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RECTYP HBA
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ADDR WASHINGTON DC 20500
SUBJECT ANDY CARD 'S MISCELLANEOUS FILES
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INDCODE 1110
ACTION RM RSZ 920318 C 920318
COMMENTS FOLDERS FOR THE FOLLOWING ARE ATTACHED:
(1) CHASE MANHATTAN BANK INTERNATIONAL
ADVISORY COMMITTEE; (2) GLOBAL CHANGE;
(3) CHRISTOPHER COLUMBUS QUINCENTENARY
COMMITTEE; (4) DOMESTIC ISSUES; (5) ICTC
(INTERNATIONAL CULTURAL & TRADE CENTER;
(6) PUERTO RICO; (7) OFFICE OF WHITE HOUSE
CHAPLAIN; & (8) SUPERCONDUCTING SUPERCOLLIDER
ALSO ATTACHED IS BACKGROUND MATERIAL FROM
JAMES A. BAKER IV TO ANDY CARD & BETWEEN
ANDY CARD & BEATRICE TAGGART.
ENCLOSURES (ONE BOX) FILED IN OVERSIZE
ATTACHMENTS #5215.

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JAMES A. BAKER IV TO ANDY CARD & BETWEEN
ANDY CARD & BEATRICE TAGGART.
ENCLOSURES (ONE BOX) HELD IN ROOM 80.

O. A. # 5215

file

To: Andy Card
From: James A. Baker IV

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Brief Summary of NMTBA Request

1. Extend Voluntary Restraint Arrangement (VRA) an additional three years, with option for two additional years after review. Negotiate, where appropriate, with other potential machine tool suppliers to the United States in order to prevent the undermining of the agreement.

Rationale: National security arguments are still valid with regard to the need to preserve the machine tool base for mobilization and for economic security. Although much progress has been made, the job of rebuilding U.S. machine tool competitiveness is not yet completed. U.S.-owned VRA-affected companies have used the five-year breathing space to invest heavily in new productivity-enhancing capital equipment; in R&D and engineering; and in other efficiency programs. However, industry pre-tax profits are very low (2.2% in 1990), putting a severe strain on company balance sheets. Without an extension of the VRAs, the U.S.-owned industry is highly vulnerable to a new wave of Asian imports and is unlikely to reap the benefits of its 1987-1991 investments. VRAs have also increased U.S. machine tool capacity by encouraging Japanese machine tool companies to locate manufacturing facilities in the U.S.

2. Amend the Anti-Circumvention Point System to provide the option of an additional two points for (a) U.S. design and engineering control of all mechanical portions of the machine tool; and (b) an additional two points for U.S. design and engineering control of the machine tool controller. Twelve points would still be required in order for the machine to qualify.

Rationale: To provide recognition for U.S. intellectual property.

3. Earmark additional funds for the machine tool industry, either directly and/or to NCMS through the Commerce Department's Advanced Technical Program (ATP) and through the Defense Department's MANTECH and DARPA programs.

Rationale: Funding would help develop the technological competitiveness of the machine tool industry and would enhance U.S. national security interests.

4. Continue U.S./Japanese cooperation plan with major emphasis on opening up the Japanese transplant market to U.S. machine tools.

Rationale: The program, which began in 1990, has resulted in many leads and serious discussions with transplants but in very few, if any, actual orders. Termination of VRAs will remove incentive for all Japanese transplants to buy U.S. machine tools.

August 2, 1991

Machine Tools: A Critical Industry for U.S. National Security

On May 20, 1986, President Reagan, recognizing the danger posed to America's national security by dependence upon foreign sources for one of this country's critical industries and concluding that the U.S. could not afford the vulnerability of dependence on the sea lanes for critical supplies of machine tools, announced his decision to seek a voluntary restraint arrangement (VRA) on certain machine tool imports. Characterizing the machine tool industry as a "small, yet vital component of the United States defense base," he directed that reduced levels of imports of six classes of machine tools be negotiated with Japan and certain other countries. VRAs were negotiated with Japan and Taiwan for a period of five years scheduled to expire on December 31, 1991.

The machine tool VRAs have provided opportunities for the industry to begin to rebuild, and it has made considerable investments toward that end without inflationary price increases. Nevertheless the industry remains vulnerable. Without an extension of the VRAs the industry could lose all of the progress that has been made and let foreigners determine the technology they wish to share with America's industrial base.

The Importance of Machine Tools to the U.S. Defense Industrial Base

The United States machine tool industry is relatively small in dollar terms, but it is a vital element within the U.S. defense readiness system. This critical industry designs and builds machines that support U.S. defense requirements through its sustenance of America's manufacturing capability. The nation's ability to compete globally in electronics, optics, aerospace, and other high technology industries and to produce advanced weapons for national defense, depends on the steady availability of quality machine tools.

Last March, the Office of Science and Technology Policy (OSTP) issued a report listing 22 critical technologies deemed essential to satisfy such U.S. needs as defense, economic competitiveness, public health, and energy. Of those critical technologies, eight are dependent on machine tools for continued progress. In fact, some of the systems described in the OSTP Report are simply groups of machine tools working together on the factory floor to manufacture products.

The OSTP report concludes that "failure to maintain world-class manufacturing capabilities would compromise the nation's ability to compete in domestic and international markets, and would threaten our ability to continue economic growth and to obtain access to the full range of components and equipment required for a strong national defense." Our nation cannot maintain its economic position and military dominance if it is dependent on foreign sources for the "tools" of manufacturing in its critical industries.

The Dangers of Foreign Source Dependency

America relies on quality, high-tech machine tools to produce weapons systems and for a strong industrial economy. The real issue is whether these tools will be manufactured at home or purchased from abroad.

There are a number of reasons why it is unacceptable to rely on foreign sources of this critical technology. First, when we allow ourselves to rely on foreign sources for machine tools and related parts and components, we are also allowing outside powers

to heavily influence our industrial competitiveness and military power. The U.S. would receive machine tools at a technology level of foreign companies' choosing. Moreover, deliveries would be at their discretion and on their terms. There is no guarantee that foreign interests will always be willing to provide machine tools of sufficient sophistication in sufficient quantities to satisfy our perceived needs. We cannot allow ourselves to be put in this potentially compromising position.

Second, even assuming that foreign suppliers are always willing to adequately supply U.S. needs, there is no guarantee that they will always be able to do so. We cannot be confident that during a military conflict, when our needs for rapid delivery of high quality machine tools is greatest, we will be able to receive shipments of these goods from across great expanses of unprotected waters.

In the most recent annual Net Assessment of the Joint Chiefs of Staff, it was noted that the defense industrial base is in serious danger of becoming dependent upon foreign sources for strategic components and supplies of materials in its critical industries. If foreign sources were unavailable in a crisis, "accelerated U.S. production of key weapons systems (such as the M1 tank and the F/A-18 jet) could continue only two months. It would take 6 to 14 months before U.S. sources could supply industries with the critical components and materials for continued production." Thus, it is vital for the United States machine tool industry to survive.

Third, development of sophisticated new weaponry can only occur if manufacturing technology keeps pace with developments in electronics, optics, nuclear technology and other areas. If the U.S. allows its indigenous machine tool industry to decline, America will be unable to develop sophisticated weapons systems without extensive foreign participation. This is of particular concern with respect to the development and manufacture of SDI technology, so-called "black programs," and nuclear weapons and delivery systems. For example, certain countries such as Japan will not allow their companies to work on nuclear weapons projects, and it is questionable whether the U.S. would be wise to share its most advanced weapons technology secrets with foreign companies in any case.

Extending the Existing Machine Tools VRAs is an Important Step in Protecting this Critical Component of Our Defense Industrial Base

The renewal of the machine tool VRAs will help ensure that the domestic manufacturers of these products remain viable contributors to our nation's defense sector. A renewal will help assure a flow of technology into U.S. defense programs with minimal added cost to the government--a major savings at a time of fiscal restraint and deep cuts in the defense budget.

The U.S. Must Maintain a Healthy Indigenous Machine Tool Industry

In short, the machine tools VRAs are very different from similar arrangements in industries such as automobiles, steel, and textiles. A machine tool VRA protects not only American jobs, but our nation's defense capacity as well. The existing VRAs were adopted based upon a presidential finding that the VRAs were sound national defense policy. This is no less true today.

RESPONSE OF THE MACHINE TOOL INDUSTRY TO THE VRAS

On May 20, 1986, President Reagan, recognizing the danger posed to America's national security by dependence upon foreign sources for one of the America's critical industries and responding to requests from over 250 members of Congress, announced his decision to seek voluntary restraint agreements (VRAs) on certain machine tool imports as part of his machine tool domestic action plan. VRAs were negotiated in 1987 with Japan and Taiwan and expire at the end of 1991.

Machine tool industry data indicates unequivocally that the companies affected by the VRAs have responded just as President Reagan and Congress intended. The manufacturers have made substantial investments in new, productivity-enhancing capital equipment; they have developed new products and new technology, committing heavily to R&D and engineering; and they have implemented significant efficiency in their own plants. They have done all this without raising prices beyond the rate of inflation and without substantial profits.

During 1987 through 1989, the U.S. machine tool industry averaged productivity gains of 11.3% per year -- among the highest productivity growth of any industrial sector. These gains are partly the result of increased investment by firms affected by the VRAs. A recent survey conducted by NMTBA of U.S.-based VRA-affected companies showed that respondents' capital investment to depreciation ratios more than doubled over the five-year period since the VRAs become effective, and their annual investment increased by 78%.

VRA-affected companies have also developed new products and technologies, committing heavily to R&D and engineering. NMTBA's survey indicated that respondents spent \$637.7 million on R&D/engineering over the five-year period. R&D/engineering increased 23% from 1987 to 1990. Eighty-eight percent of the respondents introduced new product lines, and 92% improved an existing product line. R&D/engineering spending as a percentage of sales increased by almost 40%.

In addition, VRA firms have implemented significant efficiency improvements in their own plants. And they have worked mightily to open new markets -- particularly in Japanese transplants located in the United States. Today, 30% of all U.S. machine tool production is exported.

These investments of time and capital were made without significant machine tool price increases. In fact, prices barely kept pace with the rate of inflation.

CATEGORY	PRICE CHANGE OVER PREVIOUS YEAR				
	1986	1987	1988	1989	1990
GNP Deflator	2.7	3.3	3.4	4.1	4.6
<u>VRA-Affected Machine Tools</u>					
Lathes	-0.1	0.6	3.0	6.7	6.6
Milling Machines	2.2	2.5	NA	2.6	6.0
Multi-function, NC *	-0.3	0.9	6.3	5.9	3.2
Punching, Bending, etc.	1.2	1.0	1.0	1.8	1.9

NA - Not Available. * - Includes machining centers.

Profits in the industry also rose only slightly during this time period. The U.S. machine tool industry's 1990 net income before taxes was 3% of sales, compared to pre-tax income of 5.7% of sales for all U.S. manufacturers during the same period. Pre-tax income for VRA-affected firms was even lower -- a mere 2.2% of sales.

Median Income Before Taxes
U.S. Machine Tool Industry

	<u>All Firms</u>	<u>VRA-Affected</u>	<u>Non-VRA-Affected</u>
1986	0.3%	0.1%	0.8%
1987	1.6%	0.0%	2.6%
1989	2.6%	0.6%	4.1%
1990	3.0%	2.2%	4.1%

Since the inception of the VRAs, affected companies have invested far more than traditional caution would dictate. In other words, they "bet the farm". They have committed themselves over the past five years to the restoration of manufacturing competitiveness to the detriment of their balance sheets, exposing them to a new wave of Asian imports, if the VRAs are not extended beyond their 1991 expiration date. They will, also, never have the chance to reap the benefits of their investments nor will they be able to continue to invest at current levels, both essential elements for future progress.

The United States will be left lagging behind our foreign competitors, and even worse, our national security will be jeopardized as the manufacturing technology available to our defense base is left increasingly at the discretion of foreign suppliers.

THE MACHINE TOOL VRAS SHOULD BE EXTENDED BEYOND 1991

The U.S. machine tool industry is small in terms of dollar volume, but it is one of America's most vital elements of defense readiness. The industry builds the machines that support and sustain U.S. defense requirements in peacetime and in times of conflict. Its companies constitute the belt that holds up the pants of America's defense industrial base. During the past several years, however, the U.S. machine tool industry has seen a substantial reduction in its customer base. Many machine tool consuming industries have moved manufacturing capacity offshore, equipping their foreign facilities with foreign-made tools. Many of the manufacturing firms that have retained U.S. production facilities have also purchased foreign machine tools. These factors, combined with a host of others (including the high cost of capital in the U.S., inconsistent U.S. tax policy, and a costly and cumbersome product liability system), led to the industry-wide depression in the early 1980's -- the worst industry downturn since the Great Depression of the early 1930's.

On May 20, 1986, President Reagan recognized the danger presented to our national security by dependence upon foreign sources for machine tools by announcing his decision to seek Voluntary Restraint Agreements (VRAs) on certain machine tool imports as part of his machine tool domestic action plan. Characterizing America's machine tool industry as a "small, yet vital component of the U.S. defense base," President Reagan directed that reduced levels of imports of six classes of machine tools be negotiated with Japan and Taiwan.

The VRAs began on January 1, 1987 and are due to expire on December 31, 1991. They do not bar imports. They simply assure that U.S. producers will have a share of the domestic market in the near term (which could range from 35 percent to 75 percent of U.S. consumption, depending upon the category of machine and the level of imports from other countries). The VRAs are enforced by the Commerce and Treasury departments, pursuant to authority provided in the 1988 Omnibus Trade Act.

VRA-affected firms have made full use of the temporary opening provided by the VRAs to invest in new machinery and equipment in an effort to improve their competitiveness. A recent NMTBA survey of 24 U.S.-owned, VRA-affected firms (whose 1990 gross sales were \$2.17 billion) reveals that from 1987 to 1991 they invested a total of \$350.7 million from 1987 to 1991, more than doubled their capital investment to depreciation ratios, and increased their annual investments by 78 percent.

At the same time, 88 percent of these firms report that they introduced new product lines and 92 percent improved an existing product line over the last five years. Five companies in six have a new product or technology in design or development at this very moment. U.S. machine tool manufacturers are also investing in methods of improving their efficiency in manufacturing their products. NMTBA's survey indicated that three-fourths of the respondents have formally implemented efficiency measures in the last five years. These measures include quality improvements, Crosby Programs, Statistical Process Control, Manufacturing Resource

Planning, better training, metric engineering, just-in-time delivery, cellular manufacturing, finite element analysis, CAD/CAM, and continuous flow production in the last five years.

Still, another result of the VRAs was the initiation of the Machine Tool Cooperation Program by the Commerce Department and the Japanese Ministry of International Trade and Industry (MITI) last September. This program was launched to help open the doors of Japanese transplant companies to U.S. machine tool builders and to break down the barriers to business opportunities in Japan. Though numerous contacts have resulted from this program, transplants have placed very few orders.

In short, VRA-affected companies have done exactly what the U.S. government intended them to do. They have made substantial investments in new, productivity-enhancing capital equipment. They have developed new products and new technology, committing heavily to R&D and to engineering. They have implemented significant efficiency improvements in their own plants. And they have worked mightily to open new markets. (Today, 30 percent of all U.S. machine tool production is exported.) They have done all this without making any money and without raising prices beyond the rate of inflation. Pre-tax profits for VRA-affected companies in 1990 were only 2.2 percent. In other words, they "bet the farm" -- they invested far more than traditional caution would dictate.

