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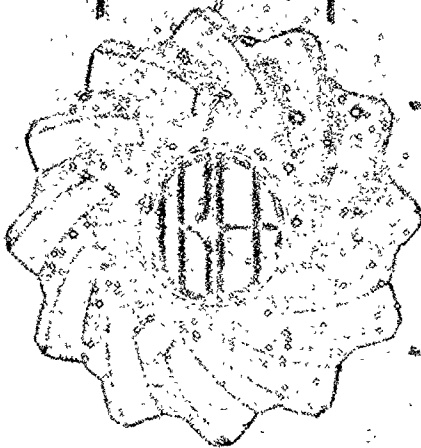
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ARMY
INVESTMENT CASTING INDUSTRY
REPORT

APRIL 1987

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**ARMY
INVESTMENT CASTING REPORT**

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PREFACE

This study was conducted under the auspices of the Army Materiel Command (AMC). Engineering and survey support was provided by the U.S. Army Industrial Base Engineering Activity (IBEA) and the Department of Commerce Office of Industrial Resource Administration (OIRA).

AMC, headquartered in Alexandria, VA, is responsible for actions necessary to provide materiel and support to the soldier in the field. Functions include: research and development; procurement and production; international logistics programs; and storage, distribution, maintenance, demilitarization, and disposal for the continental U.S. Army wholesale supply and maintenance systems as well as for overseas systems. The U.S. Army Industrial Base Engineering Activity is a field operating element of Headquarters, U.S. Army Materiel Command. One of the missions of IBEA is to provide engineering, technical, and management support to the HQ AMC Deputy Chief of Staff for Production.

The Office of Industrial Resource Administration is the focal point in DOC for analysis and regulations pertaining to the U.S. defense base. OIRA's mission is to ensure that industrial resources are available in a timely fashion for ongoing national security programs and that programs are in place to assist the defense industrial base in responding to surges in defense requirements or to other national security emergencies.

One of OIRA's functions is to collect and analyze information on the production capacity of U.S. manufacturers under authority of the Defense Production Act of 1950, as amended. OIRA developed and disseminated the mandatory survey instrument utilized to analyze the investment casting industry. OIRA and IBEA then used the collected information to perform the following assessment of the ability of the U.S. investment casting industry to support defense needs under peacetime and crisis conditions.

The Industrial Base Engineering Activity also acknowledges the active participation and constructive comments provided by the Investment Casting Committee of the American Foundrymen's Society, the Investment Casting Institute, and the Canadian Defence Industries and Emergency Planning Branch, Department of Supply and Services.

PURPOSE

The purpose of this study was to assess the ability of the investment casting industry to support the Army and the other services during peacetime, surge, and mobilization.

SCOPE

The scope of the study included ferrous and nonferrous investment casting foundries in the United States and Canada. Medical, jewelry, and art foundries were excluded. The study also included a survey of prime defense contractors to obtain utilization data for investment castings.

*Keywords: blades and vanes; shell forming;
vacuum cast; National Emergency Production*

SUMMARY

The data contained in this report was principally obtained from a mandatory survey mailed by the Department of Commerce to U.S. firms thought to be investment casters. In addition, a similar survey was mailed to Canadian investment casters by the Defense Industries and Emergency Planning Branch of Canada's Department of Supply and Services. Other information was obtained from an HQ Army Material Command letter to prime defense contractors, from the 1982 Census of Manufacturers, and from the Investment Casting Committee of the American Foundrymen's Society.

While overall investment casting shipments have increased an average of 7.3 percent annually from 1981 to 1985, DOD's share of the shipments has increased 12.8 percent annually. Currently 42 percent of the investment casting shipments go to defense needs and DOD consistently uses more of the base every year. While Canada's reported production is less than two percent of the total U.S. production, 77 percent of her shipments support the defense establishment. It should be noted that other data gathered from the Canadian survey proved to be consistent with the information gathered from the U.S. casters. These similarities coupled with the relatively small Canadian market share resulted in similar conclusions when using either the U.S. defense industrial base or the North American defense industrial base.

