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IS AMERICA LOSING ITS LEAD IN HIGH-TECH: IMPLICATIONS FOR THE U.S. DEFENSE INDUSTRIAL BASE

HEARING

BEFORE THE

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HOUSE OF REPRESENTATIVES

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IS AMERICA LOSING ITS LEAD IN HIGH-TECH: IMPLICATIONS FOR THE U.S. DEFENSE INDUSTRIAL BASE

THURSDAY, OCTOBER 16, 2003

HOUSE OF REPRESENTATIVES,
COMMITTEE ON SMALL BUSINESS,
Washington, D.C.

The Committee met, pursuant to call, at 11:04 a.m. in Room 2360, Rayburn House Office Building, Hon. Donald Manzullo presiding.

Present: Representatives Manzullo, Velazquez, Millender-McDonald, Chabot, Sanchez

Chairman MANZULLO. If we could call the hearing to order. Good morning. Welcome to this hearing of the Full Committee on Small Business.

Last year, the Advisory Group on Electron Devices, AGED, A-G-E-D, presented a remarkable document with interesting findings to top officials at the Pentagon. Among other things, the group found that "offshore movement of intellectual capital and industrial capability, particularly in micro-electronics, has impacted the ability of the U.S. to research and produce the best technologies and products for the nation and the war fighter".

Those of you who know me know I have been saying this for some time now. Fortunately for America, we have people like Dr. Hartwick, who are acknowledged leaders in science and technology industry and who volunteer their time to advise us of such issues.

We also have two other distinguished visitors and guests and I am really looking forward to their testimony. Please do not lose us in the technicals of all of this.

Ironically, other key authorities in the technology world have echoed this message since the AGED briefing. At one of our Subcommittee hearings a few months ago, the director of Microphysics Laboratory at the University of Illinois, Chicago testified that the U.S. military has become almost entirely dependent on foreign sources of materials, components and production equipment used for the manufacture of night vision infrared devices.

Defense Department witness was unmoved by this and felt no threat to supply, even though production was coming from France. What disturbs me, however, is that the same French company that supplies our military also sells to the Chinese and we ask ourselves: How could this not be a significant factor in maintaining our tactical edge in war fighting?

Another example comes from Henry Kissinger, who recently stated, "If outsourcing continues to strip the U.S. of its industrial base and the act of getting out or developing its own technology, then we will require a careful thought on national policy".

Friday's front page of the Washington Post Business Section headlines read, "Intel Chairman Says U.S. is Losing Edge". Andy Groves said that, "The software and technology service businesses are under siege by countries taking advantage of cheap labor costs and strong incentives for new financial investment."

"While some would concede we have already lost our edge in manufacturing, what would we do if we lose our leadership role in software and services?" This is Andy Grove saying this, one of the founding fathers of the new economy.

The next quote, because it is the crux of the issue he states, "He is torn between his responsibility to shareholders to cut costs and improve profits and to U.S. workers who helped build the nation's technology industry, but who are now being replaced by cheap labor."

He asked for the government to help decide the proper balance between the two, otherwise companies will focus only on stock price. This is why support for the Crane-Rangel-Manzullo-Levin bill is so critical. It is one piece of the puzzle that helps manufacturing companies decide to keep jobs here.

Yet another group of advisors has the same concern. The President's Council of Advisors on Science and Technology, PCAST, recently announced that the Asian semiconductor market surpassed the U.S. in 2001 and is expected to further widen the gap.

More strikingly, they found that R&D design capabilities are moving overseas, including China, along with the production at an increasing rate. One main concern is that "the proximity of research, development and manufacturing is very important to leading edge manufacturers." It is the link between R&D and manufacturing that drives successful innovation.

The implication for the U.S. then is an acknowledgement that our high-tech leadership is not automatic and a loss of that leadership, "would have serious implications for the nation's economy and living standards."

I wish we had the chairman of this PCAST Subcommittee here for this hearing, but George Scalise is in Europe right now giving speeches on this very topic. For those of you that do not know, Mr. Scalise is also president of the Semiconductor Industry Association.

I can go on with examples, but I will end with this one. A recent study by the National Academy states that the semiconductor "plays a crucial role in ensuring U.S. national security by allowing it advances in the capability of new devices and new applications for national defense. Preserving unencumbered access to the world's most advanced technology may provide no guarantees, but allowing the nation's technological edge or independence to slip away would be hard for future generations to understand." Mr. Howell was the co-author of that study.

Future generations notwithstanding, here is what I and other members of the Committee find hard to understand: About three months ago this Committee held a hearing to discuss the vulner-

ability of our defense industrial base, due to offshore manufacturing.

At that hearing, Suzanne Patrick, Deputy Under Secretary for Defense Industrial Policy states, "Despite the downturn in the U.S. economy, the defense industrial base is healthy, innovative and responsive."

She also said that the defense industrial base does not need to be revitalized and denied that the U.S. defense systems are vulnerable due to foreign dependencies. How is it then with so much mounting evidence, that the Defense Department cannot, will not acknowledge that our procurement process continues to foster an increasing vulnerability and dependency on foreign sources?

That is what we do not understand and that is one of the main purposes for this hearing. We look forward to the testimony of each of our witnesses.

[Mr. Manzullo's statement may be found in the appendix.]

Chairman MANZULLO. It is my pleasure to introduce to you and yield to our ranking minority member, Congresswoman Velazquez——

Ms. VELAZQUEZ. Thank you Mr. Chairman.

Chairman MANZULLO [continuing]. From New York.

Ms. VELAZQUEZ. Thank you.

Chairman MANZULLO. And the Cubs lost and you guys are still in.

Ms. VELAZQUEZ. That is right. I am sorry for you.

Chairman MANZULLO. Yes. Thank you.

Ms. VELAZQUEZ. Earlier in the year the Committee looked at trends in the technology sector and the challenges facing this industry. Sadly we found that many of the existing problems in the tech world mirrored those felt by the manufacturing sector.

This is not surprising, since the manufacturing and technology sectors are closely linked. What affects one sector will eventually affect the other.

The research and development that promotes technological advancement depends heavily on production. If manufacturing jobs are moved overseas, our strong innovation process will follow.

It is unfortunate that this sector, along with the U.S. economy, is now suffering, too. In the past two decades small businesses have become the dominant employer of high-tech innovators and produce 55 percent of all new technological developments. However, from January 2002 to December 2002, nearly half a million jobs were lost in the technology sector.

One critical concern for our nation's small tech firms is that the environment must be conducive to foster a strong domestic defense industry base. Readiness and access to cutting edge technology are necessities in regard to the U.S. defense industry and our national security.

As we recently found in the war with Iraq, many times Americans do have to turn to foreign countries for assistance and as we have experienced with France, it is not always easy. That is why the U.S. should not have to depend on countries overseas for military assistance. We need to have a secure base right here.

A strong defense base is crucial for U.S. economic and military security, yet we are hearing contradictory statements about its li-

ability. During a hearing this summer, the Department of Defense stated that its current policies do not have a negative effect on our economy or threaten our national security.

However, a recent report by the DOD Advisory Group on electron devices found the opposite. They reported that the outsourcing of the U.S. technology sector has had a negative impact on our ability to research and produce the best products for our nation.

The reports said that DOD now has to obtain a majority of cutting edge technologies from overseas, giving those countries a political and military advantage. The AGED report also claims that the Department of Defense must take immediate action to preserve our position as a leader in technological advancement and to counter the decline of the U.S. electronics and technology sector.

To compliment the report, the President's Council for Advisors of Science and Technology, PCAST, Subcommittee on Information Technology Manufacturing and Comparativeness recently warned that by outsourcing the tech sector abroad, our country will risk losing its innovation, strength for design, research, development and creation of new products.

Much of this outsourcing has been in the semiconductor industry. This industry is key to the U.S. manufacturing sectors' vitality and strength. In 1999, it posted $102 billion in sales and accounted for half of the world market. In addition, it is the cornerstone of the $425 billion U.S. electronics sector.

Continued outsourcing and decline in the semiconductor industry will create a ripple effect. It will eventually leave small high-tech firms struggling for business and our nation's domestic defense base weak.

By shifting semiconductor manufacturing overseas, we are hindering our nation's role as a leader in technological research and development. Today's hearing will us to examine how outsourcing these vital sectors are affecting U.S. competitiveness.

The weakening of our technology industry can have detrimental affects on both national and economic security. Policies need to be in place that would allow not only the manufacturing and technology sector to flourish, but also our nation's small high-tech firms so that we can remain a leader in the world market.

Thank you, Mr. Chairman.

Chairman MANZULLO. Thank you. We have been advised that there will be two votes some time between 11:30 and 12. We are going to proceed.

I am going to give each of the witnesses eight minutes. So much information, so little time. Then just bear with us and we will have the votes and then we will be coming back for questions or concluding testimony.

Our first witness is Dr. Ronald Sega, Director, Defense Research and Engineering, Department of Defense. The confusion was, I want to go in the order that the witnesses were listed on the list here, because you have a right to follow that order on the testimony.

I had the opportunity to meet with Dr. Sega. He is an astronaut. Has been up twice on space shuttles. Long extensive background in defense research, academia, government service, Ph.D. in electrical engineering, Major General in the Air Force Reserves, a tre-

mendous background and we look forward to your testimony, Doctor.

STATEMENT OF DR. RONALD SEGA, DIRECTOR, DEFENSE RESEARCH AND ENGINEERING, DEPARTMENT OF DEFENSE, WASHINGTON, D.C.

Mr. SEGA. Thank you, Mr. Chairman and members of the Committee. I appreciate the opportunity to appear before you today.

As Director of Defense Research and Engineering, I have oversight responsibility of the Department's investments in basic sciences, applied research and technology development and demonstration programs. These research and development activities are performed by universities, government laboratories as well as by small, medium and large businesses.

The over arching guidance of the Department of Science and Technology investment strategy is a collaborative product of the Office of the Secretary of Defense, the Joint Staff, our Combatant Commanders, Military services and the Defense agencies that have been developed in a direct response to the needs of our war fighter.

Advanced electronics are critical to the Department. In fact, it is one of the 12 major elements of the Defense technology area plan and one of the ten major research areas of the basic research plan, which I could go into later.

In FY 2003, the Department invested $678 million in electronics S&T and $106 million in electronics basic research. When combined with our related S&T investments for sensors and electronic warfare, this investment totaled approximately $1.9 billion. Overall this funding was nearly 20 percent of the Department's total S&T investment for FY 2003.

I would like to now touch briefly on some external sources of information used by the Department of Defense. Recommendations from various groups, such as the Defense Science Board, Navy Research Advisory Committee, Army Scientific Advisory Board, Air Force Scientific Advisory Board, National Research Council, JASONs and the Advisory Group on Electron Devices (AGED) are important sources of information for us.

On a routine basis, leaders from industry and industrial professional organizations, in fact Mr. Scalise was in our office here within the last month, these are spanning small business to large corporations, meet with my staff and me to discuss their plans and provide the recommendations on where technology opportunities and challenges may exist.

We also obtain input from leading experts and academia, various professional societies, trade groups, industry associations as we strive to remain more informed as to the state-of-the-art and emerging S&T trends. Inputs from all of these sources are important in formulating the Department's S&T's strategy to meet war fighter needs.

Key to defense technology leadership is an innovative and robust science and engineering work force within our defense laboratories and those that support the defense base. I will talk a little bit more about them.

There has been one office that we have added to the office of Director of Defense Research and Engineering since I have been there

and that is the Deputy Under Secretary Defense for Laboratories and Basic Sciences. The individual is not only of Laboratories, but also my Deputy, DDR&E and that is Dr. John Hopps. Where is Dr. Hopps?

He is responsible for the oversight of our laboratories, basic sciences, university programs and work force that we will now into the future. Extensive background in academia at Ohio State, research at Draper Labs, National Science Foundation background and recently provost at Morehouse.

This is an area of tremendous importance to me personally and to the Department of Defense. We are making important investments, new investments in secondary and undergraduate science and engineering education in order to help ensure an adequate national S&E work force for DOD needs.

We have increased the Department's graduate fellowship stipends and number of awards in order to attract the best and brightest U.S. scientists and engineers. Additionally, we are working to make employment opportunities within our laboratories more attractive to the nation's most talented scientists and engineers.

Many new educational initiatives that I just mentioned are electronics related. Our secondary and undergraduate curriculum initiatives emphasize material science and engineering, fields that are critical to the technology advances in electronics.

For example, a new undergraduate research initiative, in that initiative we are making investments in a leveraged, collaborative program with the Semiconductor Research Corporation, with a focus in electronics.

Another component of our undergraduate research efforts is being made in collaboration with the National Science Foundation in the research experiences for undergraduate program.

In closing, I appreciate the opportunity to come before you to relate to you our commitment to retaining U.S. leadership in those sciences and technologies that are critical to maintaining our war fighting superiority. Thank you, Mr. Chairman.

[Dr. Sega's statement may be found in the appendix.]

Chairman MANZULLO. Thank you, Doctor. Our next witness is Dr. Thomas Hartwick, high technology specialist for commercial and aerospace business. Been in the business for 45 years. That is your bio.

Hands-on experience, strategic planning, involvement in numerous professional activities, numerous boards including IMEC, very extensive background professionally, including business and education, academia.

It is a real honor also to have you with us today, Dr. Hartwick and we look forward to your testimony.

STATEMENT OF DR. THOMAS HARTWICK, CHAIR, ADVISORY GROUP ON ELECTRON DEVICES (AGED)

Mr. HARTWICK. Thank you, Mr. Chairman.

Chairman MANZULLO. If you could pull the mike down and closer to your mouth there.

Mr. HARTWICK. How is that?

Chairman MANZULLO. That sounds good. Thank you.

Mr. HARTWICK. Mr. Chairman, Ms. Velazquez, my name has already been stated. I am a self-employed, high-tech guy. I will give you the high-tech view.

My background roughly splits up like this: I spent the past decade serving on boards and committees in the public and private sector. I fly on a lot of airplanes from coast to coast. I am tired.

The four previous decades I spent in aerospace general management in research, project management, strategic planning, manufacturing, running a P&L organization, which is a very painful experience.

The testimony is solely my own, but I believe it fairly represents a broad cross section of the professional and business high-tech community, both in private and public sectors.

I represent only myself today. My main message today from the high-tech community is that we believe immediate government action is needed to address the offshore manufacturing problem. That is our point of view.

My focus here is on high-tech business, because as has already been stated by the Chairman and Ms. Velazquez, it is the core of new DOD systems and entirely new mega-billion dollar industries, like chips or television.

The high-tech community is most worried about the national trend for break up of clusters. I call these enterprise centers to be clear. I coin a new phrase and define it as a complexity of university, small business and manufacturing entities. So they form together a working relationship. The movement of manufacturing plants offshore breaks up these clusters and destroys the infrastructure for new business and new products.

In the past, this has occurred over a very long time period. For television, it took 40 to 50 years until all the plants around Chicago closed their doors. For flat panel displays about 20 to 25 years before active matrix LCD's went overseas.

For chips, ten to 15 years and we are seeing it accelerating now. My point is, the time keeps getting shorter. So for new technologies, we do not have that much time.