There has been a price for this investment. Almost three-fourths of the 24 VRA-affected companies in NMTBA's survey reported that their balance sheets are about the same or worse than they were in 1986 when the VRAs began. If the VRAs are allowed to expire, these firms will never have the chance to reap the benefits of their investments nor will they be able to continue to invest at current levels, both essential elements for future progress.

We must not be overly optimistic that the U.S. machine tool industry has regained full strength in such a short period of time. Imports still account for about 50 percent of the value of all machine tools consumed in the United States, the same level they were in 1986 when the President sought to negotiate the VRAs. Import levels are even higher in some individual machine tool categories. These figures indicate that lasting stability and full strength of the industry have not been achieved in just five years. United States machine tool manufacturers have managed only to pull themselves up to the bottom rungs of the ladder. They still have a long way to go. If imports are allowed to increase much beyond their current level, it won't be long before America's industrial base is at the mercy of the level of technology that foreigners choose to sell us. This would be intolerable for any great nation. The threat to military and economic security is real and substantial.

Machine tool firms producing items affected by the VRAs need additional time to achieve the strength which is necessary to ensure America's national security. Extension of the VRAs beyond their December 1991 expiration date is an important step in that direction.

"FIGHTING MACHINES"

The U.S. machine tool industry, though small, played a vital role in the success of the U.S. military in operation Desert Storm. You never saw a machine tool on the evening news. But the equipment you did see was made possible by sophisticated U.S. machine tool technology.

In 1986, Voluntary Restraint Agreements (VRAs) were negotiated with Japan and Taiwan on imports of certain machine tools that are critical to national security. The VRAs expire in December. Their effect has been marked. Since 1987, U.S. companies producing lathes, machining centers, milling machines, and punching machines have made productivity gains averaging 11.3% per year; have doubled their plant and equipment investment/depreciation ratios; have increased R&D/engineering spending by 23%; and eighty-eight percent have introduced new products. The breathing space provided by the machine tool VRAs enabled the companies you see listed below to remain in the business of designing and manufacturing the high-tech machines that provided the sophisticated weapons that won the Gulf War.

But the job of rebuilding U.S. machine tool competitiveness is not complete. The stark question before U.S. policy makers in the Fall of 1991 is whether the companies who helped provide America's victory in the Gulf War will be around to provide the weapons America needs to win the next conflict -- whenever or wherever it occurs.

Here's a sampling of the sophisticated U.S. weapons systems provided by U.S. machine tools:

MISSILES

Boston Digital Corp.	Textron/cruise missile components
Cincinnati Gilbert	Indian Head Naval facility/boring mill producing solid fuel missile propellants
Cincinnati Milacron	LTV/"6 Pack" Bulkheads for multiple launch rocket system
	Williams International/small engines for cruise missiles
	United Technologies/special 6-axis profiler to make complex aluminum center section of Tomahawk cruise missile
Cross & Trecker	Raytheon/special cells to produce Patriot missile parts
Giddings & Lewis	McDonnell Douglas/5-axis machining center and vertical turning machines for complex machining of center section of Harpoon missile; and special machine to provide missile skins
	Raytheon/machining center for Patriot & Hawk components
Hardinge Bros. Inc.	Raytheon/high precision turning machines to make electronics and guidance system for Patriot missile
Masco Machine Inc.	4-axis CNC turret machining center to make guidance system housing for Tomahawk cruise missile
	Special large, heavy duty CNC machining centers for Hercules to produce Delta, Titan and other boosters for launching satellites
Producto Machine Co.	Teledyne, Williams International/cruise missile engine parts
Saginaw Machine Sys.	General Dynamics/cruise missile parts

NAVAL COMPONENTS

Cross & Trecker	Long Beach Naval Shipyard/nuclear weapon components
Giddings & Lewis	Puget Sound Naval Yard/unique vertical turning and grinding cell for ship repair facility
	General Dynamics/submarine components
Onsrud Machine Corp.	Philadelphia Navy Yard/unique, custom made very large 5-axis milling machines to make "quiet" nuclear submarine and combat ship propellers
Strippit, Inc.	Bath Ironworks/punch press used to build and overhaul naval frigates and cruisers

HELICOPTERS

Boston Digital	Garrett-Hamilton Standard/auxiliary power units
Cincinnati Milacron	McDonnell Douglas/AH-64A Apache components
	Sikorsky/special profile milling machines to make helicopter hubs and blades
Cross & Trecker	Parker Hannifin & Bell Helicopter/servo systems
Giddings & Lewis	Sikorsky/very accurate machining centers to make transmissions
Hardinge Bros. Inc.	Bell & its subcontractors/high precision turning machines to make electronics and guidance systems

AIRCRAFT

Cincinnati Gilbert	McDonnell Douglas/large NC machines to make housings for FA-18 and panels, structures and ribs for KC10 Tanker
Cincinnati Milacron	Lockheed/tape laying equipment for F-117A McDonnell Douglas/4- & 5-axis milling machines for F-15 Fairchild Republic/milling machines for A-10 "Wart Hog" LTV/special flexible manufacturing cells and systems to make major sections of B-1
	Textron Aerospace/large special machines to make and rebuild C-141 & C-5 wings
	Boeing/four manufacturing cells to produce high tensile steel & titanium mechanism used in wing folding of A-6 Intruder - plus tape layers for rewinging the aircraft
Cross & Trecker	Northrup/B-2 bomber parts Lockheed/F-117A Stealth fighter parts Martin-Marietta/B-1 bomber parts
Giddings & Lewis	McDonnell Douglas/machining centers for F-18, F-15 Hill AFB/machining centers for repair of landing gears Cleveland Pneumatic/machining centers to make landing gears
Masco Machine Inc.	United Aircraft/5-axis CNC turret machining center to make heat exchangers for hydraulic systems
Strippit, Inc.	Wright-Patterson AFB/CNC turret punch press with laser head attachment used in the production of the Stealth bomber, design aircraft components, and pilot training equipment

JET ENGINE COMPONENTS

Boston Digital Corp.	GE, Pratt & Whitney/large jet engine parts
Cincinnati Gilbert	GE/large jet engine parts
Cincinnati Milacron	GE, Pratt & Whitney/large engine components
Cross & Trecker	Machines to make engine components for Teledyne-Continental-Allison Gas Turbine-Chemtronics-Pratt & Whitney
Giddings & Lewis Co.	Pratt & Whitney-Chemtronics-General Electric/machining centers & vertical turning machines for making jet engine components
Hardinge Bros. Inc.	High precision turning machines supplied to various subcontractors to make small engine components, electronics, & guidance systems
Producto Machine Co.	GE, Pratt & Whitney/rotation parts for large jet engines

NIGHT VISION GLASSES

Cross & Trecker	Daro/night vision glasses for personnel
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M1A1 ABRAMS TANK & BRADLEY FIGHTING VEHICLES

Cincinnati Milacron	FMC & Red River Arsenal/special machines to make the hulls for the Bradley General Dynamics/tank hull machining
Cross & Trecker	Textron/Lycoming/modu-line systems to make tank engines General Dynamics/special machines to make undercarriage & support parts for tank
Giddings & Lewis	General Dynamics/special machining centers for tank armament components
Masco Machine Inc.	Cummins Engine & Caterpillar/tank engines Watervliet Arsenal/turret spline
Strippit, Inc.	FMC/heavy duty CNC turret punch press used for building Bradley fighting vehicles and armored personnel carriers

AMMUNITION and LARGE GUNS

Cincinnati Gilbert	Rock Island Arsenal/artillery gun barrels
Cincinnati Milacron	Watervliet Arsenal/gun barrels
Cross & Trecker	Olin-Flinchbaugh/armor piercing ammunition
Giddings & Lewis	Rock Island Arsenal/armament parts Watervliet Arsenal/unique FMS cell for machining breech blocks & other artillery components
Hardinge Bros. Inc.	Rocky Flats/high precision turning machines to make nuclear devices
Masco Machine Inc.	Special machines for producing fuse bodies and land mines
Producto Machine Co.	Rocky Flats/special machine to provide plutonium samples
Saginaw Machine Sys.	Scranton Army ammunition plant/CNC vertical turning machine to produce 155mm ammunition

THE U.S. MACHINE TOOL INDUSTRY

THE CORE INDUSTRY OF AMERICA'S TECHNOLOGICAL BASE

The machine tool industry is a vital element of our defense readiness system. This critical industry designs and builds the machines that support and sustain the entire domestic manufacturing capability, and it therefore represents the foundation of the nation's defense system.

Although the technologies required to design, build and apply a machine tool are widely divergent, the most fundamental characteristic of any machine tool is its structure. A properly designed structure requires a knowledge of material properties, dynamics and thermally-induced distortions. The addition of devices to the basic structure requires a knowledge of metrology, friction and lubrication, and mechanical linkages. An intimate knowledge of the process to be performed by the machine is required in order to ensure that deflections, alignments and slide velocities are all appropriate. As basic manufacturing processes demand greater speeds, accuracies and capabilities from machine tools, structural integrity and specifications become increasingly important.

Once basic structural integrity and design are developed, the element of control is added. Advances in computer control have allowed designers to introduce configurations and features that are not possible without such control and associated software. Nevertheless, the final product remains primarily dependent on how well the mechanical elements have been conceived and implemented. Machine structure remains the limiting factor on machine performance.

Occasionally, the critical correlation between structural design and the functional efficiency of machine tools is underestimated. This misperception serves as a basis for the notion that a machine is only a medium for a message provided by computer controls. Similar logic would support the proposition that a vibrant aerospace industry depends entirely on technological progress in avionics, without regard whatsoever to airframe manufacturing processes. Were the shortcomings of such a rationale not so threatening in terms of national security, they would be amusing.

The U.S. machine tool industry, though small, played a vital role in the success of the U.S. military in Operation Desert Storm. Machine tools were never featured on the evening news, however, the equipment that was so displayed was made possible by sophisticated machine tool technology. In order to assure that the machine tool companies that helped bring about America's victory in the Gulf war remain capable of providing the weapons necessary to win future conflicts, domestic machine tool manufacturing capability must be preserved.

Clearly, the key to U.S. military and economic power rests on a healthy domestic machine tool industry. Machine tools are not simply hardware products of a smokestack industry, but rather very sophisticated technological equipment that constitutes the most basic element of America's defense needs. It is imperative that affirmative steps be taken to preserve and strengthen this critical industry. Extending existing Voluntary Restraint Agreements with Japan and Taiwan beyond 1991 is an important step toward that goal.

COMMENTARY

INSIDE VIEW

Protect Machine Tool Base Industry Is Vital Cog in U.S. National Security Network

By STEPHEN BRYEN
And PAUL FREEDENBERG

During our tenures in the Reagan administration overseeing technology transfer and the defense industrial base, disputes frequently erupted over proper policy. But there is one issue on which we have both always agreed: It is of great importance that the current Voluntary Restraint Arrangement (VRA) respecting machine tools be renewed when it expires at the end of this year.

A strong industrial base is vital to national security, particularly at a time when defense projects are being cut back substantially. A modern industrial base must include a vigorous semiconductor industry, the ability to fabricate sophisticated computers and top-quality machine tools to build advanced weapon systems and platforms. While semiconductors and computers have received high-level attention recently, machine tools have not.

America's small-machine tool industry has been in trouble for a number of years. In 1986, President Reagan convinced Taiwan and Japan to enter into a VRA to limit imports of cheap machines after he concluded that safeguarding the U.S. machine tool industrial base was necessary for national security.

Now, the VRA is about to expire, again giving rise to the specter of unlimited imports destroying the domestic industry. More than 100 members of Congress have expressed their concern in writing, but some administration officials appear not to appreciate the national security significance of machine tools.

Advanced weapon systems and platforms fabricated with sophisticated ma-

chine tools are the technological edge that helps assure international stability. In cases of conflict, advanced weapons can limit the duration and reduce U.S. and allied casualties. The minimal casualties of the Gulf War attest to this fact.

Production of advanced weapons requires a close working relationship between machine tool builders and weapon manufacturers. Development of projects involving nuclear submarines, intercontinental ballistic missiles, stealth fighter aircraft, rail guns, components for the Strategic Defense Initiative, B-1 and B-2 bombers, and advanced armor manufacturing all require maximum security and confidentiality. Defense manufacturers need to be able to work with subcontractors in a manner to accommodate the industrial security requirements of the Defense Department.

U.S. machine tool companies are best equipped to assure the integrity of the security safeguards associated with sensitive national security projects. If the U.S. defense industry has to turn to foreign producers for machine tools and for machining support, sensitive programs may be subject to compromise. Information of competitive value would pass to foreign weapon manufacturers. In turn this could enable them to take advantage of U.S. research and development dollars, allow them to sell weapon technology of U.S. origin to Third World countries whose interests may be inimical to those of the United States, and to compete with American companies for foreign military sales.

The close relationship between machine tool builders and advanced defense projects often involves customizing machines to carry out complex tasks, tailoring machine tool controller software for specific purposes (such as manufacturing silent propellers for submarines), and building special purpose machining centers to support critical production requirements.

Additionally, one of the weakest aspects of the U.S. machine tool industrial base is depth of skilled manpower. Further erosion of this vital asset can only be

avoided by the preservation of a healthy machine tool industry.

At stake is no less than the national mobilization capability. The U.S. inventory of weapons has been reduced because of the attrition in the Gulf War and defense spending cutbacks mandated by Congress. Should tension levels increase, however, ability to surge production of spare parts would be necessary to any mobilization. Defense manufacturers and their subcontractors will have to be reprogrammed for this purpose. This would require U.S. machine tool companies and their experts to work on an urgent basis with critical defense production companies to develop the machines and the quality assurance programs needed to make military equipment and components. Of course, if the U.S. machine tool companies are forced out of business, surge production cannot be assured.

Another significant aspect of mobilization is the need to rapidly modify equipment because of changes in the war-fighting environment. A typical example may be the need to modify a missile to make it compatible with a different platform. Often this involves physical changes to the missile or production of special launch rails.

Machine tool manufacturers assist in producing a vast array of specialized, sophisticated components for advanced weapon systems. Among these are special bulkheads required for cruise missiles, gimbals for the Patriot, propellers for nuclear submarines, precision inertial gyro assemblies for intercontinental ballistic missiles, wing spars and tape-laying machines needed to produce the F-117A, stealth and B-1 bombers. Also included are penetrators for tank ammunition machined from depleted uranium and tungsten carbide, and machining centers for ammunition manufacturing and for enlarged production runs of smart weapons.

The most effective way to assure the viability of the U.S. machine tool industry is to extend the VRA. In 1986, responding to severe pressure on the domestic machine tool industry and the threatened erosion of the U.S. defense mobilization base, President Reagan proposed the negotiation of the VRAs with Japan and Taiwan, the two major offshore producers of machine tools.

The president reasoned that low-cost machines exported to the U.S. market were causing severe economic harm to domestic machine tool companies that depended on commodity-type machine tool sales to sustain their business base.

This business allowed them to pursue longer-cycle sales of the type of machines most often needed for specialized defense manufacturing.