Based on indicators of materials, capital investment, and shipments, it was concluded that the investment casting process is more labor intensive than the overall U.S. manufacturing in general. This could mean competitive problems in the future with nations having low-cost labor. Subsequent contacts with the American Foundrymen's Society reinforced this concern.

Currently the investment casting industry is in a reasonable position to handle production in an emergency situation. However with investment castings further expanding into the Defense market some foreseeable difficulties that could arise would be:

- a. Lack of adequate tooling.
- b. Dependence on critical materials suppliers.

High part complexity, rigid specifications, and high production volumes make die tooling more complex and could result in unacceptable lead times. New die tooling could add from 10 to 38 weeks to existing acceptable lead times. The investment casting industry, like other industries that produce products utilizing critical materials such as cobalt, chromium and manganese, is very dependent on obtaining these materials from foreign sources. The supply of these materials cannot be guaranteed during emergency conditions. This problem is not a result of the investment casting industry but can have a significant impact on it. The solution must be addressed by the reliance on the Government stockpile and the Defense Priority Allocation System.

INTRODUCTION

The Investment Casting Process.

The process begins by injecting wax, or plastic, into a metal die shaped like the desired part. The wax parts are then assembled into a "tree" by using sprues and runners. The wax tree is coated in slurry and allowed to dry. Multiple coatings of the slurry are added to increase the thickness of the shell. The slurry materials and binders are required to have a resistance to high temperature because of the types of materials and the many parts which are investment cast.

When the shell is dry, it is inverted in a furnace, and the wax is drained out of the shell. The ferrous or nonferrous alloy is subsequently poured into the cavity produced by the drained wax. When the metal has cooled and solidified sufficiently, the shell is removed by vibration, chemical reaction or other means. The cast parts are then cut from the tree and are ready for finish machining if needed. This description is simplified for brevity, and process variations exist to allow for different waxes, plastics, slurries, metals, furnace environments and cleaning operations.

The investment casting process produces parts which require a minimum amount of finish machining (near net shape). This makes the process attractive as an alternative to other castings or full machining. The investment casting process is ideal for medium sized production runs. High volume runs may be more economical using die castings or machining depending on the part geometry and metal alloy. On the other hand, high temperature alloys will erode dies, and very intricate parts are better suited for the investment than other casting processes. Investment casting has alternatives, but, as during World War II, it is more likely to be the alternative process.

Background.

During the past few years, studies and production/delivery problems have indicated the investment castings could be a potential problem in emergency conditions. In December 1985, the Army Material Command decided to study the investment casting industry to identify peacetime production problems and to assess the industry's ability to meet surge and mobilization requirements.

The study is a cooperative effort between the US Army Industrial Base Engineering Activity, HQ AMC and the Department of Commerce. The Department of Commerce in February 1986 mailed a survey to 242 companies thought to be investment casters (see Appendix A). This was done following Office of Management and Budget (OMB) approval of the survey questions.

While the Department of Commerce was surveying the producers, the Commanding General, U.S. Army Materiel Command sent a letter to 62 prime contractors for the military asking for leadtime and supplier information on investment castings (see Appendix B). Fifty-three responses were received. The data contained herein is from both the survey and the letter responses.

3. Study Team Members.

Participants in the study included:

- a. From HQ AMC - Dr. Joel Morris.
- b. From Department of Commerce - John Tucker and Brad Botwin
- c. From IBEA - John Chesney, Rod White, Brent Starkey, Larry Hayes, and Maurice Larson.

INDUSTRY OVERVIEW

The figure below shows a breakdown of the industry by sales volume and market type.

