A national policy to maintain United States technological leadership

by Representative Ed Zschau

Today a debate rages over the proper role of government in fostering industrial growth and the creation of jobs. I would like to contribute to the dialogue on that issue by proposing a national policy to maintain United States technological leadership. Although achieving technological advances is certainly not the only objective for a proper industrial policy, I believe it is sufficiently important for industrial competitiveness, economic growth, and jobs to warrant special attention.

Some people suggest that rapid technological advances could cause the loss of jobs and make those jobs that remain less interesting. They warn us that technology is a threat to employment opportunities and our quality of life which must be countered by government actions. But the real threat to jobs, I believe, is not technological change. Nor is it changes in manufacturing processes, products, or markets. The real threat to this nation's economy and our quality of life is stagnation, which will hamper our national competitiveness and growth. The real threat to jobs and quality of life in this country is losing our technological leadership.

Several recent studies have documented the importance of technological innovation to our economic growth, productivity, job opportunities, and trade competitiveness. A study by the Massachusetts Institute of Technology estimated that 80 percent of the growth of the gross national product of the United States between 1909 and 1949 was due to technological change. Further, a recent Brookings Institution study determined that more than half of the productivity increases in the United States between 1948 and 1968 were the direct result of technological innovation. In recent years, the overall export performance of the United States has been mediocre, but the export of R&D-intensive products has shown excellent growth. From 1960 to 1979, these innovative industries increased their export surplus from $5.9 to $29.3 billion. During the same period, the trade balance of industries without technological bases declined from near zero to a negative $16.5 billion. Clearly, our technological leadership in the past has enabled the United States to create many new jobs to employ our growing work force.

But US technological leadership is being challenged from abroad. On January 25, 1983, President Reagan in his State of the Union message announced, "this Administration is committed to keeping America the technological leader of the world now and into the 21st century." This commitment by the President to spur technology may have come just in the nick of time. US technological leadership has eroded in recent years. It has not been squandered like some other resources, through overuse and waste. It has been frittered away through neglect. Over the past 20 years, research and development expenditures as a percentage of gross national product have declined in the United States. During the same period our two most aggressive trading partners, Japan and West Germany, were increasing their expenditures.

With the decreasing intensity of our research efforts, it is not surprising that our leadership in technical contributions has fallen as well. In the 1950's, the United States was credited with 80 percent of the major inventions made during that period. During the 1970's, our share of major inventions dropped to 60 percent.

High technology is now receiving considerable attention in Congress, because of a growing recognition that our leadership in technology is being challenged from foreign competitors. Since the beginning of 1983, more than 100 bills to promote high technology have been introduced in the Congress. Moreover, President Reagan has formed the Presidential Commission on Industrial Competitiveness, chaired by John Young, president of Hewlett-Packard Company.

The objective of the commission is to determine how the US can improve its competitiveness and world market share not only in those industries such as high technology, where we still hold the lead, but also in so-called "smokestack" industries, where our competitive edge is more seriously threatened.

These are welcome trends. But in its enthusiasm to help high technology, government must avoid the temptation of trying to legislate technological progress via direct government involvement. We cannot afford to let the helping hand of government strike high tech the way it has struck agriculture or energy. We should have learned our lessons. And yet some suggest that we should have some sort of high technology planning board, which would pick those technologies and industries that it feels have the most promise and would then "target" them with subsidies and other special treatment. Such proposals are patterned after the way the Ministry of International Trade and Industry in Japan is imagined to work. However, I believe such a scheme implemented in this country would be doomed to failure. Bureaucrats in Washington, DC, should not be given the job...
of picking between opportunities and dead ends. Politics would undoubtedly play a major role in their decisions. Besides, it is hard enough to make those decisions for investors or managers who are on the firing line and who have much to gain or lose personally from the results. Even the most successful venture capital investors say that they expect only one or two real successes out of every ten investments. Clearly, government “targeting” of this kind is not the answer.

There is, however, a positive role that government can play in promoting high technology. I believe that its proper role involves a “targeting” of a different kind. Rather than targeting specific technologies or industries, the proper role for government is to target on the process by which they are developed—the process of innovation. Our government should focus on creating an environment in this country in which high technology, innovation, new ideas, and new companies are likely to flourish. Making sure that such an environment exists is the best way to help America maintain its technological leadership.

Based on my personal experiences as an electronics manufacturer and my analysis of the Silicon Valley phenomenon, I believe there are at least four conditions needed for an environment that promotes technological innovation:

- **A strong commitment to basic research**—deepening and broadening our understanding of the fundamental processes that will form the basis for industries and products in the future.
- **A strong educational system**—assuring an ample quantity of trained technical and managerial personnel.
- **Incentives for investors, entrepreneurs, and innovators**—encouraging them to provide the capital and take the personal risks associated with the development of new companies and products.
- **Expansion of domestic and foreign market opportunities**—providing a healthy economic environment and developing aggressive trade policies.