The 1986 VRA arrested the invasion of foreign-built machines and enabled U.S. machine tool companies to begin to recover. The U.S. machine tool industry responded by substantially increasing investment in modern facilities and research and development.

These gains are good news for U.S. national security because they presage recovery that will enable the defense mobilization base and defense industry to be strengthened if the VRA system can be maintained for some time. The revitalization of the U.S. machine tool industrial base is likely to take about 10 years. This is reasonable, taking into account both economic ups and downs (we have been in a down for too long) and the time it takes to introduce a wholly new generation of competitive machine tools. Renewal of the VRA for another five years will fulfill the mission started by President Reagan.

VRA renewal is not a routine trade issue any more than semiconductors and computers, which were not handled routinely. In fact, the U.S. machine tool industry, even in its heyday, was too small a part of the U.S. economy to matter for our international trade balance or as a major source of national income. The machine tool industry, instead, represents a special niche industry significant to American national defense and national security. In this sense, the VRA is much more than a Voluntary Restraint Arrangement put in place for commercial reasons. The VRA could better be called an NSVRA, for National Security Voluntary Restraint Arrangement.

The NSVRA protects and enhances U.S. national security competitiveness in a unique way and, by so doing, helps to maintain order and stability worldwide. Thus, in turn, improves the security of all Americans and even assists America's economic competitors. With unprecedented international changes now going on, we cannot predict our future international obligations or what threat may be made against our security.

Just as U.S. land-, air- and sea-based missiles form our nuclear-defense triad, computers, semiconductors and machine tools are the basis of our defense-industrial triad. President Bush would not hesitate to preserve our nuclear-defense triad. He should do no less for our defense-industrial triad, and renew the National Security Voluntary Restraint Arrangement.

Communities Must Lose Financial Dependence on Military Bases

SE From Page 31

of the military scheduled to cut by 20 percent by 1995, more base closings are certain.

The communities that avoided the Pentagon's 1991 list face a serious dilemma. Should their community leaders act now to diversify their economies or should they take a wait-and-see

the wait-and-see strategy. Some communities, for example, might take the attitude that "if it ain't broke, don't fix it." For them, denial will end only when the name of their town actually appears in black and white on a future close list.

But, having wasted crucial months of planning time, these leaders will then be forced to turn

economy both in the Soviet Union and here in America takes time — a commodity that must not be wasted.

Another version of this strategy rests on the belief that the odds are on the side of the communities; that to do nothing is the more rational course of action. According to the Pentagon, there were 880 military installations in 1980.

Subtracting from that number the 34 bases recently named for closure and the 86 bases previously declared excess in 1988 but not yet closed, leaves a field of well over 700 candidates from which the 1993 and 1995 closure lists will be selected.

In gambling terms these may be very good odds, but do they

community leaders ought to begin now to adjust their region's economy to the realities of the post-Cold War world.

As Soviet citizens and leaders recently demonstrated, taking responsibility for unmaking economic change is preferable to passively sitting by at the mercy of others. For Soviet and Ameri-

August 29, 1991

**The Machine Tool National Security Voluntary Restraint Arrangement:
A Vital Element in Our National Security**

by Paul Freedenberg, Ph.D., and Stephen Bryen, Ph.D.¹

During our tenures in the Reagan Administration overseeing technology transfer and the defense industrial base, we did not always agree on the proper policy. At times the arguments were quite heated. But there is one issue on which we have both always agreed: it is of great importance that the current Voluntary Restraint Arrangement ("VRA") respecting machine tools be renewed when it expires at the end of this year.

A strong industrial base is vital to national security, particularly at a time when defense projects are being cut back substantially. A modern industrial base must include a vigorous semiconductor industry, the ability to fabricate sophisticated computers, and top quality machine tools to build advanced weapons systems and platforms. While semiconductors and computers have received high level attention recently, machine tools have not.

America's small machine tool industry has been in trouble for a number of years. In 1986, President Reagan convinced Taiwan and Japan to enter into a VRA to limit imports of cheap machines after the President concluded that safeguarding the U.S. machine tool industrial base was a requisite element of national security. Now, the VRA is about

¹*Paul Freedenberg, the former Assistant Secretary for Trade Administration and Under Secretary of Commerce for Export Administration (1985-89), is an international trade consultant with the law firm of Baker & Botts. Stephen Bryen served as Deputy Under Secretary of Defense for Trade Security Policy and as Director of the Defense Technology Security Administration from 1981 to 1988, and is President of DeltaTECH.*

to expire, again giving rise to the specter of unlimited imports destroying the domestic industry. Over one hundred Members of Congress have expressed their concern in writing, but some administration officials appear not to appreciate the national security significance of machine tools.

Advanced weapons systems and platforms fabricated with sophisticated machine tools are the technological edge that helps assure international stability. In cases of conflict, advanced weapons can limit the duration and reduce American and allied casualties. The minimal casualties of the Gulf War attest to this fact.

Production of advanced weapons requires a very close working relationship between machine tool builders and weapons manufacturers. Development of projects involving nuclear submarines, intercontinental ballistic missiles, STEALTH fighter aircraft, rail guns, components for the Strategic Defense Initiative, B-1 and B-2 bombers, and advanced armor manufacturing all require maximum security and confidentiality. Defense manufacturers need to be able to work with subcontractors in a manner that will conform to the industrial security requirements of the Defense Department.

U.S. machine tool companies are best equipped to assure the integrity of the security safeguards associated with sensitive national security projects. If our defense industry has to turn to foreign producers for machine tools and for machining support, sensitive programs may be subject to compromise. Information of competitive value would pass to foreign weapons manufacturers. In turn this could enable them to (1) take advantage of U.S. research and development dollars for their own purposes; (2) allow them

to sell weapons technology of U.S. origin to third world countries, the interests of which may be inimical to those of the U.S.; and (3) compete with American companies for foreign military sales.

The close relationship between machine tool builders and advanced defense projects often involves customizing machines so they can carry out complex tasks, optimizing machine tool controller software for specific purposes (as in manufacturing silent propellers for submarines), and building special purpose machining centers in support of critical production requirements. If more of the U.S. machining capability goes offshore, access to know-how of this kind will be either lost or in short supply. Additionally, one of the weakest aspects of the U.S. machine tool industrial base is depth of skilled manpower. Further erosion of this vital asset can only be avoided by the preservation of a healthy machine tool industry.

At stake is no less than the national mobilization capability. The U.S. inventory of weapons has been reduced because of the attrition experienced in the Gulf War and the cutbacks in defense spending mandated by the Congress. Should tension levels increase, however, ability to surge production of spare parts would be necessary to any mobilization. Defense manufacturers and their subcontractors will have to be reprogrammed for this purpose. This would require U.S. machine tool companies and their experts to work on an urgent basis with critical defense production companies to develop the machines and the quality assurance programs needed for making military equipment and components. Of course, if the U.S. machine tool companies are forced out of business, surge production cannot be assured.

Another significant aspect of mobilization is the need to rapidly modify equipment because of changes in the war fighting environment. A typical example may be the need to modify a missile to make it compatible with a different platform. Often this involves physical changes to the missile or production of special launch rails to facilitate the conversion. Again, special machine tools and know-how are needed on an urgent basis. Help of this kind must come directly from U.S. machine tool companies.

Machine tool manufacturers assist in producing a vast array of specialized, sophisticated components for advanced weapons systems. Among these are special bulkheads required for cruise missiles, gimbals for the Patriot, propellers for nuclear submarines, precision inertial gyro assemblies for ICBM's, wing spars and tape laying machines needed to produce the F-117A, Stealth and B-1 bombers, penetrators for tank ammunition machined from depleted uranium and tungsten carbide, and machining centers for ammunition manufacturing and for enlarged production runs of smart weapons.

The most effective way to assure the viability of the U.S. machine tool industry is to extend the VRA. In 1986, responding to severe pressure on the domestic machine tool industry and the threatened erosion of the U.S. defense mobilization base, President Reagan proposed the negotiation of the VRA's with Japan and Taiwan, the two major offshore producers of machine tools. The essence of the President's reasoning was that imports of low cost machines exported to the U.S. market was causing severe economic harm to domestic machine tool companies that depended on commodity-type machine tool sales to sustain their business base and allowed them to pursue longer-cycle sales of high end machines -- the types most often needed for specialized defense manufacturing.

The 1986 VRA arrested the invasion of foreign built machines and enabled U.S. machine tool companies to begin to recover. The U.S. machine tool industry responded by substantially increasing investment in modern facilities and in R&D and new technology.

These gains are good news for U.S. national security because they presage recovery that will enable the defense mobilization base and defense industry to be strengthened, provided the VRA system can be maintained for some time to come. The revitalization of the U.S. machine tool industrial base is likely to take about ten years. This is reasonable, taking into account both economic ups-and-downs (we have been in a "down" for too long) and the time it takes to introduce a wholly new generation of competitive machine tools and allow them to enter the marketplace. From the time the VRA was implemented (1987) until now is half the cycle time necessary to get the job done. Renewal of the VRA for another five years will fulfill the mission started by President Reagan.

VRA renewal, in this framework, should be given consideration because of its significance to national security. It is not a routine trade issue any more than semiconductors and computers -- which were not handled "routinely." In fact, the U.S. machine tool industry, even in its heyday, was too small a part of the U.S. economy to matter for our international trade balance or as a major source of national income. The machine tool industry, instead, represents a special niche industry significant to American national defense and national security. In this sense, the VRA is much more than a Voluntary Restraint Arrangement put in place for commercial reasons. The VRA could better be called an "NSVRA," for National Security Voluntary Restraint Arrangement.

Uniquely, the NSVRA protects and enhances our national security competitiveness and, by so doing, helps to maintain order and stability world-wide. This, in turn, improves the security of all Americans and even assists America's economic competitors! With unprecedented international changes now going on, we cannot predict our future international obligations, or what threat may be made against our security. For this reason we cannot put any segment of our industrial base at risk. Just as our land, air and sea based missiles form our nuclear-defense triad, computers, semiconductors, and machine tools are the basis of our defense-industrial triad. President Bush would not hesitate to preserve our nuclear-defense triad. He should do no less for our defense-industrial triad. The President should, therefore, renew the National Security Voluntary Restraint Arrangement.

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**Testimony of Paul Freedenberg, Ph.D.
International Trade Consultant
Baker & Botts**

**Before the
Committee on Ways & Means
U.S. House of Representatives**

September 12, 1991

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Mr. Chairman, Members of the Committee, I want to thank you for the opportunity to appear before this Committee. Your investigation into the American competitiveness highlights on one of the most critical policy issues facing the country: How do we maintain and enhance America's ability to compete in the international marketplace?

During the Reagan Administration, I had responsibility for overseeing the defense industrial base, both as the Commerce Department's Assistant Secretary for Trade Administration and as Under Secretary for Export Administration. That experience impressed upon me one rather simple point: America's national security depends on our nation's ability to compete economically. That ability depends, in turn, on the future vitality of our nation's core manufacturing industries.

A bit of background will provide some perspective on my testimony. In both of my positions at the Commerce Department I also had responsibility for regulating exports of dual-use products and technologies. Dual-use technologies are defined as those exports which, while essentially commercial in application, can add significantly to a country's military capabilities as well.

A major portion of the export control mission is determining which commercial products and technologies are of military significance. Some products and technologies are easily identifiable as having direct military applications. Other products,

such as computers, semiconductors, and machine tools are significant because they are essential to the design (or enhancement) and production of military equipment. Thus, for the past 42 years, the United States, in coordination, with its major Western allies, has consistently prohibited the sale of sophisticated dual-use products and technology to the Soviet Union and other potentially hostile countries.

Of course, what is true for our enemies is true for us as well. If we do not have access to the most sophisticated civilian technology, we will not be able to produce the technically superior defense systems.

America's national security is in a very real sense dependent upon the nation's ability to compete in the global marketplace. Certainly, throughout the Cold War we relied on our technical superiority to counterbalance Soviet and Warsaw Pact numerical advantages. However, international events and domestic budget restraints are changing both the nature of the threat to national security and the manner in which we address that threat. As first the Warsaw Pact and now the Soviet Union have dissolved, a significantly smaller military force will be required to achieve our national security goals.

A multipolar world is displacing the bipolar world of the recent past. New, more localized threats have and will continue to emerge. Regional conflicts will no longer consist of contests-by-proxy between U.S. and Soviet-backed client states. Rather, like Saddam Hussein's thrust for power in the Middle East, regional conflicts will more frequently reflect nationalistic goals and the desire for dominance by particular regional powers.

Moreover, as the Soviet nuclear threat recedes, the American nuclear umbrella becomes a less significant source of American leverage in international relations. Freed from the overriding concern with defense against Soviet attack, our allies will define

their national security more broadly. They will perceive that they need the U.S. less and may decide that other relationships are more relevant to their national interests.

In this context, the American military certainly will be smaller. As a result, it will have to be more flexible and more immediately responsive. Flexibility and responsiveness, in turn, will require the ability to mobilize quickly to respond to any threat. That ability will, in turn, be dependent on the flexibility and responsiveness of our industrial infrastructure.

The Bush Administration has recognized the necessity to revamp the military. President Bush stated last year that America's military will be restructured significantly over the next five years to reflect the new global realities. As envisioned by the President, military strategy would address our short-term security needs by retaining force sufficient to maintain a presence in key areas and respond as needed in regional conflicts.¹ In essence, the nation would retain the capacity to "reconstitute" armed forces back up to current levels, or beyond, if national security is threatened.

The linchpin of this strategy is the ability to rebuild our forces should the need arise. As a recent draft report of the Industrial College of the Armed Forces states, America's military strength

will increasingly be a function of the [country's] latent capabilities (industrial, technical, scientific, and manpower potential), . . . the speed and effectiveness with which these latent capabilities

¹The new strategy was designated as "reconstitution" by the President in an August 1990 speech in Aspen, Colorado.

can be converted to immediate use, and the willingness to activate such capabilities.²

In other words, military security will depend, perhaps decisively, on the ability to mobilize our civilian industrial base for military purposes.

This explicitly military reliance on the civilian sector requires that the U.S. develop specific policies aimed at the strengthening and preservation of the industrial base. But, as Western economies have become increasingly globalized, our nation has lost its autonomy and its dominance in the industrial sector. This has made for highly efficient multinational companies, but as more and more suppliers to the defense industry move offshore, the U.S. has become increasingly dependent on foreign sources.

The U.S. Government has three basic policy alternatives:³

1. We could require that all defense equipment be built in the U.S. from U.S.-sourced components, and take whatever steps are necessary to ensure the continued viability of all necessary industries in the U.S.;
2. Alternatively, we could rely entirely on the market to determine which U.S. industries will survive and source defense needs based solely on economic factors;
3. Finally, we could identify those industries that are critical to U.S. defense and security, and take measures to ensure their survival, leaving the location of remaining industries to market forces.

I would argue that the third option is the only viable policy. Requiring solely U.S.-sourcing of products would require massive intervention by the government in a host

²National Security Emergency Preparedness Mobilization Policy Review, quoted in Government Accounting Office, Industrial Base: Significance of DoD's Foreign Dependence 12 (January 1991).

³Office of Technology Assessment, Holding the Edge: Maintaining the Defense Technology Base (April 1989).

of industrial sectors. The federal budget simply cannot sustain anything approaching the level of investment necessary to support every industry that supplies defense equipment or technology.