<u>Firm Sales/Type</u>	<u>Number of Companies</u>	<u>Number of Plants</u>	<u>1985 Shipments (\$ Millions)</u>	<u>Average Annual Increase 1981-85(percent)</u>
More Than \$10 million	17	37	1,164	6.7
\$2.5 to \$10 million	53(e)	55(e)	307(e)	9.3
Less than \$2.5 million	<u>90(e)</u>	<u>90(e)</u>	<u>81(e)</u>	<u>9.7</u>
	160	182	\$1,552	7.3%
Major Aerospace	22	39	\$1,093	7.2%
Aerospace	86(e)	91(e)	321(e)	7.4%(e)
Nonaerospace	<u>52(e)</u>	<u>52(e)</u>	<u>138(e)</u>	<u>4.4%(e)</u>
Total	160	182	\$1,552	7.3%

(e) Estimates made by DOC to account for survey no replies.

FIGURE 1. TOTAL INDUSTRY

Aerospace firms are defined as those producing investment castings that meet military specifications. Virtually all DOD investment castings meet military specifications and are thus considered "certified". In other words, any investment casting used by the military was considered to be an aerospace part, even if it was used on an item such as a truck or tank. Major aerospace producers were defined as those that have at least 50 percent of their dollar value of shipments in aerospace quality investment castings.

In an ongoing effort that relates to Figure 1, the Department of Commerce analyzed all ferrous and nonferrous casting foundries in the 1986 U.S. Industrial Outlook. The analysis summarized die and sand casting as well as investment casting. Commerce predicted a downward trend of 2 percent per year during 1986-90 for all ferrous castings and an upward trend of 1.5 percent for all nonferrous castings. Figure 1 predicts a much brighter future for the investment casting segment of the foundry industry. Based on the 7.3 percent figure, Commerce predicts a growth rate that would range from 5 to 10 percent through 1990. One could also conclude from the chart that the growth rate would be best for the smaller aerospace firms.

Figure 2 represents the dollar value of defense and non-defense shipments from 1981 to 1985.