Without enterprise centers to nucleate and nurture a wide variety of small businesses, foreign companies eventually dominate the business and new product development is constrained and that is our fear.

Let me explain. In creating new products, there is a sequence of events. You first have to innovate. That is the conceptual part where the light bulb goes off. Then you have to design and do a prototype fab. But you have to establish the manufacturing process to create that device. If you do not, then you cannot produce items for sale.

If these steps are constrained within a single company, like was done in much of the end of this century, it is okay. It works. If it is confined within the enterprise center, the system works.

If you do not do this, then the inventions often end up on the cutting room floor, because you cannot manufacture them. That is our concern.

Sure, some businesses can employ remote design and we hear a lot of talk about virtual companies and remote design, but those

are now generation devices. They are not cutting edge, new devices that nucleate entire industries.

This is all anecdotal information and it does not accurately capture what I call the pervasive and insidious nature of enterprise center break ups. I think it takes more detailed analysis to really understand them and to understand the impact, particularly the time cycle and then to create a national strategy to prevent future loss. It is like the Titanic. You have to get on the problem early, in order to get a desired result.

I worry about that for new technologies like nanotechnologies, you have probably heard about and MEMS technologies, this is a MEMS product from our Sandia Labs, if you would like to see it. A little chip that is really a machine. These are the technologies that are most fragile right now.

National security Products parallel this commercial development, except for two differences. The first difference is that product security is difficult to maintain. Classified products are important to the national security enterprise and we must maintain that classification. It is difficult to do in a foreign environment.

Now we have most of our chips made offshore and the government is hard pressed to ensure future supplies of cutting edge technology. Second, the cutting edge technology that we use in government designs are difficult to produce on demand in a commercial plant. Why? Because the commercial plant runs product to create profit and if you just run a few products for the government, then you interrupt the production lines and it does not work. So there are two reasons why defense is different.

The Advisory Group on Electron Devices has cited these issues and they have called for prompt action. Special arrangements can be made with domestic suppliers, but these are band-aid solutions, which our government can put in place for the time being. We need a long-term national strategy to reverse the trend. It is the trend that is important.

Other examples of technologies that might fit in this category are MIMICS, these are microwave chips that fit in your cell phone. Everybody has. We dominate this industry now, but it could go offshore if we are not careful and uncool night vision devices are becoming more of a commodity today.

My message is: It is time for action in the U.S. to prevent this foreign dominance and it cannot be from the standpoint of big business or small business or national security. It has got to be complete solution that meets all needs.

I humbly submit, I guess that is the proper way to phrase it, two suggestions. I think we need an enterprise study. Mr. Howell here and the Academy has turned out a big report like this. I have another one in my briefcase that is the same size and these studies try to teach us that we have a problem.

I know we have a problem and I believe we need studies to quantify the problem and prioritize the areas that actions need to be taken on.

The second suggestion is a keep one strategy as a band-aid approach. I think we would be derelict in our duties if we did not ensure at least one on-shore manufacturing organization to handle

each of these technologies, both now and into the future. I advocate a keep one strategy.

Thank you very much. I appreciate the ability to express these views. I will take any questions you have. Thanks.

[Dr. Hartwick's statement may be found in the appendix.]

Chairman MANZULLO. Thank you. Our next witness is Thomas Howell, with Dewey Ballantine, an international trade group. He is an attorney, a long history of being involved in major trade cases and disputes and we look forward to your testimony.

STATEMENT OF THOMAS R. HOWELL, PARTNER, DEWEY BALLANTINE, LLP, WASHINGTON, D.C.

Mr. HOWELL. Thank you, Mr. Chairman. I should say that I am appearing to you today as a co-author of this National Academy study and I am speaking on my own behalf and not on behalf of a client or on behalf of the Academy.

U.S. high technology manufacturing is moving offshore. Let me illustrate that with a few figures, based on semiconductor consumption. The semiconductors are the ubiquitous core of high-tech machinery and a rough bench mark of where high-tech manufacturing is occurring can be gleaned by looking at what parts of the world semiconductors are being consumed. So in other words, where are they being actually insert into systems.

As recently as 1997, the U.S. accounted for 33 percent of global shipped consumption. That meant one-third of all the devices were being put into high-tech systems right here in the United States. Asia Pacific accounted for 22 percent. Now Asia Pacific does not include Japan. That is China and the surrounding countries, but not Japan.

Five years later, by 2002, those ratios had completely reversed. Asia Pacific consumed 36 percent of the world's chips. The United States 22 percent.

By 2005, the U.S. share is going to shrink to 18 percent and Asia Pacific's share will grow to 40 percent and is accelerating.

That shift has been driven by China. As recently as 2000, China accounted for only seven percent of global chip demand. Two years later in 2002, that figure had more than doubled, to 15 percent and that is still increasing.

Currently, the U.S. industry in terms of production of chips leads. We have 50 percent of the world's market and 77 percent of all U.S. owned semiconductor manufacturing is still located right here in the U.S., but the trend, as we know, is not favorable.

The capital investment in new facilities in the U.S. is dropping as a share of world investment. The capital equipment shipments to sites in the U.S., such as semiconductor production equipment, right now account for only about 25 percent of the world's shipments. The investment is declining here and it is increasing abroad. That is the offshore trend that we are all concerned about.

The challenges that are emerging to U.S. leadership in microelectronics are in all cases government driven. This is not just an evolution of factor advantages in other countries. These reflect deliberate foreign policies. They take two forms I could call leadership and close-followership strategies.

Japan and the European Union are pursuing leadership strategies. They are aimed at overtaking the United States in microelectronics technology. They are putting a lot of money into big joint R&D projects aimed at developing leading edge commercial technologies.

Interestingly too, in both Japan and Europe the governments are putting a lot of money into building state-of-the-art fabs within their own geographic zones. In Japan, the project is called the All Japan Foundry Project. In Europe, there are government funded state-of-the-art fabs in France and Germany that will keep some state-of-the-art manufacturing capability there and there is significant government money going into those foundries.

More interesting and more of a challenge to us are what I would call a close-followership strategy. That is where governments abroad do not seek to overtake the U.S. leadership in technology, but instead to integrate the operations of their own industries with those of our companies.

Taiwan was the most successful practitioner of this strategy, but it is now being emulated by Malaysia, Singapore, Thailand, Israel and most significantly China.

The reason close-followership is more of a challenge is actually the functions these countries are assuming in our own production processes are being offshore and that is what is drawing our manufacturing overseas.

At least in semiconductors, this movement offshore is not being driven by comparative costs. The fact is there is not much of a labor cost component to manufacturing in this industry. The cost differentials between manufacturing chips in the U.S. and chips in China or Taiwan are not that dramatic. Other factors are at work.

I will just cite a few of them. First, there is the advent of foundries. The capital costs and the risks associated with investing in state-of-the-art semiconductor manufacturing have become staggering. They are prohibitive for all but a handful of companies.

It costs now two to three billion dollars to build a state-of-the-art fab and it is going to cost ten billion, 15 billion as we move ahead technology.

The foundry model has enabled foreign countries to say essentially do not worry about those costs and risks. We will assume those ourselves. We will make the chips for you. You give us your designs. You give us the technology and we will do it all here. All you have to do is pay a service fee.

The practice began in Taiwan, but it is now spread to Singapore, Malaysia, Israel and most recently China. More and more U.S. semiconductor firms are fab-less. That means they outsource all their designs to foundries in Asia. Others are fab-lite, which means they are using foundries as a significant part of their total production.

Significantly, I am not aware of a foundry anywhere in Asia that does not enjoy significant government support, although those things are being built with either government equity participation or with large loans from government banks and in some cases both.

Then there is tax policy. The most successful foundries in the world are in Taiwan. TSMC and UMC, they control currently about two-thirds of semiconductor foundry manufacturing. The govern-

ment of Taiwan has implemented taxes which ensure that those companies essentially pay no taxes. They operate at a tax-free environment year-after-year.

In fact, reflecting accumulated credits during most recent years, TSMC has a higher after tax income than a pre-tax income reflecting the accumulation of tax credits from prior years. China is basically copying this policy now, virtually identical in its own high-tech zones in China.

There are incentives to individuals. One of the key advantages that TSMC and USMC in Taiwan enjoys is they can attract and hold many of the best and brightest quality managers and engineers. One important factor here is the tax treatment of individual compensation. The people that work for these companies receive stock or stock options and compensation. It is taxed at par value, which could be like one Taiwan dollar; whereas the market value may be $100 or many multiples of the face value.

The only tax they pay is on that face value and when they sell those, exercise the option to sell the stock, there is no capital gains tax. That is pure income to them.

In the competition for skilled managers and engineers, those companies have a dramatic edge, because they can offer really the opportunity to get rich quickly working there. Significantly, China is replicating this policy as well on a larger scale in China.

Finally, there is China's preferential value-added tax. In 2000, the Chinese government established a preferential rate of value-added tax, which basically said that while any imported device must pay a 17 percent VAT at the border upon entry into China, anything that is domestically manufactured in the semiconductor industry or designed, pays an effective VAT of only three percent.

So in other words, the differential VAT operates like a tariff and as a result, many foreign investors have rushed into the Mainland to establish fabs inside of China to take advantage of this tax preference.

At present, roughly 20 Taiwan owned fabs have begun operation or are under construction on the Mainland. They are all foundries and they are taking advantage of this VAT preference. All these factors are combining to produce a shift in investment to Asia and within Asia to China.

It is a problem for us. The prospect of this manufacturing is moving to China means that ultimately the design function will migrate as well. There is a gravitational pull being exerted now by the shift of manufacturing and ultimately, the university infrastructure that is needed to support the whole infrastructure.

My recommendations are first that the U.S. government should enforce the WTO commitments China has made against their preferential value added tax. We ought to consider in our own tax policies the tax holidays that are available abroad and we should significantly increase federal spending on university based R&D here to keep the talented people and cutting edge research going on within our own borders.

Thank you.

[Mr. Howell's statement may be found in the appendix.]

Chairman MANZULLO. So much information. I have several questions, but before that, Dr. Sega, could you take one or two minutes

and explain to the folks here what you did in our office? The four departments that you explained that are involved in your organization. I want the folks here to get a broader understanding of the exact nature of the position that you hold. Could you do that for us?

Mr. SEGA. Yes.

Chairman MANZULLO. You introduced one of your——.

Mr. SEGA. Yes, and one of those was the Laboratories and Basic Sciences. This is within the Office of Director of Defense Research and Engineering and we have the oversight over the basic, applied and advance research.

The second office is Deputy Under Secretary Defense for Science and Technology. Dr. Charlie Holland has the oversight of that office.

The third is that of Advance Systems and Concepts. The Deputy Under Secretary Defense is Sue Payton and there is a Director of Plant and Programs, Mr. Al Schaffer and we also have in the office oversight of DARPA and the director is Dr. Tony Tether.

Chairman MANZULLO. Then how many people work under you?

Mr. SEGA. In the range of 40.

Chairman MANZULLO. Okay. I needed that so we could get a broader understanding of the depth of what you are involved in.

We have a couple of lines here going at the same time. Dr. Sega who is in charge of the core research and then at the same time talking about the core research, a lot of the components of it are coming from overseas.

I guess my question to you, Dr. Sega, in terms of what you do, do you get involved in the source of supplies, studies, materials, et cetera as Director of your department?

Mr. SEGA. No, sir, I do not.

Chairman MANZULLO. So that is outside your field?

Mr. SEGA. Yes, it is.

Chairman MANZULLO. I guess my question here would be and I appreciate that, my question here would be to the other two witnesses. To what extent is our military capability imperiled by the off-shoring of the semiconductor industry?

We have heard a lot of numbers, but in terms of what that converts to for military preparedness. Dr. Hartwick, do you want to take a stab at that?

Mr. HARTWICK. I would suggest that we are not imperiled today. I cannot speak for the Department of Defense and AGED, because I am representing only myself, but the context of our work was in the trends in the future.

The trends are clear and the breaking of the linkage between the fine research that is done in Dr. Sega's organization and ultimately getting that device or product into a manufacturable state is our concern.

Currently, we have enough on-shore facilities, but that is rapidly changing. So the point is, the rapidity of the change and what it means three and four years from now.

To build a new military system takes anywhere from five to ten years. You must act now in order to prepare yourself for these changes. That is our concern and that was the concern of our forum that you have cited.

Chairman MANZULLO. What do you do? Mr. Howell, you have some tremendous insight and studies as to what the foreign nations are doing, but where do we go from there? At what point do we lose critical mass?

Mr. HARTWICK. Yes.

Chairman MANZULLO. And then what do you do about it?

Mr. HARTWICK. The organizations that are going to hurt first are the ones that really require cutting edge technology, that is the surveillance intelligence agencies. They hurt first. They must put band-aid solutions on this.

They must make deals to have government product in the case of chips run in the same manufacturing lines as commodity chips. The government must ante up, because they are interrupting the flow of high profit commodity chips on these lines. The government, near term, must make deals, band-aid solutions to ensure we have that product coming through three and four and five years from now.

Chairman MANZULLO. Ms. Velazquez?

Ms. VELAZQUEZ. Thank you, Mr. Chairman. Mr. Hartwick, an article published by Manufacturing and Technology News on May 16, 2003 stated that the AGED panel was told to stop briefing military officers, other government agencies and Congressional staff on the conclusion of its report. Can you confirm if this occurred?

Mr. HARTWICK. Yes, it did occur.

Ms. VELAZQUEZ. Why do you believe it did?

Mr. HARTWICK. I do not have any idea.

Ms. VELAZQUEZ. Can you expand a little bit more on that?

Mr. HARTWICK. We had a turnover of management with Dr. Sega's shop at that time. I believe that that may have had an influence on that decision. From my perspective, each briefing that we gave in briefing our results was extremely well received. We only briefed when we got a briefing request. We solicited no briefings.

Each briefing was well received. I was puzzled by the directive to stop briefing just as you are.

Ms. VELAZQUEZ. That directive came from?

Mr. HARTWICK. It came from Dr. Eisenstadt, who is a third tier down from Dr. Sega.

Ms. VELAZQUEZ. Mr. Sega, do you have any comment on that question?

Mr. SEGA. The briefing that I received and unfortunately it was a brief time because of a delay in an airplane I believe on the 19th of November of last year from Dr. Hartwick, was the result of a forum that was conducted.

In fact, I was the keynote speaker at the forum. A good exchange of folks and ideas and so forth at the meeting and the briefing was presented to me. There is some great content in the briefing.

Now, we need to make a decision on these briefings whether that they are as the AGED process is a direct report of industry group to me whether or not the advice being provided for making planning and policy kinds of determinations, whether the document is for official use only, is classified, is to go through a formal release process.

To go through a formal release process in the Department of Defense, then it is submitted per the Directorate of Freedom of Infor-

mation and Security Review in the department and is cleared for open publication and then one goes forward.

During our meeting, the next step was to visit with Mr. Al Schafer, who heads up the office of plans and programs and take a look at this information and see where we should go from it.

It has good information in it. It was not annotated if you will as a briefing. It did not have references.