We must, therefore, rely to some degree on the market to determine which U.S. industries will survive. However, complete reliance on the market will result in significant portions of the defense industrial base being located outside of the U.S. Consequently, it is necessary to engage in industrial planning, not so much to deal with the problem of competitiveness as to deal with the need for mobilization and surge capacity as well as the specialized needs of the Defense Department to work closely with defense contractors to develop particular weapons systems under conditions of confidentiality.

Allow me to take the U.S. machine tool industry as my example, since I am most familiar with that industry.

Last March, the Office of Science and Technology Policy (OSTP) issued a report that lists 22 national critical technologies deemed essential to satisfy such U.S. needs as defense, economic competitiveness, public health, and energy. Of the 22 technologies listed, eight depend on the machine tool industry and continuing machine tool developments for effective advances to be made. The relationship to machine tools is in some cases direct, in that they are an obvious and integral part of the technology. In other cases, machine tools and machine tool development are a necessary, but unstated, requirement for the successful development of the technology in question.

The critical technologies of Flexible Computer Integrated Manufacturing, Intelligent Processing Equipment, and Systems Management are obviously dependent upon machine tools. In fact, some of the systems the OSTP report describes in these areas are simply groups of machine tools working together to manufacture a certain product. Flexible

Computer Integrated Manufacturing specifically emphasizes machine tools. The Report states that typical equipment used includes "machining and turning centers, composite tape laying machines, and coordinate measuring machines." Flexibility in manufacturing is given great importance in this Report as well as in all other lists of critical technologies.

The OSTP Panel concluded that a significant portion of service sector employment and trade depends on the manufacturing sector. The Report goes on to state

. . . failure to maintain world-class manufacturing capabilities would compromise the nation's ability to compete in domestic and international markets, and would threaten our ability to continue economic growth and to obtain access to the full range of components and equipment required for a strong national defense.

Thus, machine tools are seen by the OSTP Panel to be a key to international competitiveness as well as national defense.

Production of advanced weapons requires a very close working relationship between machine tool builders and weapons manufacturers. Development of projects involving nuclear submarines, intercontinental ballistic missiles, STEALTH fighter aircraft, rail guns, components for the Strategic Defense Initiative, B-1 and B-2 bombers, and advanced armor manufacturing all require maximum security and confidentiality. Defense manufacturers need to be able to work with subcontractors in a manner that will conform to the industrial security requirements of the Defense Department.

U.S. machine tool companies are best equipped to assure the integrity of the security safeguards associated with sensitive national security projects. If our defense industry has to turn to foreign producers for machine tools and for machining support, sensitive programs may be subject to compromise. Information of competitive value would pass to foreign weapons manufacturers. In turn this could enable them to (1) take

advantage of U.S. research and development dollars for their own purposes; (2) allow them to sell weapons technology of U.S. origin to Third World countries, the interests of which may be inimical to those of the U.S.; and (3) compete with American companies for foreign military sales.

The close relationship between machine tool builders and advanced defense projects often involves customizing machines so they can carry out complex tasks, optimizing machine tool controller software for specific purposes (as in manufacturing silent propellers for submarines), and building special purpose machining centers in support of critical production requirements. If more of the U.S. machining capability goes offshore, access to know-how of this kind will be either lost or in short supply.

Additionally, one of the weakest aspects of the U.S. machine tool industrial base is depth of skilled manpower. Men and women cannot be trained overnight for the highly complex tasks of operating and maintaining machine tools. Skill is accrued only after years of apprenticeship and on-the-job training. Further erosion of this vital labor asset can only be avoided by the preservation of a healthy machine tool industry.

At stake is no less than the national mobilization capability. The U.S. inventory of weapons has been reduced because of the attrition experienced in the Gulf War and the cutbacks in defense spending mandated by the Congress. Should tension levels increase, however, ability to surge production of spare parts would be necessary to any mobilization. Defense manufacturers and their subcontractors will have to be reprogrammed for this purpose. This would require U.S. machine tool companies and their experts to work on an urgent basis with critical defense production companies to develop the machines and the quality assurance programs needed for making military equipment and

components. Of course, if the U.S. machine tool companies are forced out of business, surge production cannot be assured.

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Machine tool manufacturers assist in producing a vast array of specialized, sophisticated components for advanced weapons systems. Among these are special bulkheads required for cruise missiles, gimbals for the Patriot, propellers for nuclear submarines, precision inertial gyro assemblies for ICBM's, wing spars and tape-laying machines needed to produce the F-117A, Stealth and B-1 bombers, penetrators for tank ammunition machined from depleted uranium and tungsten carbide, and machining centers for ammunition manufacturing and for enlarged production runs of smart weapons. (A more complete list, highlighting the Gulf War, has been appended to this testimony.)

Another factor that must be taken into account is policy flexibility. It is quite possible that U.S. policy objectives could be compromised as the result of a disagreement with an allied government, whose approval would be necessary before key equipment could be shipped. Moreover, it need not even be disagreement. Controversy in a foreign legislature could lead to deadlock and delay, and such delay could be critical in undermining the achievement of U.S. objectives. While this did not occur during the recent Gulf War, the potential for delays in shipment of critical equipment was certainly present, given the

controversy in the Bundestag and the Diet surrounding German and Japanese participation in the war effort.

Actually, there already is a certain degree of industrial planning involved in our nation's policy towards the machine tool industry. On May 20, 1986, President Reagan, recognizing the danger posed to America's national security by dependence on foreign sources for one of our critical industries and responding to requests by over 250 Members of Congress (including the Chairman and most members of this committee), announced his decision to seek a voluntary restraint arrangement (VRA) on certain machine tool imports as part of his machine tool domestic action plan. Characterizing the machine tool industry as a "small, yet vital component of the United States defense base," he directed that reduced levels of imports of six classes of machine tools be negotiated with Japan and certain other countries. VRAs were negotiated with Japan and Taiwan for a period of five years. They will expire on December 31, 1991 unless they are extended.

Machine tool industry data indicates unequivocally that the companies affected by the VRAs have responded just as President Reagan and Congress intended. The manufacturers have made substantial investments in new, productivity-enhancing capital equipment; they have developed new products and new technology, committing heavily to R&D and engineering; and they have implemented significant efficiency in their own plants. They have done all this without raising prices beyond the rate of inflation and without substantial profits.

During 1987 through 1989, the U.S. machine tool industry averaged productivity gains of 11.3% per year -- among the highest productivity growth of any industrial sector. These gains are partly the result of increased investment by firms affected by the VRAs. A recent survey conducted by NMTBA of U.S.-based VRA-affected

companies showed that respondents' capital investment to depreciation ratios more than doubled over the five-year period since the VRAs became effective, and their annual investment increased by 78%.

VRA-affected companies have also developed new products and technologies, committing heavily to R&D and engineering. NMTBA's survey indicated that respondents spent \$637.7 million on R&D/engineering over the five-year period. R&D/engineering increased 23% from 1987 to 1990. Eighty-eight percent of the respondents introduced new product lines, and 92% improved and existing product lines. R&D/engineering spending as a percentage of sales increased by almost 40%.

In addition, VRA firms have implemented significant efficiency improvements in their own plants. And they have worked mightily to open new markets -- particularly in Japanese transplants located in the United States. Today, 30% of all U.S. machine tool production is exported.

These investments of time and capital were made without significant machine tool price increases. In fact, prices barely kept pace with the rate of inflation.

The VRAs have given the industry a chance to rebuild. The U.S. machine tool industry's 1990 net income before taxes was 3% of sales, compared to pre-tax income of 5.7% of sales for all U.S. manufacturers during the same period. Pre-tax income for VRA-affected firms was even lower -- a mere 2.2% of sales. Since the inception of the VRAs, affected companies have invested far more than traditional caution would dictate. In other words, they "bet the farm." They have committed themselves over the past five years to the restoration of manufacturing competitiveness to the detriment of their balance sheets, exposing them to a new wave of imports, if the VRAs are not extended beyond their 1991 expiration date.

CONCLUSION

These gains are good news for U.S. national security because they presage recovery that will enable the defense mobilization base and defense industry to be strengthened, provided the VRA system can be maintained for some time to come. The revitalization of the U.S. machine tool industrial base is likely to take about ten years. This is reasonable, taking into account both economic ups-and-downs (we have been in a "down" for too long) and the time it takes to introduce a wholly new generation of competitive machine tools and allow them to enter the marketplace. From the time the VRA was implemented (1987) until now is half the cycle time necessary to get the job done. Renewal of the VRA for another five years would fulfill the mission started by President Reagan.

VRA renewal, in this framework, should be given consideration because of its significance to national security. It is not a routine trade issue any more than semiconductors and computers -- which were not handled "routinely." In fact, the U.S. machine tool industry, even in its heyday, was too small a part of the U.S. economy to matter for our international trade balance or as a major source of national income. The machine tool industry, instead, represents a special-niche industry significant to American national defense and national security. In this sense, the VRA is much more than a Voluntary Restraint Arrangement put in place for commercial reasons. The VRA could better be called an "NSVRA," for National Security Voluntary Restraint Arrangement.

Uniquely, the VRA protects and enhances our national security competitiveness and, by so doing, helps to maintain order and stability world-wide. This, in turn, improves the security of all Americans and even assists America's economic competitors! With unprecedented international changes now going on, we cannot predict our future international obligations, or what threat may be made against our security. For

this reason we cannot put a key segment of our industrial base at risk. Just as our land, air and sea based missiles form our nuclear-defense triad, computers, semiconductors, and machine tools are the basis of our defense-industrial triad. President Bush would not hesitate to preserve our nuclear-defense triad. He should do no less for our defense-industrial triad. If the President decides to renew the Machine Tool Voluntary Restraint Arrangement, he can at one and the same time, enhance both our industrial competitiveness and our national security.

APPENDIX

Below is a sample list of the sophisticated U.S. weapons systems used in the Gulf War provided by U.S. machine tools:

MISSILES

Boston Digital Corp.	Textron/cruise missile components
Cincinnati Gilbert	Indian Head Naval facility/boring mill producing solid fuel missile propellants
Cincinnati Milacron	LTV/"6 Pack" Bulkheads for multiple launch rocket system Williams International/small engines for cruise missiles United Technologies/special 6-axis profiler to make complex aluminum center section of Tomahawk cruise missile
Cross & Trecker	Raytheon/special cells to produce Patriot missile parts
Giddings & Lewis	McDonnell Douglas/5-axis machining center and vertical turning machines for complex machining of center section of Harpoon missile; and special machine to provide missile skins Raytheon/machining center for Patriot & Hawk components
Hardinge Bros. Inc.	Raytheon/high precision turning machines to make electronics and guidance system for Patriot missile
Masco Machine Inc.	4-axis CNC turret machining center to make guidance system housing for Tomahawk cruise missile Special large, heavy duty CNC machining centers for Hercules to produce Delta, Titan and other boosters for launching satellites
Producto Machine Co.	Teledyne, Williams International/cruise missile engine parts
Saginaw Machine Sys.	General Dynamics/cruise missile parts

NAVAL COMPONENTS

Cross & Trecker	Long Beach Naval Shipyard/nuclear weapon components
Giddings & Lewis	Puget Sound Naval Yard/unique vertical turning and grinding cell for ship repair facility General Dynamics/submarine components
Onsrud Machine Corp.	Philadelphia Navy Yard/unique, custom-made, very large 5-axis milling machines to make "quiet" nuclear submarine and combat ship propellers
Strippit, Inc.	Bath Ironworks/42-station CNC turret punch press used to build and overhaul naval frigates and cruisers

HELICOPTERS

Boston Digital	Garrett-Hamilton Standard/auxiliary power units
Cincinnati Milacron	McDonnell Douglas/AH-64A Apache components Sikorsky/special profile milling machines to make helicopter hubs and blades
Cross & Trecker	Parker Hannifin & Bell Helicopter/servo systems
Giddings & Lewis	Sikorsky/very accurate machining centers to make transmissions
Hardinge Bros. Inc.	Bell and its subcontractors/high precision turning machines to make electronics and guidance systems
Masco Machine Inc.	United Aircraft/heat exchangers

AIRCRAFT

Cincinnati Gilbert	McDonnell Douglas/large NC machines to make housings for A-18 and panels, structures and ribs for KC10 Tanker
Cincinnati Milacron	General Dynamics/F-111 Lockheed/tape laying equipment for F-17A McDonnell Douglas/F-15 Fairchild Republic/A-10 "Wart Hog" LTV/special flexible manufacturing cells and systems to make major sections of B-1 Textron Aerospace/large special machines to make and rebuild C-141 and C-5 wings Boeing/four manufacturing cells to produce high tensile steel & titanium mechanism used in wing folding of A-6 Intruder - plus tape layers for rewinding the aircraft
Cross & Trecker	Cleveland Pneumatic/landing gears Hamilton Standard/avionics Northrup/B-2 bomber parts Lockheed/F-117A Stealth fighter parts Martin-Marietta/B-1 bomber parts
Giddings & Lewis	McDonnell Douglas/machining centers for F-18, F-15 Hill AFB/machining centers for repair of landing gears Cleveland Pneumatic/machining centers to make landing gears
Masco Machine Inc.	5-axis CNC turret machining centers to make heat exchangers for hydraulic systems
Strippit, Inc.	Wright-Patterson AFB/CNC turret punch press with laser head attachment used in the production of the Stealth bomber, deign aircraft components, and pilot training equipment.

JET ENGINE COMPONENTS

Boston Digital Corp.	GE, Pratt & Whitney/large jet engine parts
Cincinnati Gilbert	GE/large jet engine parts
Cincinnati Milacron	GE, Pratt & Whitney/large engine components
Cross & Trecker	Machines to make engine components for Teledyne-Continental-Allison Gas Turbine-Chemtronics-Pratt & Whitney
Giddings & Lewis Co.	Pratt & Whitney-Chemtronics-General Electric/machining centers and vertical turning machines for making jet engine components
Hardinge Bros. Inc.	High precision turning machines supplied to various subcontractors to make small engine components, electronics, and guidance systems
Producto Machine Co.	GE, Pratt & Whitney/rotation parts for large jet engines

NIGHT VISION GLASSES

Cross & Trecker	Daro/night vision glasses for personnel
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M1A1 ABRAMS TANK & BRADLEY FIGHTING VEHICLES

Cincinnati Milacron	FMC & Red River Arsenal/special machines to make the hulls for the Bradley General Dynamics/tank hull machining
Cross & Trecker	Textron/Lycoming/modu-line systems to make tank engines General Dynamics/special machines to make undercarriage & support parts for tank
Giddings & Lewis	General Dynamics/special machining centers for tank armament components
Masco Machine Inc.	Cummins Engine & Caterpillar/tank engines Watervliet Arsenal/turret spline
Strippit, Inc.	FMC/heavy-duty CNC turret punch press used for building Bradley fighting vehicles and armored personnel carriers

AMMUNITION and LARGE GUNS

Cincinnati Gilbert	Rock Island Arsenal/artillery gun barrels
Cincinnati Milacron	Watervliet Arsenal/gun barrels
Cross & Trecker	Olin-Flinchbaugh/armor piercing ammunition
Giddings & Lewis	Rock Island Arsenal/armament parts Watervliet Arsenal/unique FMS cell for machining breech blocks and other artillery components
Hardinge Bros. Inc.	Rocky Flats/high precision turning machines to make nuclear devices
Masco Machine Inc.	Special machines for producing fuse bodies and land mines
Producto Machine Co.	Rocky Flats/special machine to provide plutonium samples
Saginaw Machine Sys.	Scranton Army ammunition plant/NC vertical turning machine to produce 155mm ammunition Hughes/50 caliber machine gun barrels

STATEMENT BY
ROBERT E. AGAN
PRESIDENT AND CHIEF EXECUTIVE OFFICER
HARDINGE BROTHERS, INC.
BEFORE THE
COMMITTEE ON WAYS AND MEANS
UNITED STATES HOUSE OF REPRESENTATIVES
JULY 17, 1991

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I. INTRODUCTION

Good morning, my name is Robert E. Agan. I am President and Chief Executive Officer of Hardinge Brothers, Inc. in Elmira, New York. My company manufactures lathes. We are a major supplier of very sophisticated machine tools to the aerospace industry.