A proper high technology industrial policy must focus on the prerequisites for innovation. It must have specific legislative and regulatory initiatives that foster these conditions, and it should avoid government actions that would weaken them. The specific legislative and regulatory initiatives that are needed will change over time. But the following is an abbreviated outline of a legislative agenda that I believe Congress should pursue now:

We must renew our commitment to basic research. Over the next decade, America’s dominance in the computer industry will be challenged from abroad. In 1981, after three years of extensive planning, the Japanese government announced the Fifth Generation Project, a national project designed to make Japan number one in the computer industry by the late 1990’s, by developing a machine so advanced in hardware and software that it can reason with knowledge like a human being rather than just compute data or process information. The Japanese research program, involving a half-dozen or more major electronics companies and coordinated by the government, will cost a total of a billion dollars over ten years.

We can respond to the Japanese challenge in two ways. First, we should start our own federal R&D project for advanced computer design and encourage research collaboration by United States companies. A federal R&D program for advanced computer design is now being planned by the Department of Defense’s Advanced Research Projects Agency, which has an outstanding record in computer research, including the development of timesharing, computer networking, and artificial intelligence.

Second, we need to alter our antitrust laws to permit the establishment of multicomputer joint research ventures that would enable US companies to pool their research resources and share in the results that are produced. There is legislation currently before Congress that would, under certain conditions, permit such joint research ventures to be formed without the threat of antitrust suits. MCC—a joint research venture to develop advanced computer systems—was formed recently without the benefit of such legislation, and it was immediately threatened with a lawsuit by an enterprise private attorney. Taking the antitrust risk out of the formation of joint research ventures would permit our high technology companies to compete more effectively against the consortiums that have long been encouraged in other countries.

We also need incentives for the risk takers—the investors and entrepreneurs who pursue new ideas. Here, tax policy has a significant role to play. The results of the 1978 capital gains tax reduction show the power of tax policy in improving the incentives for investing in new technology companies. We should preserve and enhance such tax incentives for risk capital investment.

In addition to incentives for investors, we need incentives for corporate risk taking. The Economic Recovery Tax Act of 1981 contained such an incentive. It provided for a 25 percent tax credit on increases in R&D expenditures. This tax credit appears already to have had a positive effect on R&D expenditures. But the tax credit expires in 1986. We need to make the R&D tax credit permanent, particularly since most R&D projects are long-term in nature. A temporary R&D tax credit cannot provide the kind of incentive needed for long-range projects. In addition, Congress should make sure that the IRS regulations for the R&D credit are written broadly enough to cover software development (presently disfavored by IRS), which is becoming a most significant part of most advanced computer system development projects.

Besides basic research and incentives for risk-takers, we must ensure that there is an adequate supply of trained technical people. The future demand for engineers and technicians is predicted to far outstrip the supply. The American Electronics Association has forecast an annual shortfall of 16,000 electrical engineers and computer scientists through 1987—that’s a total of 90,000 unfilled technical positions in five years.

The basic constraint to providing efficient technical education is a lack of money. The cost of educating technical people, particularly engineers, is very high, and it is difficult to attract enough qualified professors because industrial salaries are so attractive. Currently, there are more than 2000 unfilled faculty positions in the engineering departments of colleges and universities in America causing us to turn away about 75 percent of the student applicants.

I believe private industry has an important role to play in providing the funding for increased technical education programs. The federal government has a role to play, too. By offering tax credits and larger deductions for corporate contributions of cash and equipment to colleges and universities for teaching activities, as well as research, we can encourage private sector support to increase the capacity of our technical facilities without requiring a new federal bureaucracy to carry it out.

Finally, technological innovation will not occur unless there are attractive business opportunities. We need a strong domestic economy and we need access to

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foreign markets. Government plays an important role in ensuring both. This country must pursue an aggressive trade policy aimed at achieving free and fair trade. We should negotiate in a tough-minded fashion to break down the trade barriers erected by our trading partners. Also, we should focus and streamline our export controls on high tech products, so that we can prevent trade-related transfer of militarily critical technologies, but at the same time make exporting easier for US companies.