Ms. VELAZQUEZ. Dr. Sega——.

Mr. SEGA. What the decision——.

Ms. VELAZQUEZ. You got the report a year ago, right?

Mr. SEGA. Yes. What it is, is the document is an official use only document. It is not cleared for public release.

Ms. VELAZQUEZ. Why is it not cleared for public release?

Mr. SEGA. It was my determination.

Ms. VELAZQUEZ. Who paid for it?

Mr. SEGA. Excuse me? I did.

Ms. VELAZQUEZ. The government.

Mr. SEGA. Yes. It is historically not unusual for some of AGED reports and I do not know if we have that here, to be for official use only. The purpose of the advisory group is to provide advice. It is roughly half-and-half government folks and those that are from outside of the Department of Defense, but are acting in a government consultant status to provide advice.

Ms. VELAZQUEZ. Okay.

Mr. SEGA. In terms of being able to present it to staff, to Congress and official use only forum, that from my perspective, that was always fine.

Ms. VELAZQUEZ. Are you trying to tell me that you never released reports?

Mr. SEGA. We never cleared it for open, unlimited distribution. That is a correct fact.

Ms. VELAZQUEZ. Are you planning to release the report?

Mr. SEGA. No.

Ms. VELAZQUEZ. Why is in the report that you do not want the public to know or members of Congress?

Mr. SEGA. The——.

Ms. VELAZQUEZ. The report basically is a call for action. It is a national plan of action to counter the decline of U.S. electronics manufacturing and technology.

Mr. SEGA. As I said, the recommendations and the observations and there are many of which are very, very good and we have applied those and taken actions on many of those. The group provides advice, in this case to the Director of Defense Research and Engineering. Distributing of the information is found in this government product, an official use only basis and we had those restricted to AGED reports in the past to government agencies and contractors.

It is providing good advice to us. Now without annotation, without references and without a dissenting thing of reviews, it is key to have it briefed by somebody, if you will and provide the appropriate caveats and provide additional background.

By itself, we felt that it was not appropriate to distribute it for unlimited distribution.

Ms. VELAZQUEZ. I do not get it. I just do not understand why after a year and cleaning it up you cannot release this for public consumption or even for us, members of Congress. We legislate.

Mr. SEGA. Yes. It is absolutely fine. Official use only documents are provided and they have been provided.

Ms. VELAZQUEZ. Okay.

Mr. SEGA. This document in particular to Congress and staff. It is only the unlimited distribution that has been restricted and it never went through the clearance process for doing that, because it was determined to be more appropriate as an official use only document.

Ms. VELAZQUEZ. Doesn't it pose a national security problem?

Mr. SEGA. We classify things——.

Ms. VELAZQUEZ. Dr. Sega, from a security standpoint, are there any domestic industries that the Department of Defense believes the U.S. needs to protect?

Mr. SEGA. The question you asked is outside of the purview of the Director of Defense Research and Engineering. If I can give you an example of an area once identified of a shortage, where we do have oversight, one of those is in terms of Title III.

Let me give you two examples of the Defense Reduction Act Title III. Gallium Arsenide is an electronic device and it is used in military applications, such as radars and smart weapons and electronic warfare systems. Under the stressing performance environments associated with these systems, it provides an advantage in terms of speed, power consumption, performance, reliability, not achieved in the silicon-based technology.

This is an example from the past. The Department supported the development of Gallium Arsenide technology for a number of years, even before there was a significant commercial application. When it became apparent that the long-term viability of U.S. wafer supply base was in doubt, the Department established the program under Title III of the Defense Reduction Act.

Ms. VELAZQUEZ. Okay. Now——.

Mr. SEGA. During the 1990's—can I—no?

Ms. VELAZQUEZ. That is good enough. I just would like to ask you: After hearing from the other two witnesses, have you revised any of your opinions on the state of the defense industrial base in this country?

Mr. SEGA. The purview of my job is to look at the science and technology base. We are concerned about bringing forward the best technology for the war fighter.

We stay in close contact and I think it is important to do that from day one all the way through the lifetime of a weapons system with the users, the acquisition community, which is the part that involves manufacturing and industrial base and with those in logistics. So technology, acquisition, logistics and users are working together to make this effective from day one all the way through and different parts have a lead at different times through a weapons system's lifetime.

So we get that information from them. It is a collaborative area, but it is not one that I have responsibility for.

Ms. VELAZQUEZ. Mr. Howell. Dr. Howell. Mr. Howell.

Mr. HOWELL. I am a Mister.

Ms. VELAZQUEZ. Yes. Would you like to comment on that?

Mr. HOWELL. Most of my work has been on the civilian side of microelectronics and I do not know the ins and outs of the military applications that have been given. The original question I think was when do we reach a tipping point where our national security begins to be jeopardized by the offshore movement of manufacturing.

I think that different people can have different answers to that, but I think the tipping point may be and this is not just my view, I think it is the view of many people in the community, it is when the best graduates from schools, graduate schools of electronics and integrated circuit design and so on, find that the opportunities are not here any more. The best opportunities for the best people are abroad and they start moving abroad.

At that point, it becomes very hard to retain the capability that we need really in this sector. I do not know how that ripples down exactly to the military sphere, because I know that generally it takes so long to design and insert these kinds of devices into military systems and it would take a number of years before that would reverberate into the security area, but it would if it is a long-term trend.

I think right now the state-of-the-art manufacturing is here. The best design talent is here. The best universities are——.

Chairman MANZULLO. Let me interrupt you. Did you have a comment you wanted to make, Dr. Hartwick?

Mr. HARTWICK. No, I am fine.

Chairman MANZULLO. Okay. Let me conclude here because we have to go vote. We have been holding a series of hearings on the nature and state of our manufacturing base in this country.

I find the testimony of each of you to be intriguing, yet extremely distinctive. You are talking essentially in I don't want to say three different spheres, but I would like to do is to work with the three of you.

I think we all agree here that we have to begin to formulate policy to make sure that the United States keeps its cutting edge technology, has the ability, but to keep that here at home. I think the three of you agree with me on that.

You come from three different perspectives. Three different backgrounds. If you would be willing to work with us, as part of I don't want to call it a national manufacturing strategy, but we are seeing comments from people like Andy Grove from Intel, who is just begging this Congress for leadership in order to make sure that we maintain these strategic advantages at home. It has been an extremely thoughtful testimony and I appreciate it very much.

Did you have a question you want——.

Ms. MILLENDER-MCDONALD. Mr. Chairman, thank you so much. I had a classified meeting on transportation so I was running here to try to listen to these distinguished panelists and I know that the topic is extremely critical, especially to California, given the Silicon Valley and its demise.

Because of the HB–1 bill that we presented, I am very concerned as to whether we are losing advantage in terms of technology. Again, if there is an opportunity for us to have conversation with them, I would be happy to be a part of that.

Chairman MANZULLO. Did anyone want to comment on the HB–1? Dr. Hartwick? Anybody?

Mr. HARTWICK. I don't know what the HB–1 is.

Ms. MILLENDER-MCDONALD. It was providing——.

Chairman MANZULLO. You could tell they are definite field sciences.

Ms. MILLENDER-MCDONALD. It was to accord persons coming in from other countries to do high-tech jobs here in the United States, because of a lack of personnel for those types of jobs, especially those coming in from India.

That is what that bill suggests. While we passed that bill, I was very concerned about that, given that we should have had someone here in the United States who could——.

Mr. HARTWICK. I would like to respond, if I may.

Chairman MANZULLO. Sure.

Mr. HARTWICK. First off, I would be delighted to work with whoever it is that wants to get this problem solved.

Chairman MANZULLO. Well, it is the four of us now.

Mr. HARTWICK. I am with you. I would suggest that there is more than three spheres. You see three spheres represented here. There is an education sphere. There is a big business and a small business sphere. The spheres are multiple and the very problem we have is that they do not talk with one another.

Ms. MILLENDER-MCDONALD. Here. Here.

Mr. HARTWICK. It is time to get them all together.

Chairman MANZULLO. That is why we are here. You know what? We have to terminate the talk, because we have to exercise our Constitutional obligation to vote.

Thank you for coming. The hearing is adjourned.

[Whereupon, at 12:00 p.m., the Committee meeting was adjourned.]

Statement of Chairman Donald A. Manzullo

IS AMERICA LOSING ITS LEAD IN HIGH-TECH: IMPLICATIONS FOR THE DEFENSE INDUSTRIAL BASE

October 16, 2003

Good morning and welcome to this hearing of the Committee on Small Business. Last year, the Advisory Group on Electron Devices (AGED) presented what I consider to be remarkable findings to top officials in the Pentagon. Among other things, this group found that "off-shore movement of intellectual capital and industrial capability, particularly in microelectronics, has impacted the ability of the US to research and produce the best technologies and products for the nation and the warfighter." Those of you who know me know that I have been saying this for sometime now. Fortunately for America, we have people like Dr. Hartwick who

are acknowledged leaders in the science and technology industry who volunteer their time to advise us of such issues.

Ironically, several other key authorities in the technology world have echoed this message since the AGED briefing. At one of our subcommittee hearings a few months back the Director of the Microphysics Laboratory at the University of Illinois at Chicago testified that the United States military has become almost entirely dependent on foreign sources of materials, components and production equipment used for the manufacture of night-vision infrared devices. The Defense Department witness was unmoved by this and felt no threat to supply even though production was coming from France. What disturbs me, however, is that this same French company that supplies our military also sells to the Chinese. How can this not be a significant factor in maintaining our tactical edge in warfighting?

Another example comes from Henry Kissinger who recently stated, "If outsourcing continues to strip the US of its industrial base and the act of getting out or developing its own technology, then we require a careful thought on national policy."

Friday's front page of the Washington Post Business Section headlines read: "Intel Chairman says U.S. is Losing Edge." Andy Grove said that the software and technology service businesses are under siege by countries taking advantage of cheap labor costs and strong incentives for new financial investment. While some would concede we have already lost our edge in manufacturing, what will we do if we lose our leadership role in software and services? This is Andy Grove saying this – one of the founding fathers of our new economy. Listen to this next quote, because it is the crux of the issue. He states that he is "torn between his responsibility to shareholders to cut costs and improve profits, and to U.S. workers who helped build the nation's technology industry but who are now being replaced by cheaper labor." He asked for the

government to help decide the proper balance between the two; otherwise companies will focus only on stock price. This is why support for the Crane-Rangel-Manzullo bill is so critical. It is one piece of the puzzle that helps manufacturing companies decide to keep jobs here.

Yet another group of advisors has the same concern. The President's Council of Advisors on Science and Technology (PCAST) recently announced that the Asian semiconductor market surpassed the US in 2001 and is expected to further widen the gap. More strikingly, they found that R&D design capabilities are moving overseas, including China, along with the production at an increasing rate. One main concern is that "the proximity of research, development and manufacturing is very important to leading edge manufacturers." It's the link between R&D and manufacturing that drives successful innovation. The implication for the US, then, is an acknowledgement that our high-tech leadership is not automatic and a loss of that leadership "would

have serious implications for the Nation's economy and living standards."

I wish we had the Chairman of this PCAST subcommittee, here for this hearing, but George Scalise is in Europe right now giving speeches on this very topic. For those of you that don't know, Mr. Scalise is also President of the Semiconductor Industry Association.

I could go on with examples, but I will end with this one. A recent study by the National Academies states that the semiconductor "plays a crucial role in ensuring US national security by allowing advances in the capabilities of new devices and new applications for national defense....Preserving unencumbered access to the world's most advanced technology may provide no guarantees, but allowing the nation's technological edge or independence to slip away would be hard for future generations to understand." Mr. Howell was a co-author of that study.

Future generations notwithstanding, here is what I and other Members of this committee find hard to understand. About three months ago, this committee held a hearing to discuss the vulnerability of our defense industrial base due to offshore manufacturing. At that hearing, Suzanne Patrick, Deputy Undersecretary for Defense Industrial Policy, stated, "Despite the downturn in the US economy, the defense industrial base is healthy, innovative, and responsive." She also said that the defense industrial base doesn't need to be revitalized and denied that US defense systems are vulnerable due to foreign dependencies.

How is it, with so much mounting evidence, that the Defense Department can not, will not acknowledge that our procurement process continues to foster an increasing vulnerability and dependency on foreign sources? That's what we don't understand.

I look forward to the testimony of each of our witnesses.

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SMALL BUSINESS

TESTIMONY OF

RONALD M. SEGA

DIRECTOR OF DEFENSE RESEARCH AND ENGINEERING

BEFORE THE UNITED STATES HOUSE OF REPRESENTATIVES

COMMITTEE ON SMALL BUSINESS

October 16, 2003

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Introduction

Mr. Chairman, members of the committee, thank you for the opportunity to appear before you today. I would like to discuss the Department of Defense commitment to retaining U.S. leadership in those sciences and technologies that are critical to maintaining our technological war fighting superiority. As the Director of Defense Research and Engineering, I have oversight responsibility for the Department's investments in the basic sciences, applied research, and technology development and demonstration programs. These research and development activities are performed by universities, government laboratories, as well as by small, medium and large businesses.

The overarching guidance for the Department's Science and Technology (S&T) investment strategy is incorporated in three specific documents. These documents are a collaborative product of the Office of the Secretary of Defense, the Joint Staff, our Combatant Commanders, the Military Services, and the Defense Agencies. They have been developed in direct response to the needs of our warfighter and to ensure the continued superiority of our defense systems.

The first document, the DoD Basic Research Plan, guides our investments in fundamental research. These investments explore emerging technologies that have the potential for attaining radically new military capabilities. The second, the Defense Technology Area Plan, focuses our investments in applied research and technology development essential to future warfighting capability. The third

document, the Joint Warfighting Science and Technology Plan, incorporates technology development and demonstration efforts dedicated to supporting priority near-term joint warfighting capabilities. Taken together, these documents provide a carefully planned program of S&T activities to enable the near-, mid-, and long-term technology superiority of U.S. Forces.

DoD Electronics S&T Program

Advanced electronics are critical to the Department. In fact, it is one of the twelve major elements of the Defense Technology Area Plan and one of the ten major research areas of the Basic Research Plan, which I mentioned earlier. In FY 2003, the Department invested $678M in electronics S&T and $106M in electronics basic research. When combined with our related S&T investments for sensors and electronic warfare, this investment totaled approximately $1.9B. Overall, this funding was nearly 20% of the Department's total S&T investment for FY 2003.

I would like to briefly describe past and current examples of our electronics activities. Gallium Arsenide (GaAs) electronic devices are used in military applications such as radars, smart weapons, and electronic warfare systems. Under the stressing performance environments associated with such systems, it provides advantages in terms of speed, power consumption, performance, and reliability not achievable using Silicon-based technology. The Department has supported the development of GaAs technology for a number of years, even before there were significant commercial applications. When it became apparent that the

long-term viability of the U.S. wafer supplier base was in doubt, the Department established a program under Title III of the Defense Production Act. During the early 1990's, U.S. firms had a 25% share of the world market. Their business prospects were discouraging because of the relatively small market, the dominant position of foreign suppliers, and the high capital investment required to remain competitive. Our Title III investment generated a dramatic turnabout. By the year 1998, the high-end wafer sales of these U.S. contractors accounted for 60% of the worldwide market. The dollar value of their combined sales grew by nearly 300% even while wafer prices dropped by approximately 40%.