I am also 2nd Vice Chairman of the Board of Directors of NMTBA - The Association For Manufacturing Technology. NMTBA is a trade association whose membership includes over 300 machine tool building firms with over 400 locations. With me this morning is James H. Mack, NMTBA's Vice President of Government Relations.

I appreciate the opportunity to address you concerning the risks foreign-source dependency in critical industries poses to America's national security and economic stability.

II. MACHINE TOOL INDUSTRY OVERVIEW

The United States machine tool industry is small in terms of dollar shipments, but it is a vital element within the defense readiness system. This critical industry designs and builds machines which support and sustain U.S. defense requirements and which underpin all of America's manufacturing capability. The nation's ability to compete globally in electronics, optics, aerospace, and other high technology industries and to produce advanced weapons for national defense, depends on the steady availability of quality machine tools.

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Unfortunately, in the early to mid-1980s, the U.S. machine tool industry was targeted by foreign competitors whose unfair trading practices, coupled with the economic downturn of the early 1980s, resulted in several successive loss years. During that time, the industry's revenues, and therefore, capital expenditures declined steadily. As the industry deteriorated, foreign manufacturers moved in to capture significant portions of our domestic market. Today, the United States imports roughly half of the value of all the machine tools it consumes. As a result, many critically important weapon systems have become increasingly reliant on foreign sources for key components and supplies of materials.

III. CRITICAL INDUSTRIES

Last March, the Office of Science and Technology Policy (OSTP) issued a report which lists 22 national critical technologies deemed essential to satisfy such U.S. needs as defense, economic competitiveness, public health, and energy. Of the 22 technologies listed, eight depend on the machine tool industry and continuing machine tool developments for effective advances to be made. The relationship to machine tools is in some cases direct, in that they are an obvious and integral part of the technology. In other cases, machine tools and machine tool development are a necessary, but unstated requirement for the successful development of the technology in question.

The critical technologies of Flexible Computer Integrated Manufacturing, Intelligent Processing Equipment, and Systems Management are obviously dependant upon machine tools. In fact, some of the systems the OSTP report describes in these areas are simply groups of machine tools working together to manufacture a

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certain product. Flexible Computer Integrated Manufacturing specifically emphasizes machine tools. The Report states that typical equipment used includes "machining and turning centers, composite tape laying machines, and coordinate measuring machines." Flexibility in manufacturing is given great importance in this Report as well as in all other lists of critical technologies.

The critical technology of Intelligent Processing Equipment is closely linked to improved flexibility and improved quality. As the Report states "intelligent processing equipment is the foundation on the shop floor upon which advanced manufacturing capabilities are built." The Report then goes on to mention specifically such processes performed by machine tools as machining, forming, welding, assembling, composite fabricating, and material handling.

Also related to flexibility in manufacturing systems is the critical technology of Systems Management Technologies. This technology is on the list because of its importance in enhancing smoother process flows and faster turn-around times between production runs. As the Report states, "tight integration of software and computer hardware, even for a single vendor, is difficult to accomplish..." Machine tool builders represent an important resource in the integration of these systems.

In other critical technologies the link to machine tools may be less obvious but no less important. In the area of Materials Synthesis and Processing, the Report emphasizes the increasing demands that are made on innovative processing techniques such as electron beam processing, laser hardening, and mechanical alloying in order to make useful products out of new materials. All of the

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processes mentioned involve further developments in machine tools in order to be viable.

In the area of Ceramics, the Report comments on the importance of hot isostatic pressing as a potential means for shaping these useful, but difficult-to-handle materials. In the area of Composites, the Report emphasizes the increasing importance of polymer matrix composites and emphasizes the expensive methods that are now used to fabricate these materials into useful components. The Report then states that "the implementation of high-volume, low-cost production methods is therefore critical to unlocking the commercial potential of polymer matrix composites." As has been the case with the fabrication of composites in the form of tape, it is expected that innovations in machine tools will be required to "unlock the commercial potential" of these materials.

In the area of High-Performance Metals and Alloys, problems associated with final fabrication are again emphasized. The Report states that fabrication costs and processes are the primary constraint to the widespread use of these intermetallic alloys. The Report states that "the development of processes for the superplastic forming of intermetallics has significant potential to enhance current capabilities to fashion these materials into complex, final shapes." Machine tools will be required in order to perform these superplastic forming processes.

In the general area of manufacturing, the Report states that "the [OSTP] Panel placed heavy emphasis on the importance of manufacturing and process technologies." Of course, process technologies depend on equipment such as machine tools. It is also pointed out in the Report that these technologies draw upon many of

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the other critical technologies including sensors, controls, computer software and hardware, and simulation to mention a few.

The critical technology of Aeronautics is selected because it is "essential for continued dominance of the large world aviation marketplace," and because "aeronautical technology is the single most importance component of military superiority and troop mobility..." Within this technology, emphasis is given to advanced engine components such as inlets, and propellers. Fabrication techniques for all these components depend on new processes and advanced developments in machine tools.

The OSTP Panel concluded that a significant portion of service sector employment and trade depends on the manufacturing sector. The Report goes on to state "failure to maintain world-class manufacturing capabilities would compromise the nation's ability to compete in domestic and international markets, and would threaten our ability to continue economic growth and to obtain access to the full range of components and equipment required for a strong national defense." Machine tools represent an important element of the equipment referred to above.

The OSTP report implies that United States primacy in each of these 22 critical technologies is vital to meeting America's military and economic needs. Maintaining strength in at least eight of these critical technologies depends on the continued viability of the American machine tool industry.

IV. THE RISKS OF FOREIGN SOURCE DEPENDENCY

Our nation cannot maintain its economic and military position as a world power if it is dependent on foreign sources for the "tools" of manufacturing in its critical industries. America's

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experience in both World Wars, the Korean conflict, and as recently as in the Persian Gulf War demonstrates that, if war erupts when the domestic machine tool industry is weak, delays that result would directly and gravely impair national security. In a news article that was published shortly after the Gulf war, one senior administration official described the situation in this way, "We were sweating bullets over it, and the military was sweating bullets, too."

Our overwhelming victory in the Persian Gulf must not lull us into a false sense of security. The nature and duration of the Gulf conflict did not heavily task our defense industrial base. What would have happened if Saddam Hussein had been able to destroy many of our sophisticated weapons systems? Could we have relied on our industrial base to repair the damage and provide new equipment? We probably could not in its current state of deterioration.

There is the argument that U.S. friends and allies will supply all of our machine tool needs if necessary. This rationale may work when, as was the case in the Persian Gulf victory, the world is united against a common enemy. However, in the next conflict, our allies may determine it is not in their national interest to supply our needs; or they may not be able to supply our needs, because of their own greatly increased demand, in spite of their best intentions. Sea lanes could be disrupted. Their countries could be overrun or their industries damaged.

There is also a risk in peacetime, if America's critical industries are dependent upon foreign manufacturers for their machine tools. Imagine the foreigner's power over our industrial

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competitiveness and military power. The United States would receive machine tools at a technology level of foreign companies' choosing; deliveries would be on a schedule that they would determine; and we could be cut off at their discretion.

The risk of becoming dependent upon foreign sources for machine tools is too great. The solution must be to strengthen the critical industries upon which the defense industrial base is built, and that begins with strengthening the U.S. machine tool industry.

V. THE MACHINE TOOL VRAS

On May 20, 1986, President Reagan, recognizing the danger posed to America's national security by dependence upon foreign sources for one of our critical industries and responding to requests by over 250 members of Congress (including the Chairman and most members of this committee), announced his decision to seek voluntary restraint agreements (VRAs) on certain machine tool imports as part of his machine tool domestic action plan. Characterizing the machine tool industry as a "small, yet vital component of the United States defense base," he directed that reduced levels of imports of six classes of machine tools be negotiated with Japan and certain other countries. VRAs were negotiated with Japan and Taiwan for a period of five years. They will expire on December 31, 1991 unless they are extended.

In the time since the VRAs went into effect, Hardinge Brothers and other VRA-affected companies across the United States have responded as President Reagan and you intended. First, we have made substantial investments in new, productivity enhancing capital equipment. Twenty-four VRA-affected companies surveyed by NMTBA indicated that their capital investment to depreciation ratios more

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than doubled over the five-year period since the VRAs became effective, and their annual investment increased by 78%.

VRA-affected companies have also developed new products and technologies, committing heavily to R&D and engineering. NMTBA's survey indicated that respondents spent \$637.7 million on R&D/engineering over the five-year period. R&D/engineering increased 23% from 1987 to 1990. Eighty-eight percent of the respondents introduced new product lines, and 92% improved an existing product line. R&D/engineering spending as a percentage of sales increased by almost 40%.

In addition, VRA firms have implemented significant efficiency improvements in their own plants. And we have worked mightily to open new markets -- particularly in Japanese transplants located in the United States. Today, 30% of all U.S. machine tool production is exported.

My company has made substantial investments to modernize our plant and improve the quality of the tools we produce. In fact, our emphasis on quality products has evolved into a multi-million dollar quality commitment program. We have aggressively competed for the Malcolm Baldrige National Quality Award for manufacturing excellence, finishing in the top 22 companies in the country -- a tribute to the effort we have undertaken. Without the VRAs, Hardinge may not have had the resources to commit to such a program.

The companies I've described have made these substantial investments of time and capital without raising prices beyond the rate of inflation and without substantial profits.

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CATEGORY	1986	PRICE CHANGE OVER PREVIOUS YEAR			
		1987	1988	1989	1990
GNP Deflator	2.7	3.3	3.4	4.1	4.6
<u>VRA-Affected Machine Tools</u>					
Lathes	-0.1	0.6	3.0	6.7	6.6
Milling Machines	2.2	2.5	NA	2.6	6.0
Multi-function, NC *	-0.3	0.9	6.3	5.9	3.2
Punching, Bending, etc.	1.2	1.0	1.0	1.8	1.9

NA - Not Available. * - Includes machining centers.

Source: All of the above categories, with the exception of the GNP Deflator, are Producer Price Indexes.

The U.S. machine tool industry's 1990 net income before taxes was 3% of sales, compared to pre-tax income of 5.7% of sales for all U.S. manufacturers during the same period. Pre-tax income for VRA-affected firms was even lower -- a mere 2.2% of sales.

Median Income Before Taxes
U.S. Machine Tool Industry

	<u>All Firms</u>	<u>VRA-Affected</u>	<u>Non-VRA-Affected</u>
1986	0.3%	0.1%	0.8%
1987	1.6%	0.0%	2.6%
1989	2.6%	0.6%	4.1%
1990	3.0%	2.2%	4.1%

These industry data demonstrate unequivocally that my own company and other VRA-affected companies have responded admirably to the five year breathing space provided by the VRAs. We have made substantial investments in new, productivity-enhancing capital equipment. We have developed new products and new technology, committing heavily to R&D and to engineering. We have implemented significant efficiency improvements in our own plants. In other words, we "bet the farm" -- we invested far more than traditional caution would dictate.

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But there has been a price for that investment. Almost three-fourths of the 24 VRA-affected firms responding to the NMTBA survey reported that their company's balance sheets are about the same or worse than they were in 1986 when the VRAs began. We are, however, neither despondent nor regretful that we have sacrificed current profits for future growth. We are thankful the VRAs gave us the opportunity and the incentive to take the steps necessary to restore our competitiveness as machine tool producers. Many of us doubt that we would have taken the steps outlined in this testimony had the VRAs not been in place.

But we recognize our vulnerability. We have committed ourselves over the past five years to the restoration of manufacturing competitiveness to the detriment of our balance sheets, exposing us to a new wave of Asian imports, if the VRAs are not extended. We will never have the chance to reap the benefits of our investments nor will we be able to continue to invest at current levels, both essential elements for future progress. The United States will end up back at the drawing board, lagging behind our foreign competitors in the international marketplace. Even more disconcerting, the national security of the United States will be jeopardized as our defense is left increasingly in the hands of foreign suppliers.

VI. CONCLUSION

America's defense industrial base is in serious danger of becoming dependent upon foreign sources for strategic components and supplies of materials in its critical industries. Of the twenty-two critical industries named by OSTP, eight either directly or indirectly rely on machine tools to manufacture their products.

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Yet, the United States machine tool industry is struggling to survive. During the last several years, the industry has managed to pull itself only to the bottom rung of the ladder. It still has a long way to go before the strength and stability that is necessary to our defense needs is achieved.

The machine tool VRAs have provided some much needed breathing space for the industry to begin to rebuild, and it has made considerable investments toward that end. However, imports today are at approximately the same level as they were in 1986 when President Reagan sought the VRAs for national security reasons. To pull the rug out now would be to throw away all the progress that has been made, and let foreigners determine the technology they wish to share with America's industrial base.

The key to America's military and economic power rests on a healthy machine tool industry. It is imperative that everything be done to preserve and strengthen this cornerstone of America's defense needs. Extending the VRAs beyond 1991 would be an important step toward that goal.

Thank you. I would be pleased to respond to your questions.


COUNCIL ON COMPETITIVENESS



**A COMPETITIVE PROFILE OF THE
MACHINE TOOL
INDUSTRY**

Research Paper for

GAINING NEW GROUND:

TECHNOLOGY PRIORITIES FOR AMERICA'S FUTURE

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As part of the research for *Gaining New Ground*, the Council on Competitiveness analyzed the competitive standing and technology priorities of nine industrial sectors: (1) Aerospace; (2) Chemical and Allied Products; (3) Computers and Software; (4) Construction; (5) Drugs and Pharmaceuticals; (6) Electronic Components and Equipment; (7) Machine Tools; (8) Motor Vehicles; and (9) Telecommunications. The views expressed in these profiles do not represent the official position of the Executive Committee of the Council. Their consensus findings and recommendations are contained in *Gaining New Ground: Technology Priorities for America's Future*.

Copies of these sectoral profiles may be obtained from the Council on Competitiveness, 900 17th Street, N.W., Suite 1050, Washington, DC, 20006, (202) 785-3990. The prices are \$10 for each profile plus \$1 postage and handling and \$20 for *Gaining New Ground* plus \$2.50 postage and handling.