Above all, high technology enterprises, as well as all businesses, can achieve their potential only within a good domestic economic climate. That means we must have lower interest rates and low inflation. People are unwilling to make investments, to make long-term commitments, or to borrow the funds needed for expansion in a climate of high interest rates and inflation. We must reduce significantly the substantial projected federal budget deficits for the next several years in order to remove the upward pressure on interest rates and inflation. We need a monetary policy that accommodates economic growth, a tax policy that encourages savings and investment, and the discipline needed to sharply curtail the growth of government spending.

High technology is perhaps our most valuable national resource. We must preserve it. However, innovation cannot be forced. It can only be fostered. It is fostered by creating an environment that emphasizes freedom of scientific and industrial activities and that offers incentives to the innovators, entrepreneurs, and investors who have the talent and resources to advance technology. It is fostered in a healthy economic environment and by trade policies that provide expanding opportunities for our technological products. Promoting such an environment should be a primary objective of America's national industrial policy.

Ed Zschau represents California's 12th District—which comprises much of Silicon Valley—in the US House of Representatives. First elected in 1982, he has served as a member of the Foreign Affairs Committee, as chairman of the Task Force on High Technology Initiatives for the Research Committee of the House Republican Conference, and as a member of the Republican Executive Committee.

For four years prior to his Congressional service, he was president of his own company, System Industries, a Santa Clara-based disk memory manufacturing firm which he founded in 1968. At the time of his departure, the company employed 550 people and had annual sales of more than $60 million. Earlier, he spent five years as an assistant professor at the Stanford Graduate School of Business and at Harvard Business School.

Zschau has been active in a number of volunteer projects in support of technological innovation, small business, and economic growth. He was co-chairman of President Reagan's Business Advisory Panel, a member of the President's Task Force on Entrepreneurship and Innovation, and delegate to the White House Conference on Small Business—all in 1980. Earlier, he served as a director of the American Electronics Association from 1974 to 1979 and as chairman of the board of that organization during 1978. He was also director of the American Council for Capital Formation from 1979 to 1982.

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processor-independent than that of the draft. I proposed the same scheme to the P896 committee in January 1983—that each byte lane be assigned to a byte address, leaving the weight of the byte unspecified. The lanes would have been called 0, 1, 2, and 3 depending on whether the address would end with 00, 01, 10, and 11. This would have corresponded to the odd and even lanes on the 16-bit S-100 bus. I thought that my proposal would resolve the problem, but I have been unable to convince the committee of it, since it was argued that my scheme again favors little-endian processors.

The reason for this is quite simple: practically all processors number the address lines the little-endian way, with A0 as least significant bit (LSB). As I pointed out in my article, there is a strong practical reason for this practice. If, for instance, an address is 24 bits wide, the LSB is A0 in a little-endian numbering but A23 in a big-endian one. If the address is extended to 32 bits, the same LSB is still A0 in the little-endian numbering but it must be renamed to A31 in the big-endian scheme. All lines must therefore be renumbered when one extends to a big-endian address. Since one lives with addresses of differing sizes, the logical choice is that the address be numbered in such a way that the least significant bits keep their names, i.e., in the little-endian way.

The problem arises with multiplexed, inconsistent big-endian processors like the Z8000. They are big-endians for 16-bit words, but they number the address in the little-endian way. Since the address appears on the same lines as the data, one must install a bidirectional byte swapper which either crosses the data byte lanes but not the address or the reverse.

Therefore, the Z8000 is penalized by the S-100 ordering scheme. The MC68000 is not affected since the crossing of the data lanes is static, except for the strange effect of having to cross the byte lanes, e.g., connect D0 of the processor to the bus line AD8.

So, the P896 committee decided that just four unassigned lanes with the names X, Y, W, and Z should be specified. I consider this a mistake: it only institutionalizes chaos. Since the inconsistency is caused by the Z8000, there is no reason to penalize all other processors.

So you see that even the current S-100 is not free of little-endian prejudices . . .

Now, about the TI 9900. It is no wonder that this processor can perform well on a justified bus: it does not make use of justification at all; all its transfers are 16 bits wide. As long as it only works with 16-bit devices, nothing bad should happen. But it cannot access an 8-bit peripheral, which is connected only to the justified byte lane and which responds to odd addresses. Hence, the processor board mentioned by Paterson does not comply to the S-100 specification, and it therefore cannot be fully integrated into a justified bus, since the very purpose of justification is to allow communication with 8-bit devices.

I encountered a similar problem when connecting our LSI-11/2 to a justified bus (an earlier P896). Everything worked as expected until we removed the byte swapper. To our surprise, the system kept on passing tests successfully. So we read the manuals more carefully and watched the traces on the scope. The LSI-11/2 was not doing byte operations but was using read-modify-writes on 16-bit transfers. The byte swapper had never been used since we didn't have 8-bit peripherals.

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