Radiation hardened microelectronic devices are essential for our military satellites and strategic missile systems. Recognizing that we were in danger of losing our last domestic sources for radiation hardened components, we instituted activities to ensure at least two on-shore sources for these devices. Today, the Title III program is helping these companies to modernize their production facilities through equipment purchases so that they will remain viable suppliers for our defense needs. As part of our comprehensive investment strategy, the S&T program is funding the development of next generation radiation hardened devices while our acquisition programs fund efforts to qualify and enhance their producibility.

External Interactions

In my introduction, I described some of the internal processes the Department employs to develop and manage our S&T investments. I would now like to touch briefly on some external sources of information used by DoD.

Recommendations from various groups such as the Defense Science Board, Navy Research Advisory Committee, Army Scientific Advisory Board, Air Force Scientific Advisory Board, the National Research Council, JASONs, and Advisory Group on Electron Devices (AGED) are important sources of information for us. On a routine basis, leaders from industry and industrial professional associations, spanning from small businesses to our largest corporations, meet with my staff and me to discuss their plans and to provide their recommendations on where technology opportunities and challenges may exist. We also obtain input from leading experts in academia, the various professional societies, trade groups, and industry associations as we strive to remain informed as to the state-of-the-art and emerging S&T trends. The inputs from all of these sources are important in formulating the Department's S&T strategy to meet warfighter needs.

Advisory Group on Electron Devices (AGED)

AGED is an advisory group chartered under the Federal Advisory Committee Act that reports to me. Its membership includes representatives from the government, industry and academia. Over the years, AGED has conducted a number of Special Technology Area Reviews (STARs) that provided recommendations that assisted the Department in developing its electronics S&T

program. The Department values the advice from AGED as one element in formulating the DoD Electronics S&T investment for high payoff technology.

The product AGED delivered DoD in November 2002 following their September 2002 Forum included some important observations that are consistent with those made by other groups such as the President's Council of Advisors on Science and Technology and the Semiconductor Industry Association. This product was a briefing, not a formal report, and a number of the recommendations are not within my oversight purview as Director of Defense Research and Engineering. The Forum brief was not annotated, did not contain any references, and did not include any indication of either concurrence or dissent by the various participants. After a review of the Forum brief, we determined that it was not appropriate for unlimited distribution. Historically, not all AGED products have been granted a release for distribution into the Public Domain. The Forum briefing is a "For Official Use Only" product.

S&E Workforce

A key to defense technology leadership is an innovative and robust science and engineering (S&E) workforce within our defense laboratories. We are also making important new investments in secondary and undergraduate science and engineering education in order to help ensure an adequate national S&E workforce for DoD needs. I have increased the Department's Graduate Fellowship stipends and number of awards in order to attract the best and brightest scientists and engineers. Additionally, we are working to make employment opportunities

within our laboratories more attractive to the Nations' most talented scientists and engineers.

Many of the new educational initiatives alluded to previously are electronics related. Our secondary and undergraduate curriculum initiatives include an emphasis in materials science and engineering, a field that is critical to technological advances in electronics. For example, in a new undergraduate research initiative, we are making investments in a leveraged, collaborative program with the Semiconductor Research Corporation with a focus in electronics. Another component of our undergraduate research effort is being made in collaboration with the National Science Foundation in the Research Experiences for Undergraduates (REU) Program.

Closing

In closing, I appreciate the opportunity to come before you to relate to you our commitment to retaining U.S. leadership in those sciences and technologies that are critical to maintaining our warfighting superiority. Thank you.

Oct. 4, 2003

HOUSE SMALL BUSINESS COMMITTEE TESTIMONY

Good afternoon Mr. Chairman and Madam Ranking Member, my name is Thomas Hartwick. I am self employed in high tech. My background roughly splits up like this. I've spent the past decade serving on boards and committees in the public and private sector, largely small business, and the 4 previous decades in aerospace general management in research, project management, strategic planning and manufacturing. . This testimony is solely my own, but I believe it fairly represents a broad cross section of the professional and business high tech community both in private and public sectors. My main message today from the high tech community is that ***immediate government action is needed to address the off-shore movement of manufacturing***

My focus here is on high tech business because it's the core of new DOD systems and entirely new mega billion dollar industries like chips or television. The high tech community is most worried about the national trend for the break-up of clusters which I call Enterprise Centers defined as the complex of university, small business and manufacturing. The movement of manufacturing plants off-shore breaks up Enterprise Centers and destroys the infrastructure for new businesses. In the past this occurred over a very long time period. For television it took about 50 years, for flat panel displays about 25 years, for chips about 15 years, but the time keeps getting shorter as foreign countries target our industries. Without Enterprise Centers to nucleate and nurture a variety of small businesses, foreign companies eventually dominate the business and new US product development suffers.

In creating new products the sequence of events is innovation and design, prototype fabrication, establishment of the manufacturing process and production of the saleable item for commerce or government systems. If these steps are contained within a single company or Enterprise Center, the structure works well. Small business will flourish and new generations of technology are spawned through this time honored process. When this linkage is not functioning, ***inventions often end up on the cutting room floor because they cannot be manufactured.***

Sure, some businesses which employ remote design functions in "now generation devices "are un-affected by off-shore plant locations, but others rely on "next generation cutting edge devices" to achieve competitive advantage. However, such anecdotal information about random business strategies does not accurately capture the pervasive and insidious nature of Enterprise Center break-ups. I think it takes more detailed analyses to first fully understand and then to create a national strategy to prevent potential loss of future US competitive positions, particularly in future mega-billion $$ industries like MEMS or NANO technologies.

National security products parallel the commercial process except for two differences. ***First, product security is difficult to maintain***; for example, more than 80% of all chips are now produced off-shore and our government is hard pressed to ensure future supplies of cutting edge classified chips for systems. ***Second, cutting edge government designs are difficult to produce on demand in any commercial plant*** because the low volume displaces more profitable high volume commercial products. The Advisory Group on Electron Devices has cited these issues and called for prompt action.

Special arrangements with domestic chip manufacturers are one band-aid solution which our government has put in place for the time being. However, a long term national strategy is needed to reverse the off shore trend. Other examples which may parallel the chip experience in the future are un-cooled night vision devices and MIMICS, microwave chips like the ones in cell phones.

Its time for action in the US to avoid future foreign dominance.... not just from the standpoint of big business or small business or the DOD, but for all the US. ***We desperately need a national strategy to maintain our leadership!*** I suggest:

1. Enterprise Center Study.....immediate analysis of future loss of competitive advantage for commercial and national security sectors with development of a prioritized list of vulnerable high tech industries.

2. "Keep One" Strategy.... for each vulnerable high tech business, establish the policy and financial climate to ensure at least one domestic state-of-the-art manufacturing facility for a decade or more.

The trends and consequences are clear. I believe these problems must be addressed now, well before we reach the cliff, to ensure our future competitiveness. Thank you for inviting my participation on this issue. I am happy to answer any questions.

ADVISORY GROUP ON ELECTRON DEVICES (AGED)

National Technology Leadership Forum 9/24/02
Microelectronics Case Study

11/25/2002

WHAT IS AGED?

- **CHARTER:** Constituted in 1945 by the Federal Advisory Committee Act to advise the Director, Defense Research and Engineering (DDR&E)
- **MAIN OBJECTIVE:** Advise DDR&E on electron device investment strategy and analyze selected issues
- **ORGANIZATION:** Working groups on microwaves, microelectronics and electro-optics analyze issues; report to Advisory Group
- **MEMBERSHIP:** Standing committee of Army, Navy, Air Force, DARPA, BMDO, DTRA, NASA and other agency representatives as well as OSD appointed industry and academic consultants

AGED CONSULTANT MEMBERS ARE LEADERS IN INDUSTRY AND ACADEMIA

Tom Hartwick	Chair, Former Chief Scientist, TRW
Jack Kilby	Chair Emeritus, Nobel Laureate, Inventor of the IC, IEEE Life Fellow, Recipient IEEE Medal of Honor
Bill Howard	Former Senior VP and Director of R&D at Motorola, Member of Defense Science Board and National Academy of Engineering, IEEE Fellow, AAAS Fellow
Charles (Chuck) Krumm	Chair, WG-A, Executive Director, GaAs Technology Conexant, IEEE Fellow
Barry Dunbridge	Chair, WG-B, Electronics Director, TRW
Andrew (Andy) Yang	Chair WG-C, Co-inventor S.B. IR Detectors & Cameras
Conilee Kirkpatrick	Vice President, HRL Laboratories, IEEE Fellow
George Heilmeier	Former President & CEO, Bellcore (now TelcordiaTechnologies). IEEE Fellow, Recipient IEEE Medal of Honor
Paul Kelley	Professor, Tufts University

ALL SERVE AS "SPECIAL GOVERNMENT EMPLOYEES" SUBJECT TO STRINGENT RULES & REGULATIONS WHILE CONDUCTING AGED BUSINESS

ADVISORY GROUP ON ELECTRON DEVICES FORUM

MOTIVATION FOR THE FORUM

- Global economic, political and technological trends threaten the ability of the U.S. to be a world leader in technology.
- Off-shore movement of intellectual capital and industrial capability, particularly in microelectronics, has impacted the ability of the U.S. to research and produce the best technologies and products for the nation and the warfighter.

ADVISORY GROUP ON ELECTRON DEVICES FORUM

FOCUS OF THE FORUM

- Leaders in electronics from Government, industry and academia came together to analyze these issues.
- Using **microelectronics** as a **case study**, these experts explored the elements of technology leadership, examined trends affecting these elements, their causes, and potential results of these trends.
- From that basis, Forum participants discussed approaches to change those trends that negatively affect U.S. technology leadership, particularly in technologies critical to the warfighter, and development of a **National Plan of Action**.

THE FUTURE OF TECHNOLOGY LEADERSHIP

AGED held a Forum on 24-25 September 2002 to explore the loss of U.S. leadership in manufacturing and technology

Microelectronics as a Case Study

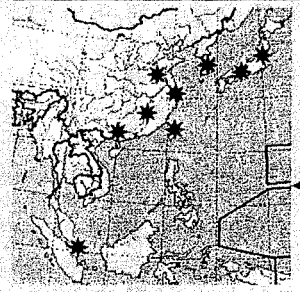
- Session 1: Elements of Technology Leadership
  - Keynote: Dr. Ronald Sega, DDR&E
  - Dr. Arden Bement, NIST
  - Dr. Benjamin Streetman, University of Texas, Austin
- Session 2: Trends of Technology Leadership; Influencing Those Trends
  - Dr. Mark Regets, NSF
  - Mr. Ronil Hira, IEEE-USA
  - Mr. Daryl Hatano, SIA
  - Dr. Bernie Meyerson, IBM
  - Dr. Ron Finnila, HRL
  - Dr. Neal Bhadkamkar, Monitor Ventures
  - Dr. Robert Leheny, DARPA & Dr. Robert Reuss, DARPA

AGED FORUM
TOP LEVEL CONCLUSIONS

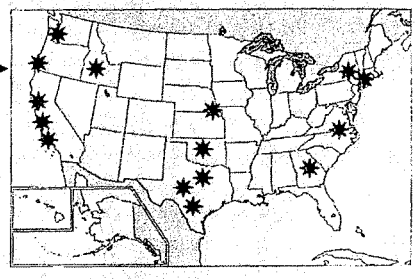
U.S. TECHNOLOGY LEADERSHIP IS IN DECLINE - ACUTELY IN ELECTRONICS.

- Off-shore migration of chip foundries must be addressed:
  - R&D going off-shore with the manufacturing.
  - DOD access to cutting edge chip technologies unreliable.
- Over the last decade, profound changes in the R&D base are adversely affecting cutting edge electronics for warfighter superiority and may potentially slow the engine for economic growth.

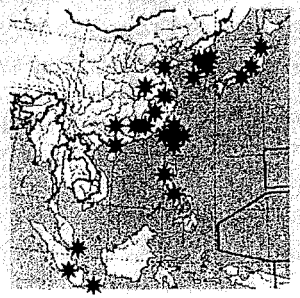
EROSION OF ELECTRONICS TECHNOLOGY LEADERSHIP



DESTRUCTION OF U.S. INNOVATION CENTERS

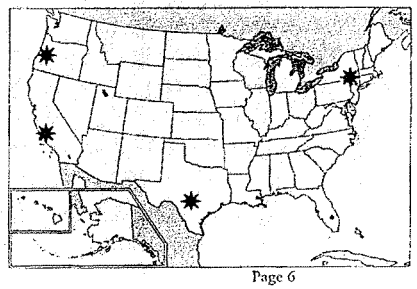


MASSIVE OFFSHORE FOUNDRY MOVEMENT



DRIVEN BY:

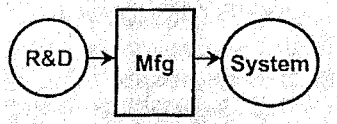
- Off-shore financial incentives
- Lower off-shore labor costs
- Less stringent environmental laws
- Tax policies
- U.S. export policies
- U.S. university-trained foreign workforce



EROSION OF ELECTRONICS TECHNOLOGY LEADERSHIP

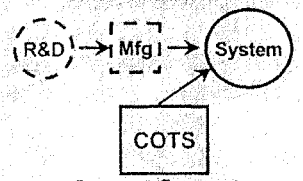
DEFENSE INDUSTRY

Traditional Scenario



Trend

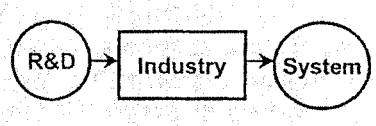
- Downsizing & merging in DoD contractor base
- Less internal technology investment & near term IR&D projects
- More use of COTS & outsourcing
- Increased cost (risk) aversion
- Focus on integrator role
- Low volumes of unique, high performance components



Current Scenario

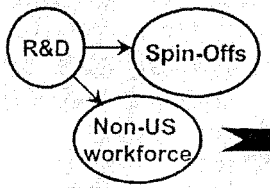
ACADEMIA

Traditional Scenario



Trend

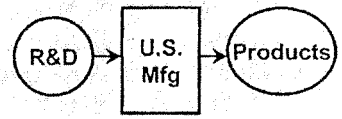
- Emphasis on $ gains from University IP
- Numerous startups by faculty and pursuit of SBIRs
- Aggressive venture capital activity
- High foreign national student enrollments



Current Scenario

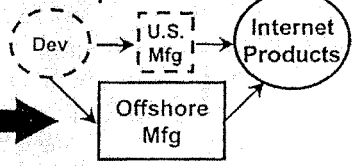
COMMERCIAL INDUSTRY

Traditional Scenario



Trend

- Offshore R&D centers
- Manufacturing moving offshore
  - Focus on lowest manufacturing cost
  - Foreign incentives, tax breaks, & strategy of manufacturing near new markets
- Pressure for near term profits
- Focus on large markets, high volume products



Current Scenario

NATIONAL TECHNOLOGY LEADERSHIP ENABLES DEFENSE & ECONOMIC SUPERIORITY

ELEMENTS OF LEADERSHIP

1. Government Leadership
   - Prominent goal or mission
   - Incentives for industry, academia and citizens
   - National on-shore focus
   - Business-friendly climate
2. Superior Capabilities
   - R&D
   - Technical workforce
   - Academic, industry & Gov. techbase infrastructure
   - Profitable, leading edge manufacturing

IMPACT OF LEADERSHIP

1. Defense
   - Continuous superiority
   - Weapon/systems edge for strategic/tactical missions
2. Economy
   - Engine for growth of U.S. economy
   - Leading edge technology, manufacturing and products onshore
   - Technical workforce stability

CONSEQUENCES FOR THE NATIONAL DEFENSE

DOD LOSES ITS COMPETITIVE EDGE

- DoD faces shrinking advantages across **all** technology areas.
- DoD is forced to rely on perceived system integration advantages to maintain superiority.