Sectoral Profile: Machine Tools

Key Points

- Machine tools are the **critical link** between intermediate products formed from raw materials and finished discrete components. Machine tools therefore have leverage across most industries since the production of virtually all goods and services is dependent on a machine tool or a machine that was built by a machine tool.
- The industry is **small** in terms of number of firms (about 600), employment (median is about 60 people per firm) and average sales (about \$7 million per company). This industry structure makes it difficult for machine tool builders to keep up with the technical needs of their customers, who are often large, integrated manufacturers.
- The industry is characterized by steep business cycles and uncertain income streams. During the 1980s, sales fluctuated between \$2 and \$5 billion annually. These market fluctuations discourage investment in R&D and the rapid diffusion of new technology. During the past two decades, investment in R&D has averaged less than 2 percent of sales.
- The U.S. share of world production has declined steadily since 1955, from about half to about 10 percent. By contrast, Japan has grown from a 1 percent share of world production to 23 percent to become the world leader, and Germany has maintained its share its approximately 16 percent share. Supported by an active government policy, Japan has focused on low cost, high quality, volume production of standardized products. They also have universal control capability that dominates the market. Germany and Switzerland have adopted a strategy focused on high performance, specialized niche products.
- Since 1978, the U.S. has had a trade deficit in machine tools. Import penetration of the domestic market has increased dramatically, now accounting for a 50 percent share.
- The U.S. industry continues to face problems related to the adoption of new technology and the use of flexible manufacturing systems. Japan has an installed FMS capability that is not matched by U.S. companies.
- The loss of firms and market share in the U.S. machine tool industry has seriously affected U.S. mobilization-surge capacity in a time of national emergency.

Factors Supporting Development of Critical Technologies

- The United States is still near the top in terms of world machine tool consumption. The large domestic market could be the basis for the U.S. machine tool industry regaining leadership in critical technologies.
- Strong relationships with its customer base, in such areas as simultaneous engineering, could result in a symbiosis which would raise the competitiveness of both the machine tool industry and its customers.

Impediments to the Development of Critical Technologies

- Technological leadership requires a financially healthy industry with the resources to invest in new products and processes. Financial health will only come with an internationally competitive industry that is free to pursue opportunities worldwide in the now global machine tool market. Factors inhibiting the ability of the U.S. machine tool industry to accumulate the resources to pursue R&D in critical technologies include:
 - small firm size in the industry;
 - industry cyclicity;
 - U.S. export control policy;
 - U.S. tax laws;
 - the U.S. product liability system.

Critical Technologies

- Advanced materials technologies, metallurgy, physics of materials and dynamics of structures.
- Electronic controls, metrology and sensors technology.
- Software and artificial intelligence.
- Laser technology and advanced precision bearings.

STRATEGIC SECTORAL PROFILE

THE U.S. MACHINE TOOL INDUSTRY

I. STRUCTURE AND IMPORTANCE OF THE U.S. INDUSTRY

Machine tools transform castings, barstock, or sheet metal into finished components. Machine tools are thus the critical link between intermediate products formed from raw materials and finished discrete components. These components are then assembled either into end products or into yet other machines that will in turn make end products.¹

All manufactured goods, directly or indirectly, require the use of machine tools, so they are considered vital to the nation's competitiveness. The major users of machine tools are the fabricated metal products, machinery, and transportation industries. The U.S. machine tool industry ranks fourth in world machine tool production, behind Japan, West Germany and the Soviet Union.

Manufacturing technologies, worldwide, are rapidly changing. Advances in computers and electronics technology substantially changed the traditional industry beginning around the mid-1970s.

The introduction and evolution of computer numerical controls have led to significant increases in the productivity of machine tools. By adding ancillary equipment (material handling devices, robots, automatic guided vehicles, etc.) to connect two or more machines in a system under computer numerical control, it is possible to form flexible cells and systems capable of machining families of workpieces in small quantities, even in single quantities, or in continuous production.

Parallel developments in the field of computer-aided design and manufacturing systems have made it possible to establish computer links between the design and the manufacture of the product (e.g. the dimensions of a part to be machined are carried over from the design phase to the machining of the part). This greatly improves the flexibility of these systems and results in shortened lead times. It also eliminates the need to inventory parts because they can be machined quickly using the appropriate part programs stored in a computer.

Different concepts have evolved in the design and application of flexible manufacturing systems. The U.S. machine tool industry pioneered the technology required to produce multi-function machining centers and flexible machining and manufacturing cells and systems. While the United States is regarded as a leader among the world's machine tool builders in technology and experience, the U.S. industry has been overtaken in many areas, as Japanese and European machine tool builders innovate in design and application.

Industry Structure

- In 1987 (the last year reported) there were 624 machine tool builders, with only 352 having more than 20 employees.²
- The median number of employees for firms in the industry during 1989 was about 60.
- The typical U.S. machine tool company had sales of just \$7 million per year in 1989.
- The production of U.S. machine tools during the 1980s fluctuated between \$2.0 and \$5.0 billion, reflecting the highly cyclical nature of the industry.

The U.S. industry is currently characterized by mid-sized family firms that have technical origins and tend to specialize in narrow product lines for particular markets. The structure of the industry was traditionally reinforced by reputations built around particular types of machines, and high tooling costs the user would incur by switching from one make to another. In the absence of modular design and flexible automation, production economies were not enhanced by broader lines, but by standard models and long product life-cycles. This design/production paradigm was not a problem as long as product-life cycles were long and there was no alternative production paradigm. It became increasingly dysfunctional, however, as new technologies (e.g. CNC) emerged and Japanese production capabilities changed the nature of competition by introducing new economies of scope and scale.³

The machine tool industry is dependent on the availability of key items from suppliers of motors, bearings, electronic controls and measurement devices. Over the last several years, important segments of the supplier base for these items have come under foreign control. Most of these critical items are now engineered and produced offshore and must be imported.

A close user-builder relationship is not only important to machine tool builders, but also to the manufacturing companies that use machine tools. Many U.S. users have shifted to foreign suppliers of machine tools because U.S. suppliers could not provide the leading edge equipment that was required or could not meet foreign price and delivery schedules. This situation, however, can put U.S. users at a disadvantage, since their foreign competitors often have access to the same leading edge equipment a year or two ahead of U.S. companies. In some cases the equipment is not even available to U.S. companies.⁴

The critical issue is that domestic machine tool user industries that are dependent upon foreign equipment for manufacturing key components will chronically lag their foreign competitors and will perpetually be trying to catch up rather than leading. If a manufacturing company's machine tools lag those of its competitors, so will the downstream equipment and products that depend on them.⁵

Industry Performance and National Defense

The loss of firms and market share in the U.S. machine tool industry has seriously affected U.S. mobilization-surge capability. Machine tools are fundamental in the production of the critical war-fighting components (e.g. tanks, missiles, ships, planes, transportation equipment, etc.). It has recently been estimated that 25 percent of the total consumption of machine tools in the United States is linked directly or indirectly to defense requirements. Past experience suggests that demands on the industry could rise 6 to 8 times higher during wartime. The high-level of import penetration in the U.S. market means that the mobilization base is heavily dependent upon foreign-based suppliers, who may prove unreliable in an emergency.⁶

In announcing the decision to seek Voluntary Restraint Agreements on machine tool imports in 1986, President Reagan acknowledged that machine tools were a small yet vital component of the U.S. defense base and that the high levels of imports could potentially erode U.S. capabilities to manufacture critical machine tool product lines. The U.S. Department of Defense has further recognized the industry's crucial role through its funding of R&D projects by machine tool companies. The "Buy America" provisions that have been inserted in Department of Defense appropriation bills have been inserted in an effort to reduce the U.S. dependency on imported machine tools.

A strong, viable domestic machine tool industry is needed to engineer, design, and build special machine tools for highly classified military applications, for example:

- The special multi-axis machines built to produce propellers for nuclear submarines requires technology not available commercially.
- In the aerospace industry, the computer-controlled tape laying machines required to measure, cut and lay down the composite layups used to build aircraft wings and fuselages requires expertise that only a few of the world's top machine tool builders possess. At present, U.S. machine tool builders are recognized for their leadership in this area.

Without an experienced engineering staff to design, build, and assemble special machine tools, the lead time to produce them in a time of national mobilization would be unacceptable.

The U.S. Machine Tool Industry's Technological Leverage Across other Industries

The leverage of the machine tool industry is broad-based because the production of virtually all goods and services are dependent on a machine tool or a machine that was built by a machine tool.

As key suppliers to manufacturing industries, machine tool builders are increasingly being called on to offer not just machines, but solutions to manufacturing problems. Many of manufacturing's competitive battles lie not in developing products, but in developing efficient, flexible and inexpensive manufacturing production processes.

While purchasers of machine tools are cutting costs and streamlining operations, machine tool builders must not only offer competitive products, but also ensure that those products make the customer more competitive. Machines must be integrated with customer programs such as "just-in-time" and total quality control. Today, the challenge to machine tool builders is not just to offer buyers machines. In addition, they must offer the following:

- Product designed to maximize flexibility and minimize the disruption and high cost of changeover.
- Product designed to minimize in-process inventory in order to reduce the working capital needs of the manufacturer.
- Product designed to enhance control and predictability of the manufacturing process through advanced sensor and feedback capability.
- Product designed to produce increasingly stringent part quality levels, thus reducing manufacturing costs.
- Product designed to blend the various industrial disciplines into a comprehensive package. This requires integration from product design/engineering through to product completion.

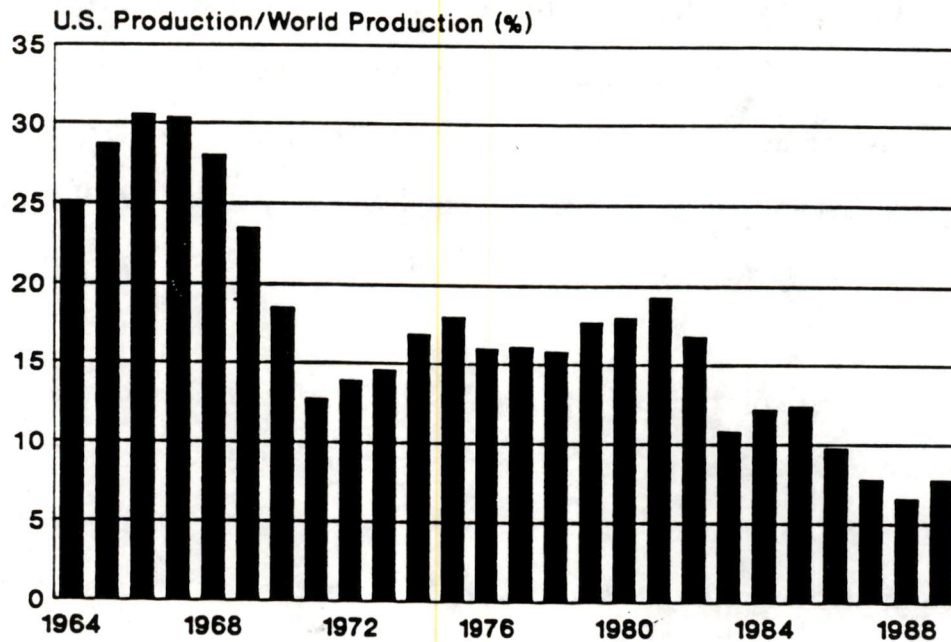
International Competition

The most notable trend in the industry during the past three decades has been the rise of Japan and the decline of the U.S. as a dominant international machine tool supplier. From less than 1% of world production in 1955, Japan grew to become the world leader in machine tool output in 1982. During the same period, the U.S. declined from just under half, to just over 10% of world production; Germany and Switzerland maintained their share; the U.K. and France suffered major declines; and Italy increased its share.⁷ In addition, since 1978 the U.S. has had a trade deficit in machine tools. Import penetration of the domestic market has increased dramatically, now accounting for a 50% share.

Although there are European firms which produce high volume, standard machine tool products, many European companies are characterized as specializing in high-performance, precision-engineered, customized products. They need a large share of the world market in order to have enough volume to profit by producing specialized niche products. They are therefore driven by export strategies.⁸

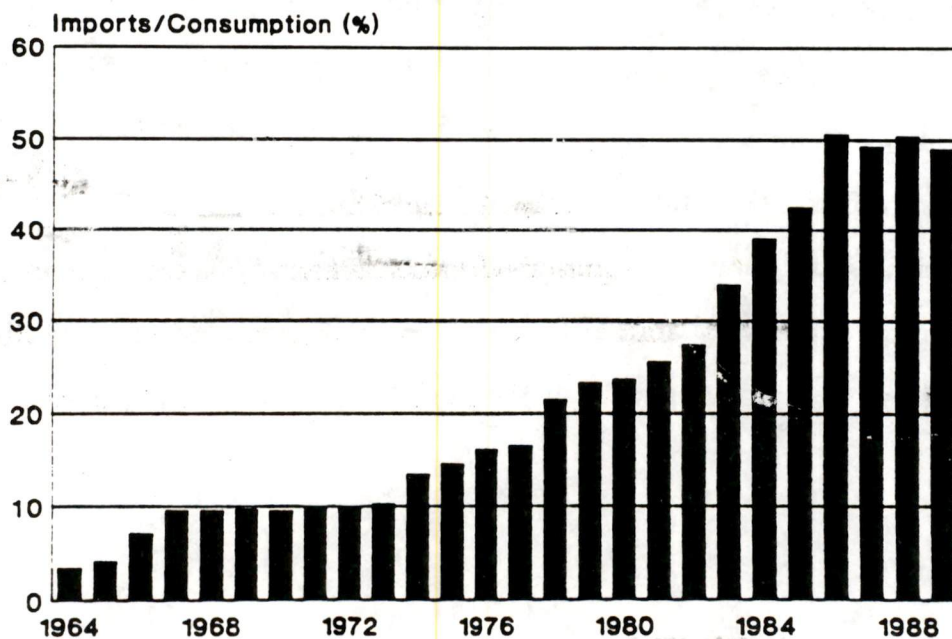
By contrast, the Japanese do not aim for specialized market niches, but for consistent, reliable, low-cost, standardized products that many different companies can use. They have concentrated on a few types of general purpose products for high volume markets. Exports are also an important part of their strategy because in order to generate economies of scale and offer low cost products, they need large production runs. In the past few years, the Japanese have ceded cost leadership at the low end of the market to the Koreans, Taiwanese and Brazilians.⁹

U.S. Share of World Machine Tool Production



Source: American Machinist

Import Penetration of the U.S. Machine Tool Market 1964-1989



Source: NMTBA

II. The Role of Technology

Innovation Processes

Budgeted R&D does not reflect the full technical effort of the industry, but it has traditionally been low. Estimates for the 1970s placed R&D at about 1.6 percent of sales. This declined to 1.3 percent in the 1980s. R&D has been concentrated in larger machine tool firms. There is however, a great deal of engineering and technical effort among builders, particularly those involved in special purpose and customized work.¹⁰

The small size of machine tool firms is in part responsible for the investment pattern in the industry, but U.S. conglomerates have also played a role. Profitable U.S. machine tool companies were attractive acquisitions for conglomerates in the 1960s and early 1970s, but the conglomerates did little to change the historically low level of R&D of the industry. Profit opportunities were viewed as inadequate to support major new technologies and innovation in the industry. The conglomerates failed to provide the greater investments necessary to develop new NC/CNC product lines.¹¹ The investments in controls and product upgrade which were made, were not enough to offset the market inroads a single Japanese controls manufacturer had achieved through its low cost, reliable controls. (A significant portion of this low cost advantage can be attributed to the overvalued dollar in the first half of the 1980s.) This single company maintained and enhanced its share of the world market through the aggressive pursuit of additional features.