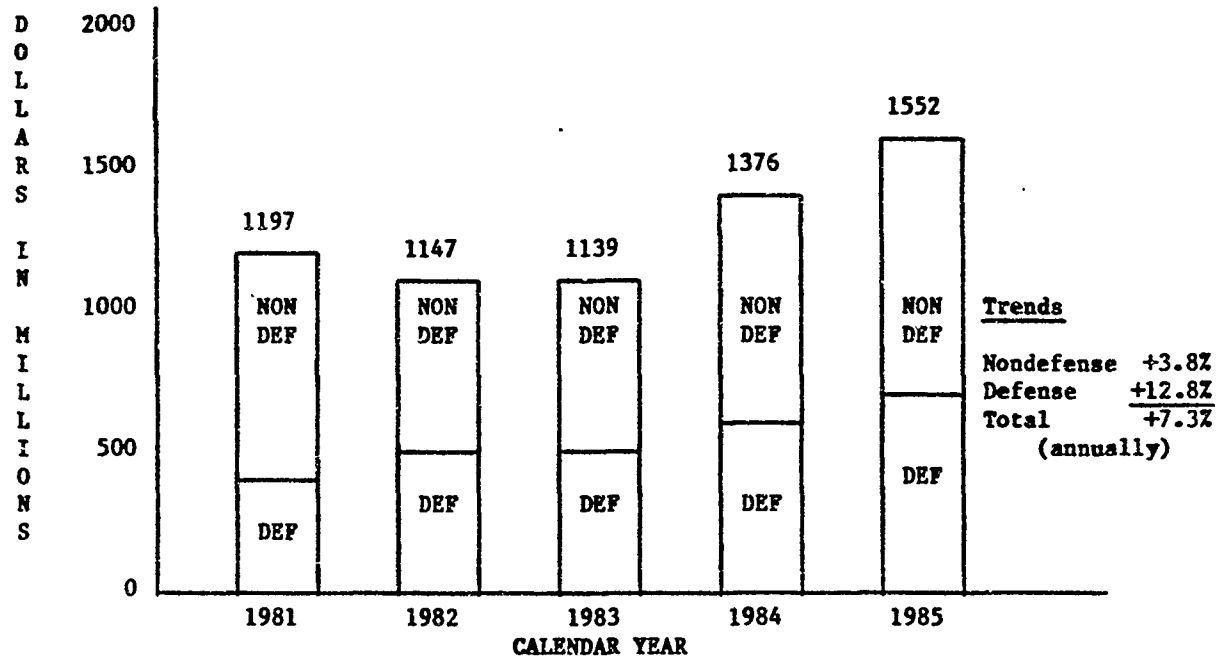


FIGURE 2. TOTAL SHIPMENTS

A key finding in this table is the increase in defense shipments since 1981. The trends, established using linear regression, show that overall shipments have grown 7.3 percent annually, but that defense shipments have grown 12.8 percent annually. With over 40 percent of the investment casting shipments going to defense needs, the trend shows that DOD consistently uses more of the industry base every year.

Figure 3 represents the amount of money the companies are investing in their plants and equipment.

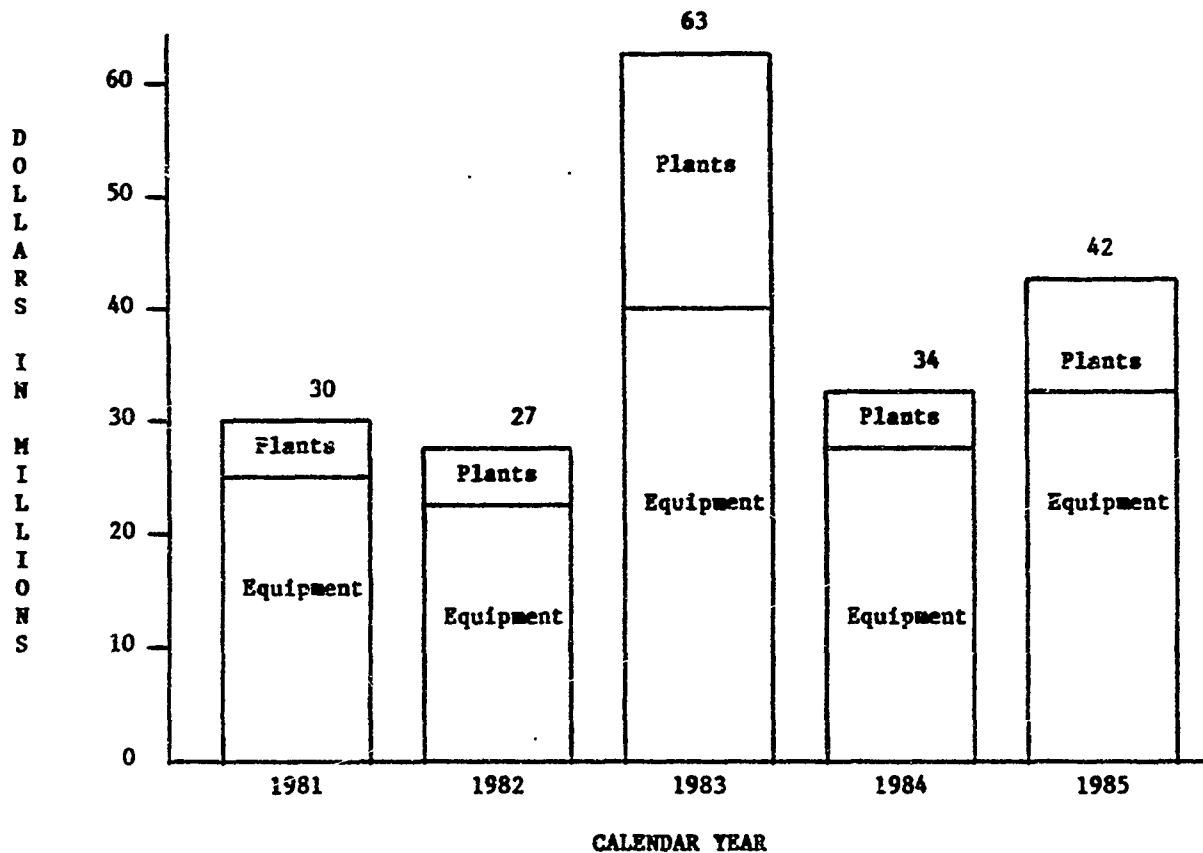


FIGURE 3. PRIVATE INVESTMENT EXPENDITURES

In 1983 three companies launched major expansion programs which account for that year's peak in capital investments. Significant is the fact that the survey responses indicated no Government investments were made in the industry during the 1981-85 period.