SETS UP ENVIRONMENT FOR DOD TECHNOLOGY DEPENDENCE

- In order to obtain best technology, DoD is forced to import products from other nations.
- Assigns those nations political and military leverage over the U.S.

OBJECTIVE

⇨ Re-establish robust research and development base for warfighter technologies and secure permanent military technology leadership.

IMPACT ON WARFIGHTER OF TECHNOLOGY LEADERSHIP LOSS

CASE STUDY #1: WE USED TO OWN THE NIGHT?

LEADERSHIP ADVANTAGE

- Warfighter tactical edge from night vision equipment in sea, air, and ground environments have provided demonstrated advantage - we have "owned the night."

PROBLEM

- Advent of Si microbridge, room temperature sensitive thermal detector technology has resulted in low cost, mass production - now a commercial commodity.

NEED

✓ Re-establish strong R&D capability to leapfrog current generation of sensors and explore camouflaging technologies.

BATTLEFIELD COMM & DATA NETWORKS

CASE STUDY #2: LOSS OF COMMAND AND CONTROL DOMINANCE?

LEADERSHIP ADVANTAGE

- To date superior comm and data networks created competitive edge for the US warfighter enabling great mobility and strike coordination among all battle elements.

PROBLEM

- Global availability of wireless communications (e.g., cell phones) and high data rate fiber optic land lines has greatly reduced this advantage even against the less sophisticated terrorist threat. Use of best commercial chips and processors levels the playing field for allies and adversaries.

NEED

✓ Deploy next generation of comm and data equipment to maintain an electronics system lead in the battlefield. Apply to streaming real time video and distributed processing networks.

IMPROVEMENT OF THE U.S. CLIMATE FOR TECHNOLOGY LEADERSHIP

DOD ACQUISITION POLICY

Commercial off the shelf

- **PROBLEM:** Use of **only** COTS for lowered risk and cost results in weapons systems without competitive advantage.
- **OBJECTIVE:** Recognition of criticality of non-COTS Electronics for maintaining future warfighting superiority
- ✓ **ACTION:** **OSD AT&L to organize DoD/Industry analysis team to formulate actions for trend reversal.**

INTELLECTUAL PROPERTY

- **PROBLEM:** Federal grant policy gives University unrestricted IP ownership.
- **OBJECTIVE:** Include Government-use rights in Government funding to universities to encourage use by DoD contractors in defense systems.
- ✓ **ACTION:** **Task DARPA/NSF/Academic Community/Industry team to analyze issue and offer improved scenarios. Involve the ABA.**

COUNTERACT TREND FOR FOUNDRY MOVEMENT OFF-SHORE

FOREIGN GOVERNMENTS EFFECTIVELY TILTING THE PLAYING FIELD

- **PROBLEM:** Foreign governments luring U.S. companies in with massive financial and tax incentives
- **SOLUTION:** Counter by increasing U.S. incentives and implementing favorable tax policies
- ✓ **ACTION:** **Utilize SIA to analyze tradeoffs made by U.S. firms in decisions to move off-shore and develop mitigating strategies**

EXPORT POLICY

- **PROBLEM:** US semiconductor equipment suppliers are losing market share and their existence threatened because of restrictions on export of the most advanced SME tools to newly constructed foreign fabs.
- SOLUTION: Re-establish cutting edge IC merchant semiconductor fabrication in the US.
- ✓ ACTION: **Utilize SIA to analyze tradeoffs made by U.S. firms in decisions to move off-shore and develop mitigating strategies. Engage DTSA to supply Defense context.**

IMPROVEMENT OF THE U.S. CLIMATE FOR TECHNOLOGY LEADERSHIP

UNIVERSITY ENROLLMENT POLICIES

- **PROBLEM:** Huge influx of foreign national graduate students, particularly from People's Republic, resulting in scarcity of U.S. citizens for defense workforce and potential for unintended technology transfer with those returning to offshore homelands
- **OBJECTIVE:** Academic recognition of responsibility to educate U.S. workforce.

✓ **ACTION:** **Organize NSF/DoD/industry team to formulate actions for more favorable scenario**

TAX AND BUSINESS INCENTIVES

- **PROBLEM:** Foreign Governments offer lucrative incentives and tax advantages to attract U.S. investments in manufacturing and R&D offshore.
- **OBJECTIVE:** Business and tax environments which level the playing field for investment in operations in the U.S.

✓ **ACTION:** **Organize IRS/Business/Commerce/DoD/Congressional team to formulate actions for more favorable scenario.**

SUMMARY OF PROPOSED ACTIONS

ADVISORY GROUP ON ELECTRON DEVICES

- ⇨ **STAR #1:** Assess erosion of unique night vision capability and trends
- ⇨ **STAR #2:** Delineate military microelectronic advantages and trends
- ⇨ **STAR #3:** TBD

DDR&E

- ⇨ **ACTION #1:** Recommend AT&L Organize DoD/industry team to review and recommend acquisition policy changes.
- ⇨ **ACTION #2:** Form DoD/NSF/industry team to amend IP provisions
- ⇨ **ACTION #3:** Ensure Congressional Involvement in the process & solution.

OTHER AGENCIES....OUR BRIEF OF AGED FORUM

- ⇨ **DoC:** Brief Dr. Bement (Director, NIST), Deputy Secretary Bodman, Assistant Secretary Jochum, Under Secretaries Juster & Mehlman
- ⇨ **CONGRESSIONAL STAFF:** Brief Mr. Morrison, Mr. Reed, Mr. Seraphin, Ms. Hanna, Mr. Goldston
- ⇨ **INDUSTRY GROUPS:** Brief IEEE, SIA (Mr. Scalise), NEMA
- ⇨ **NSF:** Brief emphasis on workforce and IP issues

AGED FORUM SUMMARY

THE PURPOSE OF THE FORUM WAS TO ANALYZE
TECHNOLOGY LEADERSHIP,
USING MICROELECTRONICS AS A 'CASE STUDY'.

TECHNOLOGY LEADERSHIP CONCERNS EXIST IN ALL AREAS OF ELECTRONICS ESSENTIAL FOR SUPREMECY IN MILITARY SYSTEMS --- THIS INCLUDES UNIVERSITY, AEROSPACE, COMMERCIAL, AND INTERNAL GOVERNMENT LABORATORY CAPABILITIES.

WE RECOMMEND THAT
IMMEDIATE CORRECTIVE ACTIONS MUST BE TAKEN IN ORDER TO SUSTAIN OUR TECHNOLOGY LEADERSHIP.

Significant Findings of Selected Studies and Reports
Concerning the Semiconductor Industry

Advisory Group on Electron Devices (AGED)

- **U.S. technology leadership is in decline—Acutely in electronics:**
  - R&D going off-shore with the manufacturing.
  - DOD access to cutting edge chip technologies unreliable.

- **Over the last decade, profound changes in the R&D base are adversely affecting cutting edge electronics for warfighter superiority and may potentially slow the engine for economic growth.**

- Consequences for the national defense:
  - **DOD faces shrinking advantages across all technology areas.**
  - **DOD is forced to rely on perceived system integration advantages to maintain superiority.**
  - **In order to obtain the best technology, DOD is forced to import products from other nations, which assigns those nations political and military leverage over the U.S.**

- Technology leadership concerns exist in all areas of electronics essential for supremacy in military systems—this includes university, aerospace, commercial and internal government laboratory capabilities.

- We recommend that immediate corrective actions must be taken in order to sustain our technology leadership.

President's Council of Advisors on Science and Technology (PCAST)

- Overall, U.S. manufacturing output has remained steady over the past 50 years while employment and share of GDP has been halved, productivity has increased.

- U.S. IT manufacturing has declined significantly since the 1970's.

- **U.S. is preeminent in leading-edge design work, but anxiety exists for long-term.**

- **Past 5 years decline in IT has accelerated; 400,000 jobs lost from Jan. 00 to Dec. 02.**

- **Asian semiconductor market surpassed U.S. in 2001 and is expected to further widen the gap.**

- As basic IT component, semiconductor market reveals IT manufacturing trends.

- **Panel found a consistent sense of anxiety for long-term implication of trends.**

- U.S. advantages (best R&D system, best workforce talent and Universities, best infrastructure) are large, but not absolute.

- Reasons for Foreign Inroads:
  - All companies compete globally and customers demand lowest cost.
  - Labor Costs dominate as some product cycles evolve but capital cost issues more important in others.
  - R&D design capabilities moving overseas too.
    - ✓ Labor costs 1/3 to 1/10 of U.S. in India and Asia
    - ✓ Emergence of global (24 hour) design cycles.
  - Proportion of foreign math/science grads of U.S. Schools increasing, with growing tendency of foreign students to return home.
  - Confidence in foreign design capabilities slowly growing.
  - Government subsidies—foreign governments are aggressively courting IT industries as key economic development targets.
  - Tax benefits:
  - Currency Valuation—40%differential w/China.

- **U.S. high tech leadership is not automatic.**

- **Our own ecosystems (R&D-manufacturing relationship) can be damaged via deterioration of anchors (R&D or manufacturing).**

- Other countries become more competitive as they strive to replicate out innovation ecosystems.

- **While threat is not imminent, if anchors are lost, what will companies decide 10-20 years from now?**

<u>Securing the Future (National Academies of Science)</u>

- **Increasingly, foreign countries have been forming and supporting national and regional consortia with programs aimed at conducting collaborative research, creating industry standards, and mapping out future technological issues; yet the U.S. has no national policy platform and the public research development funds that support this enabling industry have sharply declined since the mid-1990's.**

- Although corporate spending grew to nearly 60% of the national R&D effort in the final two decades of the last century, industry has devoted greater resources to product development than to the basic research upon which future economic growth ultimately depends.

- **The semiconductor industry is U.S. manufacturing star performer. But if the semiconductor is an important enabler of national economic health, it also plays a crucial role in ensuring national security by allowing advances in the capabilities of new devices and new applications for national defense.**

- ***Allowing the nation's technological edge or independence to slip away would be hard for future generations to understand.***

- Innovation requires talented, highly trained personnel, and there are signs that the pool of skilled labor available to the U.S. semiconductor industry is shrinking.

- The number of engineering degrees granted annually by U.S. universities has been all but static over the past decade and comes to only 1/6 of the combined total granted in China, India, Japan, South Korea, and Taiwan each year.

- Dwindling of U.S. production of undergraduate engineers has coincided with cuts in federal funding for university research in disciplines relevant to information technology.

- Over time, the results of these reductions may affect the ability of the U.S. to maintain its leading position in semiconductors, computers, and related industries, with potentially significant consequences for the nation's level of economic growth and national security.

- Contrasting with U.S. reticence to provide R&D support are trends in Europe and east Asia, where national and regional programs are rapidly expanding as governments signal the importance they attach to their semiconductor industries with substantial levels of both direct and indirect funding.

- **Among them are Taiwan's plans to build numerous semiconductor fabs by 2010, Singapore's public goal of 20 new fabs by 2005, and Japan's vigorous pursuit of a national revival in microelectronics.**

- **Things are moving so quickly that some of these plans are being overtaken by the very recent emergence of effective Chinese government efforts to attract foreign capital, management, and technology that would allow it to replicate Taiwan's success in microelectronics on a much larger scale.**

- Also 16 major initiatives at the national and European Union level.

Prepared by House Committee on Small Business Staff

President's Council of Advisors on Science and Technology

Preliminary Draft "Findings and Observations"

Subcommittee on Information Technology Manufacturing and Competitiveness

* * * * *

George Scalise (Chair) Michael Dell Bobbie Kilberg
Gordon Moore Steve Papermaster Luis Proenza

PCAST Subcommittee on Information Technology Manufacturing and Competitiveness

- Subcommittee Task and Focus
  - Explore IT Manufacturing Status and Trends
  - Examine Long-Term Ramifications for Nation's R&D and Innovation Leadership
- Subcommittee Activities to Date
  - Two Panel Sessions; Numerous Teleconferences
  - More than 20 Meetings with Leading Academics, Corporate Executives and Other Industry Representatives
  - Backup Research and Analysis by RAND

PCAST Subcommittee on Information Technology Manufacturing and Competitiveness

- Rationale for IT Focus:
  - Overall Manufacturing was Surveyed
  - IT Focus Allowed for In-Depth Analysis
  - IT Provides High Value-Added to Economy and Nation
    - As a Distinct Manufacturing Sector
    - As a Business Market for Increased Innovation and Economic Growth
    - As a Technological Enabler for Increased Productivity

PCAST Subcommittee on Information Technology Manufacturing and Competitiveness

Subcommittee's Preliminary Findings:

- Overall Manufacturing Trends
- Information Technology Trends
- Reasons for Foreign Inroads
- Implications and Concerns
- Domestic Success Stories

PCAST Subcommittee on Information Technology Manufacturing and Competitiveness

- Overall Manufacturing Trends
  - Overall, U.S. Manufacturing Output has Remained Steady over the past 50 years
  - While employment and share of GDP has been halved, productivity has increased
    - Employment has declined from 30% of U.S. FTEs in 1947 to 15% in 2001. Past two years jobs decline has continued.
    - GDP share has declined from 27% in 1947 to 14% in 2001. In constant dollars (1996), GDP share has declined only slightly (cost of services has increased more swiftly)

PCAST Subcommittee on Information Technology Manufacturing and Competitiveness

- Overall Manufacturing Trends
  - Productivity Increases have Allowed Output to Remain Steady and Prices to Remain Low
  - Increased Productivity is Associated with Higher Wages and Standards of Living
  - Underlying Basis for Productivity Gains has been *Continued Innovation and Integration of IT into the Manufacturing Process*

PCAST Subcommittee on Information Technology Manufacturing and Competitiveness

- Overall Manufacturing Trends
  - *Continued Innovation and Integration of IT into the Manufacturing Process*
    - Considerable Room for Improvement Remains through Continued Enterprise Integration
    - Further, as Technological Frontier Pushes Forward, New Potential Productivity Gains are Created for Companies to Exploit
    - With *Pace of Application of IT* a Competitive Issue, US Economy's Flexibility Provides a Global Advantage