One of the driving forces in developing new technology is user demand for advanced new products and processes. This kind of "technology pull" is critical in machine tools. Because machine tools are durable and have long product life cycles, machine tool builders rely on user growth and product change as the basis for developing more advanced kinds of tools.

Unfortunately, until recently, many U.S. users did not focus on manufacturing process innovation essential to their competitiveness and did not work with machine tool builders to innovate and provide leading-edge equipment.¹²

Sometimes new machine tool technology derives from observation of inventions and developments in other fields, some related and some not related:

- The original concept of numerical control came from a small Michigan company. The concept was developed by Air Force-funded studies at MIT. The U.S. Air Force needed faster, less costly and more productive machinery systems to produce aircraft. NC was originally conceived as ideal for small lots, large aircraft parts, and adaptable to complex configurations. The U.S. Air Force purchased machines, and then installed them in the factories of prime and subcontractors, thus creating a growth in applications. The machine tool industry responded with the development of less sophisticated point-to-point machines which were more suited to the bulk of U.S. applications at the time. However, they were still confronted by user complacency and doubts about implementing this new technology.

- The development of semiconductors in the communications field led to a series of improvements in the capability of numerical control units.
- The servo control concepts developed during World War II for the U. S. Navy also made numerical control of machine tools practical.
- The machine tool industry introduced the numerically-controlled automatic tool changer, which made possible the machining center and flexible machining cells and systems that are the leading technology in manufacturing today.
- Hydrostatic bearings, which were developed for the steam and hydro turbine industries to carry tremendous loads with little or no friction, have made possible super-precision machine tools and enabled large, massive machines to be able to accelerate and decelerate at very rapid rates.

Critical Technologies

Machine tool design has evolved from basically mechanical mechanisms to highly sophisticated systems involving many different technologies. The following list represents the critical technologies that affect the capability and competitiveness of machine tools in manufacturing.

- Metrology
- Physics of materials
- Advanced precision bearings
- Electronic controls
- Artificial intelligence
- Laser technology
- Metallurgy
- Dynamics of structures
- Advanced materials technology
- Software
- Sensors technology

Each of these technologies is critical to competitiveness because each affects the performance and capability of machine tools. They are universal in their application, although each one may not be used in every machine type. The performance and characteristics of a particular machine are determined by the:

- basic mechanical and physical design of the machine;
- materials used in its construction;
- selection and application of various bearings;
- controls that direct the motion and speed of movement as well as the repeatability of the machine;
- software that commands the controls;
- sensors and measuring devices that inform the software in the controls about the operation and positions of the various elements of the machine tool.

Developing these critical technologies requires significant multi-disciplinary research and development programs. Even within these general research needs lies a large range of prerequisite and application-specific research programs. For example:

- Precision improvement includes tool sensing to correct for deviation from programmed tolerances; hardware/software monitoring, mapping and correction procedures; and positional and thermal sensing to compensate for structural errors.
- Sensing-research projects include the development of position transducers, so that sensors are accurate in increasingly higher-speed machining; sensor arrays to integrate the measurement taken during the various steps of the machining process; and the development of lower cost laser feedback systems.
- Computer software projects include expert systems and artificial intelligence; improved machine controls; and the development of a real-time, object-oriented computer language to develop numerically controlled machine software, as hardware development is constrained by the high cost of concurrent software development.

The complexity of these research undertakings is multiplied as advances in new materials and microelectronics continue. The scope and expense of such research efforts precludes all but the top few machine tool builders from undertaking the necessary effort. For the typical machine tool builder, with annual sales of about \$7 million, mounting even a small research and development effort is prohibitive.

Detailed information on the critical technologies is provided below:

CRITICAL TECHNOLOGY:

Electronic Controls

DESCRIPTION:

Electronic controls are used to command and control the motions and functions of machine tools. These controls may be relatively sophisticated Computer-based Numerical Controls (CNCs) which use numerical part programming information to command the machine, or Programmable Logic Controls (PLCs) which utilize electronic components to effect the sequential control logic previously provided by electromechanical relays.

WHY IS IT A CRITICAL TECHNOLOGY:

In order to meet the demand for increased machine versatility and to efficiently produce parts having complex shapes and/or close tolerances, which are increasingly used in aerospace, defense and consumer products, it is necessary that the machines producing these parts be electronically controlled. Such controls eliminate the variability and inefficiencies associated with human control of machines. The increased emphasis on product quality also dictates use of electronic controls that allow the manufacture of parts with close part-to-part consistency.

U.S. POSITION RELATIVE TO THE REST OF THE WORLD (RoW):

		<u>Lag</u>	<u>Par</u>	<u>Lead</u>
J = Japan	1990	J, E		
E = Europe	2000	J, E		

THREATS TO U.S. RETAINING/GAINING PROMINENCE IN TECHNOLOGY:

Although the concept of numerical controls was created in the United States and further developed at MIT in the early 1950s, the dominant supplier of such equipment today is Fanuc of Japan, which accounts for over 70 percent of the world market. As a result of this and the fact that the Japanese government subsidizes considerable industrial research conducted in their country, the United States will have a hard time regaining the lead it once enjoyed. Recently the Japanese have exploited the U.S. developed capability which allows user-friendly programming of complex parts right at the machine.

TECHNOLOGICAL INTERDEPENDENCIES - RELATED TECHNICAL ISSUES:

Electronic controls are technologically dependent upon advances made in the semiconductor and computer industries. The emerging popularity of 32-bit Central Processing Units (CPUs) has decreased their cost to both computer manufacturers and to suppliers of electronic controls for production equipment. This development has in turn allowed the design and development of electronic controls having both increased functions and speed.

CRITICAL TECHNOLOGY:

Sensor Technology

DESCRIPTION:

Sensors are devices that provide an indication of force, displacement, power, temperature, or other process variables. They typically provide inputs to the electronic controls used to control a production process or piece of equipment.

WHY IS IT A CRITICAL TECHNOLOGY:

The control over a manufacturing process is a function of the degree to which process variables can be measured and of the relationship between these process variables and the attributes of the finished part. Because of this, sensor technology is critical to the efficient production of close tolerance parts. Of critical importance is not only the technology of the sensors themselves, but also the technology of signal processing and communication related to the sensor output.

U.S. POSITION RELATIVE TO RoW:

	<u>Lag</u>	<u>Par</u>	<u>Lead</u>
1990	J, E		
2000	J, E		

The United States lags the Europeans in the technologies associated with measurement of vibration, noise and displacement. It lags Japan in the technologies associated with solid-state video imaging.

THREATS TO U.S. RETAINING/GAINING PROMINENCE IN TECHNOLOGY:

The U.S. machine tool industry is dependent upon others for much of the sensor technology it uses. Many of these suppliers are foreign firms. No U.S. firm is large enough or profitable enough to undertake by itself a research program of sufficient scope to compete with any of the foreign companies who have well-established footholds in these areas.

TECHNOLOGICAL INTERDEPENDENCIES - RELATED TECHNICAL ISSUES:

In many cases the critical element of a sensor is made of semiconductor material, thus there is a dependence of the sensor industry upon the semiconductor industry. This dependence extends to the devices used for sensed signal conditioning for signal conversions, and for sensed signal mixing and decoding.

CRITICAL TECHNOLOGY:
Software

DESCRIPTION:

Software is the collection of programmed instructions used to define the responding, controlling and communicating functions of computer-based engineering and manufacturing equipment and systems.

WHY IS IT A CRITICAL TECHNOLOGY:

Software defines the responding, controlling and communicating functions of manufacturing equipment, it is critical in determining the capability and efficiency of the equipment being controlled. (An even more critical first-step is having a clear understanding of the process to be controlled.)

U.S. POSITION RELATIVE TO RoW:

	<u>Lag</u>	<u>Par</u>	<u>Lead</u>
1990			J, E
2000		J, E	

THREATS TO U.S. RETAINING/GAINING PROMINENCE IN TECHNOLOGY:

The United States has been a recognized leader in software programming expertise. This exists primarily because electronic computers were first developed in the United States, and the installed base of computers, both main-frame and personal, is much larger here than in any other country. The rest of the world is rapidly catching up with the United States, as evidenced by the increasing number of Computer-Aided Design (CAD) systems available from overseas suppliers and by the increasing number of user-friendly features being added to Computer-based Numerical Controls (CNCs) produced abroad.

TECHNOLOGICAL INTERDEPENDENCIES - RELATED TECHNICAL ISSUES:

As noted above, being able to efficiently program computer-based systems can only be done once the process to be controlled is sufficiently understood. Thus, the development of "good" software requires a background in manufacturing engineering, process engineering, and mathematics as well as a good background in computer programming. In effect, continuing state-of-the-art expertise in software is dependent upon continually updated experience and/or education in all of the aforementioned fields.

CRITICAL TECHNOLOGY:
Artificial Intelligence

DESCRIPTION:

Artificial intelligence as applied to manufacturing is that branch of science devoted to computer control of a product or a process using algorithms, logic and/or cause-effect relationships which might otherwise exist in the mind of a human operator or process designer.

WHY IS IT A CRITICAL TECHNOLOGY:

Artificial intelligence has the potential to significantly improve the productivity of manufacturing operations by incorporating human experience and/or human thought processes in the control regimen. As such it has the potential to improve the competitiveness of those businesses which employ it.

U.S. POSITION RELATIVE TO RoW:

	<u>Lag</u>	<u>Par</u>	<u>Lead</u>
1990			J, E
2000		J, E	

THREATS TO U.S. RETAINING/GAINING PROMINENCE IN TECHNOLOGY:

The United States has pioneered efforts to develop artificial-intelligence technology particularly as it relates to manufacturing and/or the organization of data bases. It is anticipated, as a result of international interest in the subject, that competitive advances in this field will come from around the world and will not be limited to those made by U.S. investigators.

TECHNOLOGICAL INTERDEPENDENCIES - RELATED TECHNICAL ISSUES:

The utilization of artificial intelligence techniques, as is the case with the development of manufacturing-related software, is dependent upon a knowledge of both the manufacturing processes to be controlled and the science of artificial intelligence. A strong background in both manufacturing and in computer science is required.

CRITICAL TECHNOLOGY:

Laser Technology

DESCRIPTION:

Laser technology is the use of narrowly-focused light beams for measurement, and processes requiring the discrete application of heat.

WHY IS IT A CRITICAL TECHNOLOGY:

Possessing a continually updated inventory of state-of-the-art laser technology is critical to U.S. manufacturers because it can profitably be applied to such varied manufacturing tasks as measurement, cutting, joining, marking, etching, surface finishing, scribing, hole cutting, deburring, heat treating, chip breaking, etc. Indeed, many aerospace and commercial parts could not be economically produced without the use of laser technology.

U.S. POSITION RELATIVE TO RoW:

	Lag	Par	Lead
1990			J, E
2000		J, E	

THREATS TO U.S. RETAINING/GAINING PROMINENCE IN TECHNOLOGY:

It is known that the Japanese have for some years had a program to develop a manufacturing system utilizing a high-powered laser and a split-beam delivery system. This and other Japanese and European research endeavors will challenge the leadership currently enjoyed by the United States in laser technology.

TECHNOLOGICAL INTERDEPENDENCIES - RELATED TECHNICAL ISSUES:

Laser technology is dependent upon precision turning and finishing technologies for mirrors, and on optics and fiber-optics technologies for other aspects of the beam-delivery systems.

CRITICAL TECHNOLOGY:
Physics of Materials

DESCRIPTION:

The physics of materials relates to the measurable properties and characteristics of materials. For manufacturing, these properties are primarily those that relate to how the material cuts, bends, shears and welds.

WHY IS IT A CRITICAL TECHNOLOGY:

In order to produce a manufactured part, it is necessary to design an efficient process to create that part. In order to design the process, it is critical that one understands the physical characteristics of the material of the part, and especially how the characteristics of the part and the selected tool(s) will interact.

U.S. POSITION RELATIVE TO RoW:

	Lag	Par	Lead
1990		J, E	
2000		J, E	

THREATS TO U.S. RETAINING/GAINING PROMINENCE IN TECHNOLOGY:

For a number of years the U.S. manufacturing engineers have maintained a wealth of data showing what feeds and speeds should be selected for the efficient production of parts produced by metal cutting techniques. These data were available for a variety of combinations of workpiece materials and tool materials. With the advent of new tool materials (such as coated carbides, ceramics and Cubic Boron Nitride (CBN) materials) the previously published data are no longer sufficient. Research and/or lab tests to establish appropriate feeds and speeds for workpieces made of newer alloys and for tools made of new materials must be developed.

TECHNOLOGICAL INTERDEPENDENCIES - RELATED TECHNICAL ISSUES:

The magnitude of the project to develop new feed and speed information is a function of the rapidity with which new alloys are developed by the primary metals industry and how fast tooling manufacturers develop new materials and/or coatings for tooling. It is likely that the need for the development of information on the physics of new materials (for both workpieces and tooling) will be forever ongoing as new materials continue to be developed.

CRITICAL TECHNOLOGY:
Advanced Materials Technology

DESCRIPTION:

Advanced materials include those not considered primary metals or their common alloys. They include metal matrix composites, graphites, fiber glass, ceramics and other man-made materials.

WHY IS IT A CRITICAL TECHNOLOGY:

Many industries require the use of special materials capable of withstanding the rigors of unusual environments. These industries include the aerospace and supersonic transport industries, nuclear industry, undersea exploration industry, petrochemical industry, etc. These industries require parts manufactured from materials capable of withstanding severe temperature, pressure, nuclear bombardment, corrosive, and similar environments. In order to retain our lead in the industries requiring these types of parts, it is necessary that we retain our lead in advanced materials technology.

U.S. POSITION RELATIVE TO RoW:

	<u>Lag</u>	<u>Par</u>	<u>Lead</u>
1990		J	E
2000	J	E	

THREATS TO U.S. RETAINING/GAINING PROMINENCE IN TECHNOLOGY:

While the United States currently leads in advanced materials technology, this lead could be eroded by ignoring the research being pursued by firms in other countries including Japan, West Germany, France, Great Britain and Israel. The United States needs to be aware of and know the properties of these advanced materials in order to design and offer machines capable of producing parts made of such materials. The industry also needs to be aware and take advantage of the characteristics of these advanced materials when selecting the materials to be used in all newly designed machine tools.

TECHNOLOGICAL INTERDEPENDENCIES - RELATED TECHNICAL ISSUES:

The U.S. machine tool industry depends upon other industries for the development of these advanced materials and must work closely with them in order to minimize the time delay between the availability of advanced materials and the availability of manufacturing equipment capable of processing and/or utilizing those materials.

CRITICAL TECHNOLOGY:
Advanced Precision Bearings

DESCRIPTION:

Advanced precision bearings are used in machinery and technical products where there is a high demand for accuracy and reliability. Applications in jet engines, navigation devices and precision machine tools are typical.

WHY IS IT A CRITICAL TECHNOLOGY:

Modern machine tools require bearings of high geometric accuracy and low mechanical wear over time. Jet engines also require advanced precision bearings because of the necessary tolerance for high temperatures.

U.S. POSITION RELATIVE TO RoW:

	<u>Lag</u>	<u>Par</u>	<u>Lead</u>
1990	J	E	
2000	J	E	

Precision bearing races are especially ground, checked and paired together. Many state-of-the-art bearings come with ceramic balls for longer life and increased accuracy. Ceramic bearing technology is relatively new and only a few countries – Japan, West Germany and the United States – have that capability. Japan has a considerable lead over the United States.

