knit the resources and manufacturing and marketing strengths of our large firms together with the creativity and dynamism of our entrepreneurial culture. It's time to bring the entrepreneur "in from the cold."

Today's competitive and technological environment is so challenging that marginal change is not sufficient to assure survival. It is time for U.S. industry to reconsider every time-honored belief, every traditional practice, and every customary procedure. We are up against competitors that show an aggressive impatience with the status quo even in the best of times.

For example, the Technology Administration has several programs that address this manufacturing issue, which I don't have time to go into. Also, we promote a method to put the power of advanced manufacturing technology in the hands of small- and medium-sized firms that lack the financial and technical capabilities needed to automate. Shared flexible computer-integrated manufacturing, or FCIM, is a center which leases time on flexible manufacturing systems. Four centers are now operating, and about 14 others are in various stages of planning and development.

Small firms should carefully consider cooperative opportunities like the shared FCIM. As large companies increasingly adopt flexible manufacturing, they too will be attracted to the niche markets that have long been the bread-and-butter of small firms. The bigger firms will use their large financial and technical resources to give small firms a run for the money in today's rapidly fragmenting markets.

Conclusion

As we stand at the threshold of the 21st century, our future is now less constrained by the costs of natural resources and the limits of human strength. Instead, technology and the management skill and vision with which we put it to work for us will largely determine our nation's success in an unprecedented economic transition that is sweeping the globe.

In summary, quite a number of government policies have been formulated over the past few years in response to the changing environment policies that are consistent with the free-market philosophy I described earlier. Many of these policies are being implemented. They include mechanisms for better diffusion of technology, economic incentives, reduction of barriers, access to low cost capital, and strengthening the R&D infrastructure.

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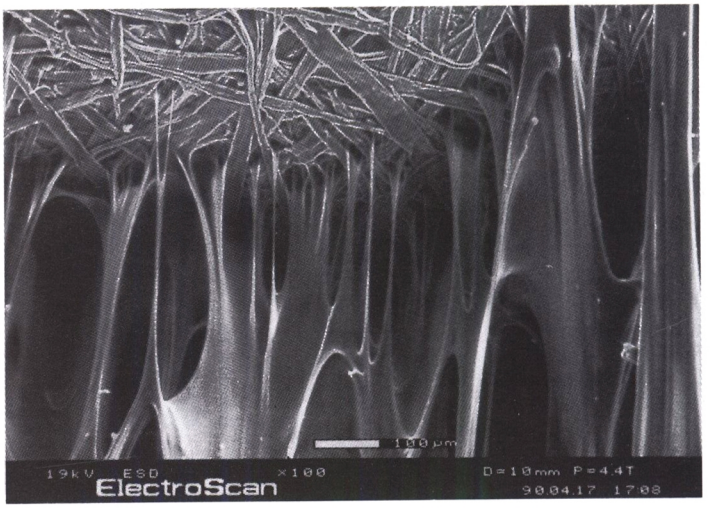

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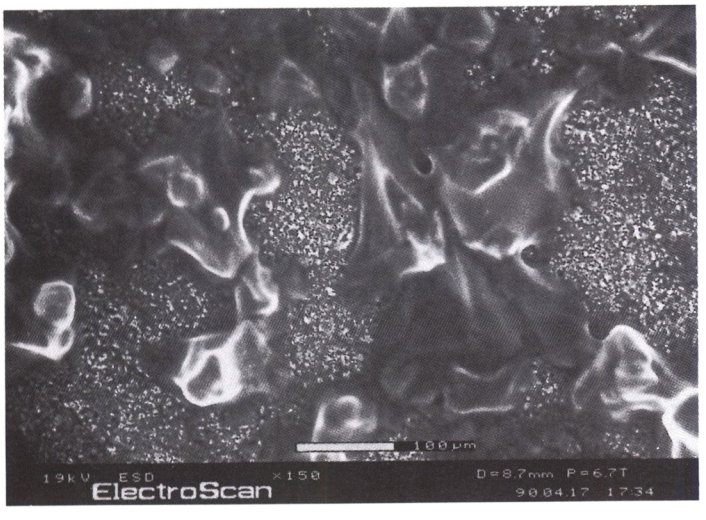

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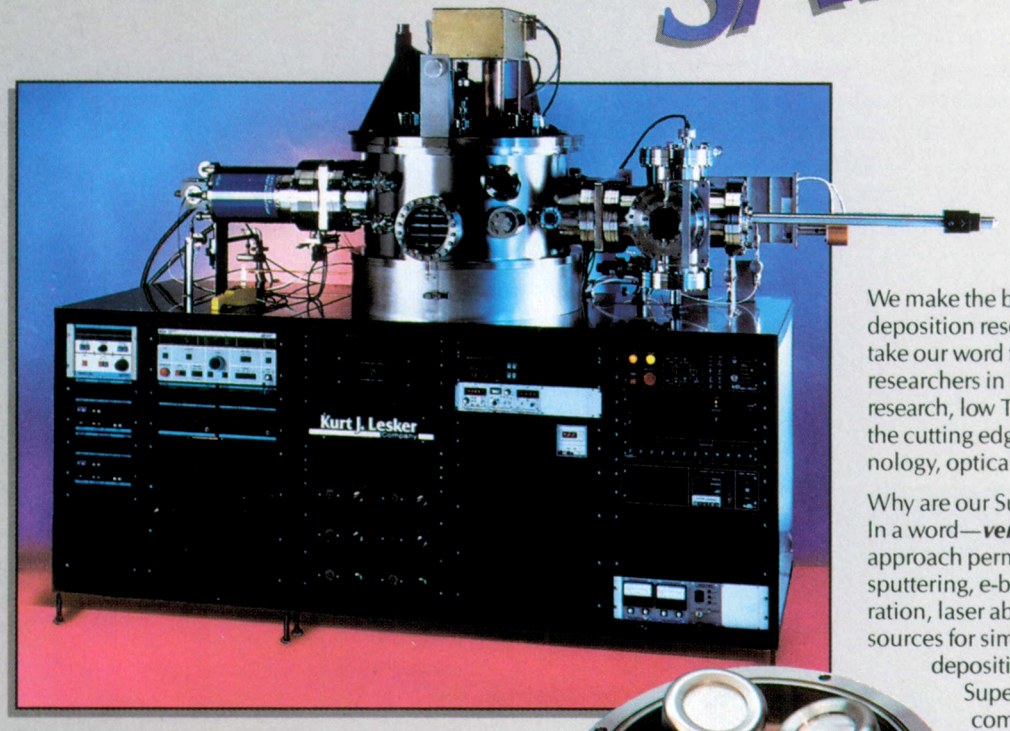

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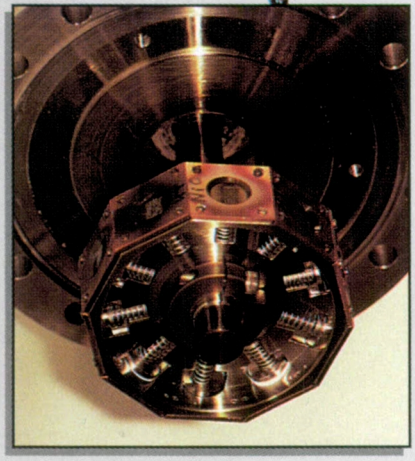

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