PCAST Subcommittee on Information Technology Manufacturing and Competitiveness

- Information Technology Trends
  - US IT Manufacturing Has Declined Significantly Since the 1970s
  - U.S. is Preeminent in Leading-Edge Design Work, but Anxiety Exists for long-term
    - Global R&D Centers are Emerging around Manufacturing
    - Foreign Government Subsidies

PCAST Subcommittee on Information Technology Manufacturing and Competitiveness

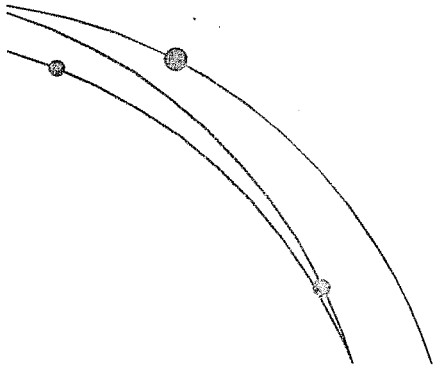
- Information Technology Trends
  - US IT Manufacturing
    - Past 5 Years Decline has Accelerated
    - 400,000 jobs lost from Jan. 2000 - Dec. 2002
    - While overall manufacturing declined 6% 1997-2001, computer manufacturing declined 20 %
    - Asian Semiconductor Market surpassed U.S. in 2001 and is expected to further widen gap
      - → As basic IT component, semiconductor market reveals IT manufacturing trends

PCAST Subcommittee on Information Technology Manufacturing and Competitiveness

- Information Technology Trends
  - U.S. Remains Preeminent in Leading-Edge Design Work
  - But Panel Found a Consistent Sense of Anxiety for Long-Term

PCAST Subcommittee on Information Technology Manufacturing and Competitiveness

- Reasons for Foreign Inroads
  - U.S. Advantages
  - Economic Factors
  - Government Subsidies



PCAST Subcommittee on Information Technology Manufacturing and Competitiveness

- Reasons for Foreign Inroads
  - U.S. Advantages
    - World's Best R&D System
    - Best Workforce Talent and University Excellence
    - Most Flexible, Entrepreneurial Business Climate
    - Best Gov't and Rule of Law (stability, IP, etc.)
    - Best Infrastructure
    - World's Largest Market for High Tech Goods
  - Advantages Large but not Absolute

PCAST Subcommittee on Information Technology Manufacturing and Competitiveness

- Reasons for Foreign Inroads
  - Economic Factors
    - All companies compete globally and customers demand lowest cost
    - Labor Costs and Proximity to Market
      - ➔ Lowest Cost Product to Consumers
      - ➔ Global Supply Chain Management (evolving business model fueled by increased capabilities -- and competition -- due to Internet "real time" communications)
    - Labor Costs Dominate as Some Product Cycles Evolve but Capital Cost Issues More Important in Others (*e.g.*, new semiconductor plants)

PCAST Subcommittee on Information Technology Manufacturing and Competitiveness

- Reasons for Foreign Inroads
  - Economic Factors
    - R&D Design Capabilities Moving Overseas Too
      - ➔ Labor costs: 1/3rd to 1/10th of U.S. in India and Asia
      - ➔ Emergence of Global (24 Hour) Design Cycles
    - Proportion of Foreign Math/Science Graduates of U.S. Schools in Increasing
      - ➔ Growing Tendency of Foreign Students to Return Home
    - Confidence in Foreign Design Capabilities Slowly Growing
      - ➔ As with global supply chains, management of global design systems improving too

PCAST Subcommittee on Information Technology Manufacturing and Competitiveness

- Reasons for Foreign Inroads
  - Government Subsidies

    "We are not just competing against foreign companies, but foreign countries"

    - Foreign Governments are Aggressively Courting Information Technology Industries as Key Economic Development Targets

PCAST Subcommittee on Information Technology Manufacturing and Competitiveness

- Reasons for Foreign Inroads
  - Government Subsidies -- Wide and Varied
    - Tax Benefits
      - ➔ Chinese VAT rebate (11-14% on 17% VAT); "5+5" corporate tax plans
      - ➔ Stock Option Treatment (par value w/ no cap gains tax)
      - ➔ $1.3 Billion differential for one firm on tax basis alone
    - Currency Valuation -- 40% differential w/ China
    - Subsidy Programs
    - Science-Based Industrial Parks
    - Worker Training

PCAST Subcommittee on Information Technology Manufacturing and Competitiveness

- Implications and Concerns
  - US High Tech Leadership is Not Automatic
  - Loss of Leadership would have Serious Implications for Nation's Economy and Living Standards
    - The upward drive of our innovation system has continually created "higher rungs" on the economic ladder for our citizenry and workforce
    - Continued trends in manufacturing or R&D may portend fractures in the web of "ecosystems" that drive the U.S. innovation system

PCAST Subcommittee on Information Technology Manufacturing and Competitiveness

- Implications and Concerns

"The proximity of research, development and manufacturing is very important to leading edge manufacturers"

- Panel Focus: *Through what Process does the U.S. Maintain its Technological Preeminence, and How Could This Leadership be Lost?*

PCAST Subcommittee on Information Technology Manufacturing and Competitiveness

- Implications and Concerns
  - R&D-Manufacturing "Innovation Ecosystem"
    - Linkages between R&D and Manufacturing -- Cyclical, Dynamic Relationship that Drives Successful Innovation
      - ➔ New Leading Edge Design (New Products)
      - ➔ Swifter/Better Integration of IT into Manufacturing Processes (Improved Productivity)
    - Importance of Human Capital, and thus Proximity, in the Information Technology Arena

PCAST Subcommittee on Information Technology Manufacturing and Competitiveness

- Implications and Concerns
  - R&D-Manufacturing "Innovation Ecosystem"
    - Two Basic Anchors: Manufacturing and R&D
    - Locations Possessing both Anchors have a Competitive Edge
      - ➔ "Clusters of Innovation" Studies
      - ➔ Advantage in Pace of IT Integration
      - ➔ Statements of Companies to PCAST Panel (decisions to locate near strong R&D centers)

PCAST Subcommittee on Information Technology Manufacturing and Competitiveness

- Implications and Concerns
  - Implications for U.S. -- Two Dangers:
    1. Our own ecosystems can be damaged via deterioration of anchors (R&D or Manufacturing)
    2. Other countries become more competitive as they strive to replicate our innovation ecosystems.
  - Maintenance of U.S. Technological Preeminence not Forever Assured
    - While threat is not imminent, if anchors are lost, what will companies decide 10-20 years from now?
    - Denigration would most likely be a slow, evolving process

PCAST Subcommittee on Information Technology Manufacturing and Competitiveness

- Domestic Success Stories

"US States are competing against foreign states"

- Several States have been Highly Successful in Attracting High Tech Manufacturing
- States' "Best Practices"
  - Long-term Commitment from State Leadership
  - Strong University R&D Support
  - An Educated Workforce
  - Pre-Approved Sites
  - Friendly Tax Policies

PCAST Subcommittee on Information Technology Manufacturing and Competitiveness

- Conclusions
  - R&D-Manufacturing Ecosystems maintain our standards of living over the long term (via innovation and swifter productivity enhancements)
  - Foreign Inroads Occurring due to economics and foreign subsidy programs
  - US Enjoyment of Technological Preeminence is not assured

PCAST Subcommittee on Information Technology Manufacturing and Competitiveness

- Future Work Plan
  - Continue to Meet with Experts and Interested Parties
  - Continue to Finalize Underlying "Findings" -- based on today's discussion and continued consultations
  - Develop Recommendations for December PCAST Meeting –
    - How to Maintain U.S. Technological and Innovation Preeminence
- Questions, Discussion, and Comments

George Scalise (Chair) Michael Dell Bobbie Kilberg
Gordon Moore Steve Papermaster Luis Proenza

Before the

COMMITTEE ON SMALL BUSINESS

U.S. HOUSE OF REPRESENTATIVES

Washington, D.C.

Is America Losing Its Lead in High-Tech?: Implications for the U.S. Industrial Base

Testimony of

THOMAS R. HOWELL

Dewey Ballantine LLP

October 16, 2003

My name is Thomas R. Howell. I am a partner in the Washington, D.C. law offices of Dewey Ballantine LLP, where I specialize in international trade. I have spent over 20 years studying foreign government systems of industrial and technological promotion. I am appearing before you today as a contributing author to the study recently published by the National Academy of Sciences, *Securing the Future: Regional and National Programs to Support the Semiconductor Industry*. I have represented U.S. manufacturers in a number of industries, including the semiconductor industry, but I am speaking today on my own behalf only, and not on behalf of any client or of the National Academy. I appreciate the opportunity appear before you today.

I would like to summarize briefly what governments outside the United States are doing to promote their high technology industries, with a particular focus on the semiconductor industry, and the challenges these government measures pose for us.

Seen from abroad, the United States offers a model for other countries to emulate in promoting their own high tech industries. While we may debate among ourselves about the appropriate role of government in a particular industrial sector, foreign observers characterize the U.S. system of industry-government-university collaboration that has emerged in microelectronics since the mid-1980s as "ideal" and "perfect," a system to be carefully studied and, if possible, emulated. While "ideal" is undoubtedly an overstatement there are aspects of the U.S. system that have clearly worked well and are reflected in the leadership position our high tech industry currently enjoys. These include:

- An excellent university system, with industry and government backing for leading edge, basic R&D;
- The "Silicon Valley phenomenon," characterized by a clustering of dynamic companies, research universities, and venture capital enterprises within a limited geographic area;
- The success of industry-government consortia, most notably Sematech and the Semiconductor Research Corporation in the semiconductor field;

- The unparalleled ability of the United States to attract the best talent from all over the world; and
- The technological leadership of U.S. high tech companies, which reflects all of the factors cited above.

But U.S. leadership in high technology is coming under pressure as high tech manufacturing is increasingly performed outside the U.S. Data on semiconductor consumption reflect the level of electronics manufacturing activity around the world. In 2001 the Asia Pacific region, driven primarily by growth in China, surpassed the U.S. as the largest semiconductor consuming market in the world. In 1997, the U.S. accounted for 33 percent of the world's chip consumption, while the Asia Pacific region represented 22 percent. Five years later, in 2002, the Asia Pacific share had grown to 36 percent, compared to the U.S. share of 22 percent -- a complete reversal of positions. By 2005, the U.S. is projected to account for only 18 percent of world semiconductor consumption, less than half of the 40 percent share that the Asia Pacific market is projected to represent. The growth of the Asia Pacific market has been driven by the growth in China. China's $18 billion integrated circuit market represented 15 percent of total world demand in 2002, a doubling of the 7 percent share of world consumption it held just two years previously, in 2000.

While Asia Pacific has become the largest semiconductor consumer, the United States remains the largest chip producer. However there are concerns that the U.S. chip industry may lose its leadership role as other regions vie for semiconductor investment. The remainder of my testimony will focus on these concerns, and in particular the role government policies are playing in shaping these trends.

The emerging challenges to U.S. leadership in semiconductors are in all cases government-driven, and in many cases seek to replicate aspects of the U.S. system which are seen as keys to success. These foreign strategies take two basic forms, what can be called "leadership" and "close followership" strategies.

Leadership strategies. Japan and the European Union, the traditional rivals of the U.S. in microelectronics, are pursuing promotional strategies designed to capture the leadership position from the United States:

- Japan and the EU are implementing large scale, long range, industry-government R&D projects aimed at leading edge commercial technologies.
- Both Japan and the EU plan to challenge U.S. PC-based microelectronics technologies with alternatives based on the cell phone, which is coming to rival the PC as a mode of internet access.
- Japan and the EU are promoting their industries' ability to design and manufacture specialized (system-on-chip) devices for use in downstream industries in which their companies are strongest: telecom, digital cameras, smart card, automotive, home networks.
- In both Japan and the EU government support is being provided to develop leading edge manufacturing process technology and to build state-of-the-art manufacturing facilities within the European Union.

"Close followership" strategies. The other basic strategy being pursued abroad is one of "close followership," in which governments do not seek to overtake U.S. leadership but rather to integrate the operations of their own industries with those of U.S. and other leading edge foreign producers, and by so doing to achieve a technological position which is just behind the leading edge and which enables their firms to participate in the businesses of leading U.S., Japanese, and European companies. Taiwan has been the most successful practitioner of this strategy but it is now being emulated in countries such as Malaysia, Singapore, Thailand, Israel, and most significantly, China.

While the Japanese and European efforts deserve to be taken seriously, in many ways the "close followership" strategy poses a greater challenge to U.S. leadership because it is drawing offshore important parts of the U.S. microelectronics infrastructure, particularly in the area of semiconductor manufacturing. The danger is that over the

longer run other key functions, such as design, R&D, and leading-edge university faculty and students will follow the manufacturing function to East Asia. At some point in this process the U.S. could lose its technological edge in this key industry, with serious implications for the U.S. economy and national security.

It is often thought that the shift in semiconductor manufacturing activity from the U.S. to East Asia is being driven by lower manufacturing costs, particularly labor costs, in Asia. But semiconductor manufacturing is capital, not labor intensive. With respect to a 300mm, 90nm wafer fab, for example, Taiwan has a cost advantage over the U.S. of about 7 percent, and China, about 10 percent, assuming constant yields. That cost edge is not inconsequential, but it also does not provide an explanation for the shift of manufacturing from the U.S. to Asia which has occurred and is occurring, particularly when the higher production yields achieved in the U.S. offset at least part of the Asian cost advantage. I would like to briefly outline some of the foreign government policy measures which underlie the current trend.

The advent of foundries. The growing capital costs and risks associated with semiconductor manufacturing have become prohibitive for all but a handful of producers worldwide. Establishment of a single 300mm wafer fabrication facility, for example, requires an investment of over $2 billion, a cost that is expected to increase substantially as further technological advances are achieved. Taiwan pioneered the semiconductor foundry as a response to this growing investment burden -- in effect, offering to assume that burden itself in return for technology and a key role in the business plans of advanced western producers. A foundry is a manufacturing facility which produces semiconductors designed by another firm on a contractual basis, allowing the designing firm to avoid the high capital costs of a fabrication facility. Foundries were established with government support in Taiwan, and subsequently in Singapore, Israel, Malaysia, and China. An increasing number of U.S. semiconductor firms are "fabless" and outsource all of their designs to foundries, while others are "fab-lite," outsourcing a significant part of their total production.

Foundries have enabled host countries to dramatically enhance competencies in semiconductor manufacturing, to build capability in IC design, to attract foreign investment and technology, and ultimately to draw in semiconductor infrastructural enterprises (makers of production equipment and materials, and providers of logistics and other services) as well as talented individuals. Increasingly, design firms are choosing to locate physically near foundries, and the foundries themselves are offering some forms of design services.

Most, if not all of the semiconductor foundries established around the world receive substantial government financial support and in many cases, are partially government-owned. TSMC, the world's first enterprise to undertake foundry-only operations, was considered so risky a venture that it could not have been undertaken without a substantial equity investment from a special fund administered by Taiwan's Executive Yuan (cabinet). New foundries being established in Shanghai and Beijing under Taiwanese management feature equity participation by the municipal governments of those cities. But direct government financial support for the establishment of foundries is only one element in a much broader array of government policy measures being implemented in East Asia to attract semiconductor-related investment, technology and personnel.