THREATS TO U.S. RETAINING/GAINING PROMINENCE IN TECHNOLOGY:

The main threat is that these bearings are available from Japan at competitive prices. Their usage has been relatively low and U.S. suppliers have not been eager to adopt this technology.

TECHNOLOGICAL INTERDEPENDENCIES - RELATED TECHNICAL ISSUES:

Advanced precision bearing technology and especially ceramic bearing technology is dependent on the development of quality ceramic materials resistant to heat-induced cracking, and the availability of equipment to machine them. Here again, Japan has a considerable lead over the United States resulting from their previous work on ceramic rotors for automotive turbochargers and their research and experimental work on developing components for the so-called "adiabatic engine."

CRITICAL TECHNOLOGY:

Metrology

DESCRIPTION:

Metrology is the science of measurement and comparison of these measurements to an established system of references. Metrology is used extensively in manufacturing industries and especially in the machine tool and related industries.

WHY IS IT A CRITICAL TECHNOLOGY:

Present day technical products require accuracies unheard of a few years ago. The established "rule of thumb" requires that measuring instruments be at least ten times more accurate than the tolerance on the measured value. This necessitates the use of such technologies as optics, fiber-optics, laser beams, microelectronics, computers, etc. Without well-founded metrology principles and the associated precision instruments, the United States would be incapable of manufacturing the precision parts required for contemporary products.

U.S. POSITION RELATIVE TO RoW:

	<u>Lag</u>	<u>Par</u>	<u>Lead</u>
1990	J,E		
2000	J,E		

THREATS TO U.S. RETAINING/GAINING PROMINENCE IN TECHNOLOGY:

U.S. research and innovation in this area has been lagging behind that of Japan, West Germany and Switzerland. While in the past, Germany was at about the level of the United States, it continued with its thrust toward better, more complex measuring instruments. Japan has made great strides over the last 10-20 years, and is today neck and neck with West Germany.

While the United States still maintains equality in the theoretical field, regaining superiority in the commercial metrology industry will take substantial investment in manpower and capital.

TECHNOLOGICAL INTERDEPENDENCIES - RELATED TECHNICAL ISSUES:

Future advances in metrology may be fueled by new developments in fiber-optics, opto-electronics and high speed microcomputers. There is renewed interest sparked by the drive for product quality throughout the manufacturing sector, including the machine tool industry.

CRITICAL TECHNOLOGY:
Dynamics of Structures

DESCRIPTION:

The dynamics of structures is a scientific discipline based on the fundamentals of the strength and elasticity of materials. This science focuses on the minute elements of a structure, analyzing its behavior when subjected to a given set of external forces.

WHY IS IT A CRITICAL TECHNOLOGY:

Mechanical structures deform when subjected to external forces, such as those incurred by a machine tool. It is advantageous if the resulting deformation can be calculated and if steps can be taken to either minimize it or to use it as an advantage. Although the fundamentals of the dynamic behavior of structures have been known for some time, modern day computers have made possible comparisons between different structures subjected to a given set of forces. By using a technique known as "finite element analysis," one can predict the static and dynamic behavior of such structures and undertake countermeasures by either redesigning the structure or by rearranging the applied forces.

This technology makes it possible to design superior structures, be they machine tools, aircraft, automobiles, bridges or any other complex product.

U.S. POSITION RELATIVE TO RoW:

	Lag	Par	Lead
1990			J,E
2000		J,E	

THREATS TO U.S. RETAINING/GAINING PROMINENCE IN TECHNOLOGY:

The United States acquired prominence in this field at the time of the first mass introduction of powerful commercial computers. Lately, however, several industrialized nations have caught up with the United States. Japan, West Germany, Great Britain, Italy and even smaller countries like Belgium and the Netherlands are becoming world players in this discipline.

TECHNOLOGICAL INTERDEPENDENCIES - RELATED TECHNICAL ISSUES:

Computer technology plays a major role in this field. Proficiency in the use of computers and availability of the related software are of the utmost importance.

CRITICAL TECHNOLOGY:

Metallurgy

DESCRIPTION:

Metallurgy is the science of production and use of metals. It includes several disciplines, such as the extraction of metals from the ore, purification of the extracted metals, and their alloying, heat treatment and testing.

WHY IS IT A CRITICAL TECHNOLOGY:

Modern high-technology metals are exposed to a variety of environments, such as high temperature in aerospace engines. Another key application for specialty metals is in hostile environments, such as highly corrosive environments, chemically aggressive environments, mechanically abrasive environments and the like. The rotor blades of the gas turbine portion of a jet engine are heavily stressed by centrifugal force and are subjected to thermal stress as well as to mechanical abrasion from ingested debris. In some applications, the requirement is based on the light weight of the metallic components and this is where light alloys come into play. In machine tools, the emphasis is on structural integrity, resistance to wear of moving parts and suppression of vibration induced by the cutting or on inertia forces due to the cycling of the machine.

U.S. POSITION RELATIVE TO RoW:

	Lag	Par	Lead
1990		E	J
2000		J,E	

THREATS TO U.S. RETAINING/GAINING PROMINENCE IN TECHNOLOGY:

This is one of the areas where the United States once had overwhelming international superiority, some of which still exists. Much of this technology was first developed by the automotive industry and later by the aerospace industry, including NASA. Over the last several years, foreign auto manufacturers have at least caught up with the United States. The European "Airbus" consortium has made great strides in civilian aircraft technologies, including metallurgy. In addition, Japan is planning to develop a fighter plane based on the U.S. F-16. It is almost certain that they will learn some of the existing U.S. technologies. One of the factors working against future U.S. superiority in metallurgy is the fact that in the United States emphasis has shifted from metals to other man-made materials such as plastics, carbon fiber and different high-tech composites.

TECHNOLOGICAL INTERDEPENDENCIES - RELATED TECHNICAL ISSUES:

There is a high degree of competition between metallic materials and the newly developed high strength composites. In the automotive industry, plastics are replacing metal parts. All this directly affects the amount of funds budgeted for metallurgical research, chipping away at the historic U.S. preeminence in this field.

III. Threats to U.S. leadership in the Critical Technologies

Technological leadership requires a financially healthy industry, with the resources to invest in new products and processes. Financial health will only come with an internationally competitive industry that is free to pursue opportunities worldwide in the now global machine tool market. The U.S. industry does not maintain competitive footing in many markets, resulting in lost sales, and lost opportunities for customer driven innovation.

Factors inhibiting the ability of the U.S. industry to muster the resources required to actively pursue the research and development of critical technologies include:

- Small size and family ownership have reinforced a pattern of fragmentation and slow model-production changes. This, in turn, has contributed to limited resources for reinvestment and research, few links to university research joint projects, and often limited efforts to develop new products. Although many U.S. firms have a strong technical footing, because of their small size they have difficulty sustaining systematic long-term R&D efforts.¹³
- The extreme business cycles that characterize the industry also work against systematic investment in R&D. Dramatic shifts in demand for machine tools result from the multiplier effects of machine tool customers' orders and cancellations in response to their own business cycles. The cyclical nature of the business has resulted in volatile cash flow, problems in recruiting and retaining skilled technical people and a tendency to backlog orders to cushion against cyclical market forces.¹⁴

- U.S. export control policy is characterized by intransigence and delay. Uneven interpretation, administration and enforcement of COCOM's multilateral export control regime, in comparison with our allies, has seriously damaged U.S. machine tool exports. Not only does the U.S. Government enforce the rules more rigorously than its allies, it has refused to update the machine tool control list for 16 years. Largely as a result, in 1988 the United States exported just \$1.3 million of machine tools to the Soviet Union. In the same year, West Germany exported \$568 million worth of machine tools to the Soviets, and Japan exported \$122 million.
- U.S. tax laws are biased against savings and investment and provide inadequate capital cost recovery. The 1986 Tax Reform Act's elimination of the investment tax credit and creation of a new Alternative Minimum Tax (which decelerates depreciation and increases the tax burden of marginally profitable, capital-intensive firms) have increased the cost of capital for America's machine tool industry and its customer base. While the United States decelerated depreciation schedules, other nations accelerated depreciation schedules and therefore stimulated investment.
- The U.S. product liability system, which is characterized by uncertainty, high transaction costs and lack of uniformity, unnecessarily burdens U.S. manufacturing firms. In 1988, the median machine tool builder spent seven times more on product liability than it did on research and development.

U.S. competitiveness in the critical technologies is also confronted by the large pool of resources foreign governments provide to ensure their domestic machine tool industry's leadership, particularly Japan and West Germany:

- During the 1950s, the Japanese government did not support any indigenous R&D projects, but controlled the flow of technology licensing agreements into Japan. Beginning in the early 1970s, government policy focused on broad subsidization of R&D through tax breaks and direct aid, and sponsorship of a number of specific projects. The government allocated \$60 million to a cooperative effort to develop FMS, and once the basic technology was widely available, focused on financial assistance for installation. Although no specific figures are available, it is estimated that direct Japanese government expenditures for the machine tool industry has been approximately \$500 million, and total assistance could be as high as \$1 billion. More recently, the government has taken the leading financial role, committing to underwrite \$400 million of a \$1 billion 10 year international R&D effort on intelligent manufacturing systems.
- The European Community offers direct research and development assistance to individual companies through its BRITE, EUREKA and ESPRIT programs.

- The West German government has encouraged broad cooperation in R&D, training, setting of standards, and sales and service support in foreign markets. Contract research has been performed at eight major technical institutes, providing research that small companies could not undertake on their own. Individual firms have been able to obtain funding for their own research projects, if they published the results within two years of completion. The government has also helped to channel bank funds to specialist producers for their expansion efforts, and has strongly promoted trade within the Eastern Bloc.
- Canada, the United Kingdom, Italy and Japan heavily subsidize foreign buyer visits to their countries. Visits to the United States are funded entirely by the foreign visitor.
- Canada, France and the United Kingdom heavily subsidize foreign trade missions to promote exports. The United States does not.

Currently, certain U.S. machine tool products (lathes, machining centers, milling machines, and punching and shearing machines) are covered by a Voluntary Restraint Agreement (VRA) with Japan and Taiwan, instituted in 1987. The agreements are scheduled to expire in December of 1991. If the VRA is ended in 1991, foreign competitors are likely to reassert their pre-1987 domination of the U.S. market.

IV. Factors Supporting U.S. Leadership in the Critical Technologies.

The United States is still near the top in terms of world machine tool consumption. This large domestic market could be the basis for the U.S. machine tool industry regaining leadership in the industry's critical technologies. Strong relationships with its customer base, in such areas as simultaneous engineering, could result in a symbiosis which would raise the competitiveness of both the machine tool industry and its customers.

A number of public policies have had some positive impact on the competitiveness of the U.S. industry. But many of the programs are not intended to directly help the machine tool industry.

The support to U.S. industry pales in comparison to that provided the machine tool industries of Europe and Japan:

- The National Center for Manufacturing Sciences (NCMS) was established in 1986. It is funded by membership fees and government grants. Its mission is to provide research support to the community of U.S. manufacturers in order to enhance their competitive position. A primary means of providing support is through the sponsorship of R&D activities which are critical to the advancement of state-of-the-art manufacturing technology.

- The Small Business Innovation Research (SBIR) program, administered by the U.S. Small Business Administration and established in 1982, is authorized through FY 1993. The program provides Phase I awards of up to \$50,000 for evaluation of the technical merit and feasibility of ideas of potential use to businesses having fewer than 500 employees. Follow-on awards are possible.
- The U.S. Department of Defense Manufacturing Technology program (MANTECH) has the potential for addressing some of the research needs of the machine tool industry, provided there is significant direct participation by machine tool companies in the development and diffusion of new technologies. The Air Force, which was involved in the development of numerical controls in the 1950s, has recently shown interest in such participation. There is also a potential for significant DARPA participation in machine tool research and development projects.
- The National Institute for Standards & Technology (NIST) for several years has funded, directly or with help from the U.S. Navy, work at the Advanced Manufacturing Research Facility (AMRF) whose function is to help develop manufacturing standards applicable to the machine tool industry.
- The National Science Foundation (NSF) provides research awards. In recent years, awards relating to manufacturing technology projects have increased. Research into high speed milling, grinding, process simulation, analysis of machine structures and robotics has been augmented by NSF funding.

- The U.S. Congress has modified the R&D Tax Credit so it is more usable by small, slow-growth companies, such as many U.S. machine tool builders.
- The United States currently has the lead in the emerging artificial intelligence and expert system technologies. However, West Germany and Japan are rapidly catching up.

Other Opportunities for the U.S. Industry

- Regrowth of U.S. supplier base is necessary to secure the products necessary to build U.S. machine tools.
- Export potential exists, particularly to the newly industrializing countries, Europe, the Soviet Union and Central Europe.
- U.S. industry must find a way to apply high-tech inputs (CAD, CNC, etc.) to small companies that cannot afford, let alone understand, electronic inputs. Drawings on paper are becoming increasingly obsolete.

FOOTNOTES

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ABOUT THE PROJECT

This research paper is part of an in-depth, two-year study to assess whether U.S. national technology priorities meet the needs of American industry in the global economy. The final report of the project, Gaining New Ground: Technology Priorities for America's Future, was published in March 1991.

The project had three fundamental objectives: 1) to identify, on a sector-by-sector basis, the critical technologies that will drive performance in key sectors of the economy in the 1990s, 2) to assess the strengths and weakness of U.S. industry and the U.S. policy environment with respect to developing these technologies and 3) to use this information to develop national technology priorities to guide U.S. public policy and private-sector management related to technology.

This research paper is one of nine studies of technology intensive sectors of U.S. industry. Each study evaluated the sector's approach to technology, its competitive position, and the key technologies driving its performance. These studies served as a basis for deliberations by the Council's technology advisory committee and for the findings and recommendations in the final report.

Each of the nine research papers was reviewed by the technology advisory committee and by leading technology experts, business executives, university professors and officials, labor leaders, and industry associations. Although these groups all provided valuable input, they do not necessarily agree with everything in the studies.

These research papers were not reviewed or approved by the Executive Committee of the Council on Competitiveness. Consequently, the views expressed in these profiles do not represent the official position of the Executive Committee of the Council. The Council's consensus findings and recommendations are contained in the final report, Gaining New Ground: Technology Priorities for America's Future.

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ABOUT THE COUNCIL

Founded in 1986, the Council on Competitiveness is a nonprofit, nonpartisan organization of chief executives from business, higher education and organized labor who have joined together to pursue a single overriding goal: to improve the ability of American companies and workers to compete more effectively in world markets while raising the standard of living at home.

To build consensus within the public- and private-sectors on the actions needed to help Americans compete, the Council pursues a three-part agenda: increase public awareness of the breadth and severity of America's economic problems; mobilize the political will required to set the United States on a positive economic course; and assist in the development of specific public policies and private-sector initiatives. To that end, the Council combines action and analysis in four issue areas: fiscal policy, science and technology, international economics and trade, and human resources.

The Council is governed by an executive committee and draws on the resources of its national affiliates -- more than two dozen trade associations, professional societies and research organizations -- to help analyze issues and develop consensus. The Council is privately supported through contributions from its members, foundations and other granting institutions.