Tax policy. The world's most successful foundries are TSMC and UMC, both located in Taiwan, which between them account for nearly two-thirds of world semiconductor foundry manufacturing. In addition to direct financial support, which has become less important over time, the government of Taiwan has implemented policies which ensure that these and other similar Taiwan-based semiconductor enterprises pay no taxes, year after year. In fact, in most recent years, TSMC's after-tax income has been higher than its pre-tax income, reflecting the application of accumulated tax credits. Operating in what is, in effect, a zero-tax environment has given such companies significantly improved cash flow for R&D and new investments.

Infrastructure. The dynamic industrial clustering effect which characterizes Silicon Valley has been intensively studied abroad, and foreign governments have created

their own versions of the Valley in many countries. Perhaps the most successful version has been Taiwan's Hsinchu Science-Based Industrial Park, which has become a magnet for foreign and domestic semiconductor investment. In addition to tax-free status and other forms of financial support, enterprises located in the Park enjoy extensive infrastructural support, nearby research universities, and superb research institutes, including the Industrial Technology Research Institute (ITRI), perhaps the best applied industrial research organization in the world. China is now creating multiple versions of Hsinchu on the mainland. All of the new foundries being established in East Asia are located in such special high technology zones.

Incentives to individuals. One of the key advantages enjoyed by TSMC and UMC has been their ability to attract and hold many of the highest quality managers and engineers in the industry. A key factor in the competition for such talent is Taiwan's tax treatment of company stock and stock options given as compensation to individuals. Shares are taxed on their par value rather than on their actual market value at the time received, which may be many times par value. In addition, when the shares are sold, there is no tax on the income received (apart from a nominal transaction tax) because Taiwan has no capital gains tax. As a result, Taiwanese companies have been able to offer highly talented Taiwanese and foreign engineers the prospect of rapid accrual of substantial personal wealth. Chinese tax policy, while not identical, seeks to replicate such incentives to individuals. In addition, China is offering a sweeping array of incentives to overseas Chinese and foreign talent to relocate in China and contribute to the development of the semiconductor industry. The "talent rush" which occurred to TSMC and UMC in the 1990s is now being replicated by an inflow of expatriate talent to the new Taiwan-managed mainland foundries.

China's preferential value-added tax (VAT). In 2000, the Chinese government issued Circular 18, which provided a series of promotional measures for the semiconductor and software industries. Among other things, Circular 18 established a preferential rate of value-added taxation (VAT) for domestically based semiconductor design and manufacture. While all imported devices are subject to a 17 percent VAT, under the new policy domestic designers and manufacturers of semiconductors receive a

rebate, resulting in an effective VAT rate of 3 percent. While this benefit is available to foreign enterprises which locate in China as well as to domestic enterprises, it is inconsistent with GATT Article III because it imposes a tax on imported products that is greater than the tax on comparable domestic products..

The preferential VAT functions effectively as a tariff around the Chinese market, which is currently the fastest-growing major market for semiconductors in the world. Numerous foreign investors, predominantly Taiwanese, have rushed to the mainland and established new wafer fabs which benefit from the VAT preference. At present roughly 20 new Taiwanese-owned fabs have begun operations, are under construction, or are planned by 2008 on the mainland, all of them foundries. Executives at these new foundries cite the VAT preference, which gives them an "unbeatable" edge over imported devices, as the principal factor underlying their new operations. In effect, China is using the prospect of loss of access to its market to draw in investment and talent that would have located elsewhere, whether in Taiwan itself or in other parts of the world. To date the principal effects of this policy have been felt in Taiwan, but in the future the preferential VAT is likely to affect investment decisions by U.S., Japanese, European and other foreign semiconductor makers.

Conclusion

The prospect that the U.S.-based infrastructure for the design and manufacture of semiconductors could migrate outside the U.S. has serious implications which have been addressed in *Securing the Future*. If the U.S. is to reverse or even slow this trend, we must first recognize the factors which underlie it, and which often have their roots in government measures implemented abroad. Countries are now competing for inward investment in this industry much as state and local government have long competed in this country for manufacturing investment through the use of local incentives. The full dimensions of an appropriate U.S. response can emerge only after the kind of extended industry-government-university dialogue that occurred in the 1980s and arguably resulted in the reversal of what was then an eroding U.S. industry position. But I would like to offer several specific suggestions:

First, the U.S. government should place a priority on the elimination of measures like China's preferential value added tax. The use of this WTO-inconsistent measure to attract inward investment that might not otherwise occur is a serious distortion in a strategic industry, and should not be regarded as acceptable by our government.

Second, the U.S. government needs to examine domestic tax polices that affect U.S.-based manufacturing in light of foreign tax policies that are functioning like a magnet for manufacturing investment. While it is unlikely that the U.S. would ever replicate the 100 percent tax holidays now found in China and Taiwan, U.S. tax policy must be formed with at least reference to those policies and a recognition of the effects they have on locational decisions by individual manufacturing enterprises.

Finally, we must recognize that competition in this industry is increasingly a competition for talented people, whether U.S. or foreign born, and that national governments are aggressively deploying incentives and other measures to influence the outcome of this competition. While the U.S. may not choose to emulate such incentives, it should be recalled that this country has historically been successful in retaining the best and the brightest people in significant part because the leading-edge R&D and design activity resides here and professional opportunities have traditionally been better here than abroad. Measures should be considered which help maintain this edge, such as substantially increased federal spending on university-based, leading-edge R&D and other forms of support for U.S. research universities.

Government Supported Microelectronics R&D Initiatives Outside the United States

Country	Project	Research Period	Government Contribution	Themes
Japan	Next Generation Semiconductor R&D Center (super clean room)	2001-08	$300 million ($60 million in 2001)[1]	Process and device technology for 70 mm generation
Japan	Future Information Society Creation Laboratory	2001-06	$300 million	Create small-scale, very short-term semiconductor production line
Japan	Asuka	2001-06	Will use METI super clean room	Develop design technologies for 0.10- to 0.07-micron system-on-a-chip and device process technologies
Japan	NEDO projects	2001-	Budget for one NEDO project, development of a gas cluster ion-beam system, is reportedly 2 billion yen (about $20 million)	Cluster ion beam process technology, system-on-a-chip design technology, advanced parallel-compiler technology
Japan	ASET	1995-	$500 million	Lithography, semiconductor manufacturing technology
Japan	Selete	1996-	[2]	Manufacturing technology for 300 mm wafers
Japan	STARC	1995-	[3]	Basic research
European Union	MEDEA	1997-2000	$720 million (est.)	Process technology, design, applications
European Union	MEDEA Plus	2001-09	$1,350 million (est.)	System-on-a-chip, UV lithography
European Union	PIDEA	1998-2002	$135 million (est.)	Packaging and interconnection
Germany	Semiconductor 300	1996-2000	$680 million	300-mm wafer technology
France	Crolles I and II	1998-	$136 million (est.)[4]	Pilot 300 mm-fab
Belgium	IMEC	Permanent research institute	$40 million/year (est.)	System-on-a-chip designs; next-generation (sub 0.10-micron) production technology; packaging
France	LETI (GRESSI, PLATO and PREUVE)	Permanent government laboratory	Performs R&D for transfer to industry	CMOS technologies, alternatives to CMOS, UV silicon semiconductor technology
Germany	BMFT programs	Permanent	Direct funding of R&D and contributions to FHG institutes of applied research	Flexible manufacturing, microsystems, non-silicon semiconductor technology
Taiwan	ASTRO	2000-	Government will fund half	Technology induction, upgrading of local industry

[1] METI requested $60 million in FY2001 budget for first year of a 7-year project.

[2] Privately funded but received NEDO contract to develop technology to cut PFC use.

[3] Mostly private funding; Key Technology Center provided subsidy for CAD software development.

[4] Crolles I reportedly received subsidies of FF 900 million to FF 1 billion. Additional subsidies have been requested for Crolles II.

Further information about foreign government promotional measures in microelectronics may be found in my research paper "Competing Programs: Government Support for Microelectronics" in Charles W. Wessner (ed.) *Securing the Future -- Regional and National Programs to Support the Semiconductor Industry* (National Academies Press, 2003)

"Competing Programs: Government Support for Microelectronics" is available on the internet at the Dewey Ballantine Trade Group website: www.dbtrade.com under publications, books & studies in PDF format.

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Intel Chairman Says U.S. Is Losing Edge

By Jonathan Krim
Washington Post Staff Writer
Friday, October 10, 2003; Page E01

One of the founding fathers of the nation's high-technology industry warned in dire terms yesterday that U.S. dominance in key tech sectors is in jeopardy, threatening the country's economic recovery and growth.

Speaking via satellite to a global technology summit in Washington, Intel Corp. co-founder and chairman Andrew S. Grove said that the software and technology service businesses are under siege by countries taking advantage of cheap labor costs and strong incentives for new financial investment.

"I'm here to be the skunk at your garden party," Grove said, noting wryly that his remarks coincidentally fell on the same day as one devoted to promoting nationwide screening for depression.

Grove, 67, singled out China and India as key threats. India's booming software industry, which is increasingly doing work for U.S. companies, could surpass the United States in software and tech-service jobs by 2010, he said.

More ominously, Grove said, the software and services industries -- strong drivers of U.S. economic growth for nearly two decades -- show signs of emulating the struggles of the U.S. steel and semiconductor industries.

In the case of steel, U.S. companies never recovered, dropping from nearly 90 percent of worldwide market share to roughly 10 percent. The semiconductor industry, Intel's core business, faced similar challenges in the 1980s, when it began its drop from 90 percent to 40 percent of the world market, Grove said, before aggressive trade and other U.S. policies helped it recover and stabilize at about 50 percent.

Grove said that even as the U.S. economy is improving, tech employment is not.

According to industry figures, more than 500,000 technology jobs were lost from mid-2001 to mid-2003. Many of these were due to a contraction of the tech sector after the dot-com bubble burst in 2000.

But Grove acknowledged under questioning that the tech industry itself is responsible for numerous jobs leaving the United States, as firms take advantage of considerably cheaper labor costs in India and elsewhere.

Grove said he is torn between his responsibility to shareholders to cut costs and improve profits, and to U.S. workers who helped build the nation's technology industry but who are now being replaced by cheaper labor. Grove did not offer a solution, saying only that the government needs to help decide the proper balance between the two. Otherwise, he said, companies will revert to their obligation to increasing shareholder value.

Recent estimates from financial consulting firms paint a stark picture of "offshoring," which allows companies to get software development and other services at one-third to one-sixth the cost.

The Gartner Group, a market research firm, estimates that 10 percent of jobs at U.S. information technology vendors will move offshore by next year.

Throughout all U.S. companies, Forrester Research predicts the loss of roughly 3.3 million jobs by 2015.

Grove said that the move offshore has been aided by the telecommunications bubble of the late 1990s. So much infrastructure for high-speed Internet connections was laid, much of it never used, that the cost of achieving high-speed communication plummeted. As a result, Grove said, "the engineer sitting 6,000 miles away might as well be in the next cubicle."

Grove chided U.S. policymakers for all but ignoring the problem.

"What is the U.S. public policy?" he asked. "I am hard put to find a document" outlining a policy strategy.

He said he had detected no recognition of the problem from any of the presidential candidates.

Grove also criticized the nation's overburdened patent system, which he said is causing an abundance of innovation-slowing litigation.

He said that the inability of patent examiners to handle the workload has led to a backlog of important applications, but also less than thorough vetting of patents that perhaps should not be granted.

Grove also said the country lags dangerously behind in popular use of high-speed Internet connections, funding for science and technology research, and education.

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Securing the Future:
Regional and National Programs to Support the Semiconductor Industry

Board on Science, Technology, and Economic Policy

Microchip technology has advanced at a breakneck pace since its invention by U.S. scientists four decades ago. Right now change is occurring at a rate judged exceptional even for the semiconductor industry, generating forces able to redistribute expertise, wealth, and ultimately power among the nations competing in this critical economic sector. Accelerating technological progress in recently industrialized nations has narrowed the technological gap with the United States—the current world leader. In addition, an innovative business model is apt to rattle even the most agile of the vertically integrated U.S. chip makers: Low-cost but high-performance fabrication facilities are turning out devices under contract for firms that work exclusively in the design of integrated circuits—a novel arrangement that may herald a revolution in semiconductor production. And adoption of uniform wireless standards has given manufacturers in both Europe and Japan a leg up on U.S. rivals in mobile communications. This advantage, combined with advances in the rapidly growing digital home appliances market, may pose real challenges to the U.S. lead in microelectronics.

Amid such changes, the semiconductor industry faces huge technical and financial demands just to stay on its current trajectory. To help meet this challenge, governments in both Asia and Europe appear to be taking a cue from the success of SEMATECH, the public-private partnership widely credited with helping to restore the U.S. semiconductor industry's competitiveness in the 1990s. Increasingly, they have been forming and supporting national and regional consortia with programs aimed at conducting collaborative research, creating industry standards, and mapping out future technological issues. An important part of this collaboration is carried out by the former U.S.-only consortium, now International SEMATECH. Yet as effective as International SEMATECH is, the United States has no national policy platform, and the public research and development funds that support this enabling industry have sharply declined since the mid-1990s. Current trends in R&D funding make these reductions all the more disturbing. Although corporate spending grew to nearly 60 percent of the national R&D effort in the final two decades of the last century, industry has devoted greater resources to product development than to the basic research upon which future economic growth ultimately depends. Yet, just as policy makers abroad are expanding programs, policy measures in the United States remain limited in scope and funding.

Box 1. Why National Policies Focus on the Semiconductor Industry

The semiconductor's rapid evolution, unfolding along the path described by Moore's Law (See Box 2), has had a powerful impact on the economy. The semiconductor industry:

- ***Powers Other Industries.*** *Semiconductors contribute to the productivity of many sectors, serving as key inputs to a wide variety of intermediate and final products and services, ranging from construction to finance.*
- ***Spurs Economic Growth.*** *Performance increases and price decreases in semiconductor-based products make higher-powered investment goods more available throughout the economy, boosting worker productivity.*
- ***Creates High-Wage Jobs.*** *Unlike the traditional manufacturing sector, hit by stagnation and slight pay decline over the past three decades, this modern, knowledge-based industry has been a source of new and well-paid employment.*
- ***Fosters Competitive Advantage.*** *Improving semiconductor productivity speeds advances in information technology, which can often translate into a competitive advantage for firms investing in high-tech equipment, from trucking to banking.*
- ***Bolsters National Defense.*** *Semiconductor-based systems play a growing role in national security, and increasingly sophisticated technology is needed to defend against terrorism and other threats. Having information and communication systems that outperform our adversaries is a key component of homeland security.*

What Does it Mean?

What does leadership in the semiconductor industry mean to the United States' economic and military security? How is the nation's industry positioned for the technological and financial hurdles it is rapidly

approaching? Will parts of the U.S. semiconductor industry benefit from new business practices—and will other parts have the resilience to compete with those who are employing them? What options do policy makers have to help keep U.S. industry on a level playing field? To bring these vital questions into focus for U.S. policy makers, and to bolster their knowledge of the diversity and scale of regional and national programs that aid the semiconductor industry elsewhere, the National Research Council's Board on Science, Technology, and Economic Policy (STEP) has published *Securing the Future: Regional and National Programs to Support the Semiconductor Industry.* Assembling the expertise of business, government, and academic leaders from many of the key countries seeking the benefits of the semiconductor industry, the report, released in May 2003, provides an up-to-date fix on conditions and trends throughout the industry, as well as specific recommendations concerning public support for research in the disciplines that are indispensable to succeeding in it.

Contributions to National Well Being

The semiconductor industry is U.S. manufacturing's star performer. On the strength of a 17 percent annual growth rate, its output climbed from 1.5 percent of manufacturing GDP in 1987 to 6.5 percent in 2000. In 1999, when it posted $102 billion in sales, it accounted for not only half the world market in its product but also for over 5 percent of manufacturing value-added in the U.S. economy, making it the manufacturing sector's leader. It boasted 284,000 employees as of August 2001 and paid them an average hourly wage 50 percent higher in real terms than it had 30 years before—a remarkable achievement in light of the overall 6 percent real decline in manufacturing wages over the same period. And it provides the guts of the $425 billion U.S. electronics industry.

Box 2. Moore's Law: Key to Better Products

In 1965, Intel Corporation co-founder Gordon Moore made the historic observation that each year semiconductor producers were managing to fit twice as many transistors onto an integrated circuit, or chip, as the year before. The world's most complex chip then held only 64 transistors, but transistor density continues doubling annually without raising chip cost even today, when each integrated circuit holds hundreds of millions of transistors. This principle, known as Moore's Law, has had far-reaching implications. The more closely transistors can be placed on the chip, the more rapidly they can interact, yielding in turn increased computer processing power. Faster and cheaper chips have led to greater market demand and encouraged the spread of semiconductors from computers to a broad range of products from automobiles to medical equipment. Indeed, much of the advance in medicine through improved diagnostics or drug discovery technologies ultimately relies on advances in semiconductors. Thus, Moore's Law has boosted productivity in general while making the semiconductor an engine of growth for fledgling industries and a source of revitalization and increased efficiency for established industries.

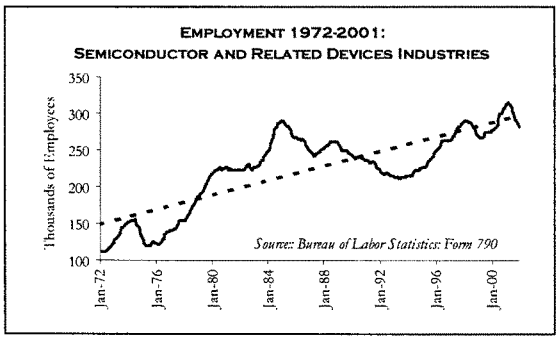
Impressive as these contributions are, they represent only the tip of the iceberg. Declaring that it "carries an importance far beyond the specific trade, employment, and revenue figures of the industry itself," *Securing the Future* analyzes the semiconductor's role in the United States' recent turnaround in productivity.

It was in the mid-1990s when the rate of decline of semiconductor and computer prices, which had been steady at 15 percent per year, jumped to 28 percent. This event has been linked to an abrupt end of the slowdown in U.S. productivity growth that had taken hold in the early 1970s and had coincided with a significant erosion in the United States' industrial power. **U.S. labor productivity increased 2.4 percent annually in the period 1995-1998, a full percentage point higher than the average rate for the preceding five years, as investment in computer technology exploded and its contribution to growth rose more than fivefold.**

With individuals and businesses alike rapidly taking to the Internet and other information technologies, new forms of communication became available at low cost. Pointing to a "structural acceleration" in the U.S. economy, the President's Council of Economic Advisers in 2001 argued that not only were improvements within the information technology sector pushing up average productivity, "the spread of information technology throughout the economy has been a major factor in the acceleration of productivity" overall.

But if the semiconductor, which *Securing the Future* calls "analogous to the steam engine of the first industrial revolution," is an important enabler of national economic health, it also "plays a crucial role in ensuring [U.S.] national security by allowing advances in the capabilities of new devices and new applica-

tions for national defense." In an age when international terrorism is replacing classic warfare, threats are far more difficult to anticipate and guard against. The targets are not only military personnel and equipment, but also civilians and civil infrastructure. The sources of threat are difficult to identify and locate. As devastatingly disruptive attacks can now come from or be directed at cyberspace, the battlefield is literally all around us. Preserving unencumbered access to the world's most advanced technology may provide no guarantees, but allowing the nation's technological edge or independence to slip away would be hard for future generations to understand.



Pushing the Limits of Physics and Affordability

The semiconductor industry owes its phenomenal growth to achieving large and consistent increases in the complexity of integrated circuits while holding prices level. This fact of industrial life is commonly referred to as "Moore's Law" (see Box 2).

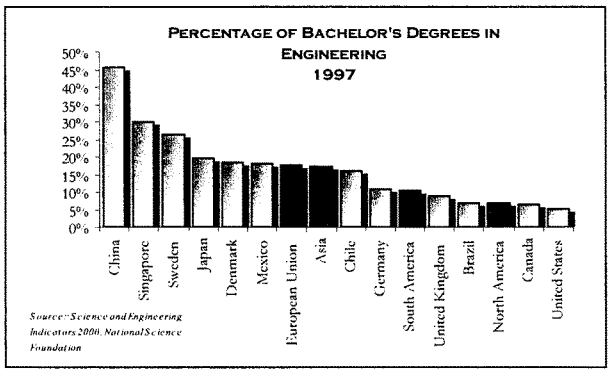
But continued shrinkage of transistor size, on which this progress has depended, may run semiconductors up against the laws of physics. So fine are transistors today that electrons can pass through the gates designed specifically to hold them back, while small changes in the exact number and precise distribution of individual atoms can alter the behavior of a device. These quantum effects are "the most difficult challenge," judges one expert, that "the semiconductor industry has ever faced." Yet even if Moore's Law can be made to withstand these physical limits, advances in packaging technology and chip-level Computer-Aided Design tools are urgently needed as well. According to *Securing the Future* "absent dramatic innovation in these two areas, it may prove impossible to exploit the enhanced functionality, gate density, and speed of future semiconductor products, creating a disincentive for new-product adoption and leading to stagnation in semiconductor sales."

Soaring manufacturing costs pose an additional problem. If chips' increased complexity has not been reflected in their price, it has been reflected in the price of machines used to produce them. Such a machine, at Intel's founding in 1968, cost around $12,000; today, semiconductor makers spend billions on a new fabricating plant, or "fab," an investment that is expected to continue rising as devices become even more complex. As it turns out, capital costs are climbing far faster than revenue: In 2000, average total expenditures for a six-inch equivalent wafer were 117 percent higher than in 1989 and 390 percent higher than in 1978. Cost pressures, just like technological barriers, have the potential to constrict the industry's growth and thereby crimp its role "in stimulating productivity growth in the broader economy," the NRC report states.

A Shrinking Pool of Skilled Labor

Innovation requires talented, highly trained personnel, and there are signs that the pool of skilled labor available to the U.S. semiconductor industry is shrinking. The number of bachelor's degrees in engineering granted annually by U.S. universities has been all but static over the past decade and comes to only one-sixth of the combined total granted in China, India, Japan, South Korea, and Taiwan each year. These foreign-educated engineers have been filling many of the student and faculty slots left unclaimed at U.S. institutions. As attracting skilled labor becomes an integral part of international industrial competition, these skilled workers are being offered significant inducements to return home. "Almost without exception, top management and researchers from the leading consortia and companies" of the U.S. semi-

conductor industry, *Securing the Future* reports, have "expressed misgivings about the adequacy of the labor force to meet foreseeable demand."



Declines in Federal R&D Support

The dwindling of U.S. production of undergraduate engineers and graduate students in the sciences, abetted by a sharp decline in electrical engineering B.A.s in the decade beginning around 1988, has coincided with cuts in federal funding for university research in disciplines relevant to information technology. This affects far more than the labor supply: "Over time," the NRC volume cautions, "the results of these reductions may affect the ability of the United States to maintain its leading position in semiconductors, computers, and related industries, with potentially significant consequences for the nation's level of economic growth and national security." Compounding the slump in funding for university research, the traditional U.S. ambivalence over the use of public money to support industry R&D has kept Washington's purse strings tied.

Although U.S. private R&D outlays have been growing at a robust pace overall, federal spending has not kept up with private-sector investment. This is worrisome, since industry now finances far less long-term research than it did in the heyday of Bell Labs. "Leading figures in the industry and academic experts," states *Securing the Future*, "are concerned that the federal government is not allocating adequate resources to the basic research required to maintain technical advance in what is now the largest manufacturing industry in the United States."

...and New Programs and Government Support Abroad

Contrasting with U.S. reticence to provide R&D support are the trends in Europe and East Asia, where national and regional programs are rapidly expanding as governments signal the importance they attach to their semiconductor industries with substantial levels of both direct and indirect funding. As evidence, *Securing the Future* offers a catalogue of national programs. Among them are Taiwan's plans to build numerous semiconductor fabs by 2010, Singapore's public goal of 20 new fabs by 2005, and Japan's vigorous pursuit, with multiple programs, of a "national revival" in microelectronics. Things are moving so quickly that some of these plans are being overtaken by the very recent emergence of effective Chinese government efforts to attract the foreign capital, management, and technology that would allow it to "replicate Taiwan's success in microelectronics on a much larger scale." The report documents 16 major initiatives at the national and European Union level; while they are aimed at diverse aspects of both product and process technology, government policy support and/or funding is common to all. The perception that the U.S. device makers' consortium, SEMATECH, "contributed to the resurgence of the American industry" after its crisis of the late 1980s "has led to its emulation in many producing countries—often on a significantly larger scale and with greater underlying political support," the report observes.

Policy tools such as preferential tax treatment and direct subsidies, particularly in Taiwan, have nurtured the growth of foundries. Foundries, which for a fee produce chips designed by other firms, flag a trend toward the separation of design and manufacturing that may pose a challenge to the part of U.S. semiconductor industry dominated by integrated manufacturers. Changes in technology and in market struc-

ture have favored the emergence of a new production tandem consisting of the foundry, which designs no chips of its own, and the fabless firm, which designs chips but does not produce them. By allowing design firms to bring products to market without financing production facilities, this new scheme lowers the barrier to entry, facilitating new designs. This is a good thing because the high productivity and rapid turnaround that foundries emphasize cut manufacturing costs and accelerate the pace of product innovation. Yet it is also a double-edge sword. "The push toward vertical specialization contrasts with much of the U.S. industry, notably the merchant device manufacturers, which typically house both design and production under one roof," *Securing the Future* observes. "As capital costs rise, fabrication capacity increases, and alternative business models gain prominence, the competitive position of some U.S. device manufacturers may be challenged." This could have major consequences for U.S. economic growth and national security.

Partnering for the Future

Against this background, the report argues, a response from the policy sphere is more than appropriate—it may even be critical. And as the report points out, such a response is far from unprecedented in U.S. experience. "Driven by the exigencies of national defense and the requirements of transportation and communication across the American continent, the federal government has played an instrumental role in developing new production techniques and technologies."

As far back as a 1798 contract with the inventor Eli Whitney for interchangeable musket parts, Washington participated in the nation's scientific, technological, and industrial development. Government programs helped develop industries from telegraphy, railroads, and agriculture to pharmaceuticals, petrochemicals, and aviation to computing and genomics. Specifically, "beginning with the mid-1980s, the United States has undertaken a remarkably wide range of public-private partnerships in high-technology sectors," not the least of which was SEMATECH, the example that has most inspired rival nations' efforts at consortium-building. The United States has "public-private consortia of many types and multiple aims; some leverage the social benefits associated with federal R&D activity, while others seek to enhance the position of a national industry."

Box 3. Major Long-Term Challenges in the Semiconductor Industry

Performance Enhancement

- ***Novel methods and materials.*** *Non-traditional device structures and architectures, extending to the design of chip interconnections and memory, must be implemented.*
- ***Next-Generation Lithography.*** *With the demands of miniaturization set to exceed the limits of optical lithography, new technologies must be developed.*

Manufacturing Cost-Effectiveness

- ***Noise Management.*** *If semiconductors are to run at ever-higher speeds with "low noise"—few disturbances or unwanted signals—more attention must be devoted to modeling, analysis, and estimation at all design levels.*
- ***Error Tolerance.*** *As increasing transistor count and design complexity greatly reduces the potential for failure, relaxing device correctness standards may reduce manufacturing, verification, and testing costs.*
- ***Substrate Materials.*** *There is a pressing need for research and engineering to find new, large-area starting substrate materials if the rate of semiconductor productivity gain is to be maintained.*

The Steering Committee for Government-Industry Partnerships for the Development of New Technologies, which prepared *Securing the Future* under the STEP Board's auspices, draws on this enduring precedent in its recommendations to U.S. policy makers (see Box 4). It calls upon industry, academia, and government to team up to promote research and training in the semiconductor field. While noting that the measures it proposes are "modest," the Committee emphasizes their long-term importance. Above all, it warns against complacency: "The considerable technical challenges that must be addressed by the industry, and the ambitious foreign programs designed to do so, are reminders that continued U.S. leadership cannot be taken for granted. In fact, the development of new production models, such as the foundry system, as well as increases in national subsidies for domestic production facilities, present serious competitive challenges to the U.S. industry."

"Overcoming these and other challenges will require continued policy engagement and public investment through renewed attention to basic research and cooperative mechanisms such as public-private partnerships."

Box 4. COMMITTEE RECOMMENDATIONS

The Committee's recommendations outline a series of modest steps that nonetheless may prove important to the long-term welfare, economic growth, and security of the United States.

Resources for University-based Semiconductor Research

To better address the technical challenges faced by the semiconductor industry and to better ensure the foundation for continued progress, more resources for university-based research are required.

The Committee believes that universities have an important role in maintaining a balance between applied science and fundamental research. This balance is key in generating ideas for future research.

The Committee suggests consideration of the development of three-way partnerships among industry, academia, and government to catalyze progress in the high-cost area of future process and design. These partnerships would:

a. **Sponsor more initiatives that encourage collaboration between universities and industry,** especially through student training programs, in order to generate research interest in solutions to impending and current industry problems.
b. **Increase funding for current programs.** Research programs that are already operational, such as the Focus Center Research Program developed by the Semiconductor Research Corporation, could usefully be augmented through substantially increased direct government funding. These centers also represent opportunities for collaborative research with other federal research programs, such as those supported by the National Science Foundation.
c. **Create Incentives for students.** A key role for universities is to ensure the flow of technical innovation and skills that originate with students. In order to address the undersupply of talented workers and graduate students in the industry, more incentive programs should be established. Since professors typically respond to appropriate research incentives, augmented federal support for programs that encourage research in semiconductors would attract professors and graduate students. In addition, specific incentive programs could be established to attract and retain talented graduate students.

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