Figure 4 shows average age of equipment according to dollar sales volume and market capability.

<u>Firm Sales/Type</u>	<u>Die Tooling</u>	<u>Shell Forming</u>	<u>Finishing</u>	<u>Casting Melt</u>	<u>Pattern Assembly</u>	<u>Inspection</u>
More Than \$10 Million	8	7	9	8	9	6
\$2.5 Million to 10 Million	5	6	7	5	6	4
Less Than \$2.5 Million	<u>5</u>	<u>6</u>	<u>10</u>	<u>10</u>	<u>6</u>	<u>8</u>
OVERALL	7	7	8	7	8	6
Major Aerospace	8	7	8	8	9	6
Aerospace	5	5	6	5	5	4
NonAerospace	<u>7</u>	<u>6</u>	<u>11</u>	<u>9</u>	<u>6</u>	<u>6</u>
OVERALL	7	7	8	7	8	6

FIGURE 4. AVERAGE AGE OF EQUIPMENT - YEARS

The industry on average has newer equipment than all industrial averages U.S. wide. It restates that the investment casting base is not made up of old, out of date equipment in need of replacement. The \$2.5 million to 10 million firms have the newest equipment and the firms supporting DOD needs (i.e. those producing aerospace parts) generally have newer equipment than those which don't. IBEA's Industrial Plant Equipment Vintage Study found the following average ages of comparable U.S. machine tools: grinders, furnaces - 10 years, and inspection equipment - 14 years.

Figure 5 shows the 1985 capacity utilization rates for the different sectors of the industry. Companies with sales in excess of \$10 million are enjoying the highest average utilization rate at 73 percent. The overall industry, on average, is operating at 69 percent of practical capacity.

<u>Firm Sales/Type</u>	<u>Current Utilization (Range in %)</u>			<u>Time to Reach Full Capacity (in Weeks)</u>	
	<u>lowest</u>	<u>average</u>	<u>highest</u>	<u>average</u>	<u>highest</u>
More than \$10 million	40%	73%	100%	19	52
\$2.5 to 10 million	30%	68%	100%	11	36
Less than \$2.5 million	18%	57%	100%	13	75
Average	-	69%	-	18	-
Major Aerospace	30%	66%	100%	25	52
Aerospace	20%	76%	100%	17	75
Nondefense	18%	64%	100%	11	36
Average	-	69%	-	18	-

FIGURE 5. CAPACITY UTILIZATION RATES

The capacity utilization rate indicates that larger firms are making more efficient use of existing capacity. The same trend holds true whether the organizations are evaluated by sales dollars or product type (i.e., major aerospace vs nondefense). This could reflect that Defense sales, comprising over 40 percent of the market, provides a stabilized efficiency factor for those firms that support defense needs.

Figure 6 compares the steel investment casting industry with all manufacturing.

	<u>ALL MANUFACTURING</u>	<u>STEEL INV. CASTING</u>
Cost of Materials (% of value)	58%	37%
Capital Investment per employee	\$6,013	\$2,611
Shipments per employee	\$102,660	\$60,988

Reference: 1982 Census of Manufacturers

FIGURE 6. LABOR INTENSITY INDICATOR

Analysis of Figure 6 indicates that steel investment casting is more labor intensive than all U.S. manufacturing in general.

DEFENSE ASPECTS

Figure 7 shows defense and non-defense market shares for the three size categories of companies.

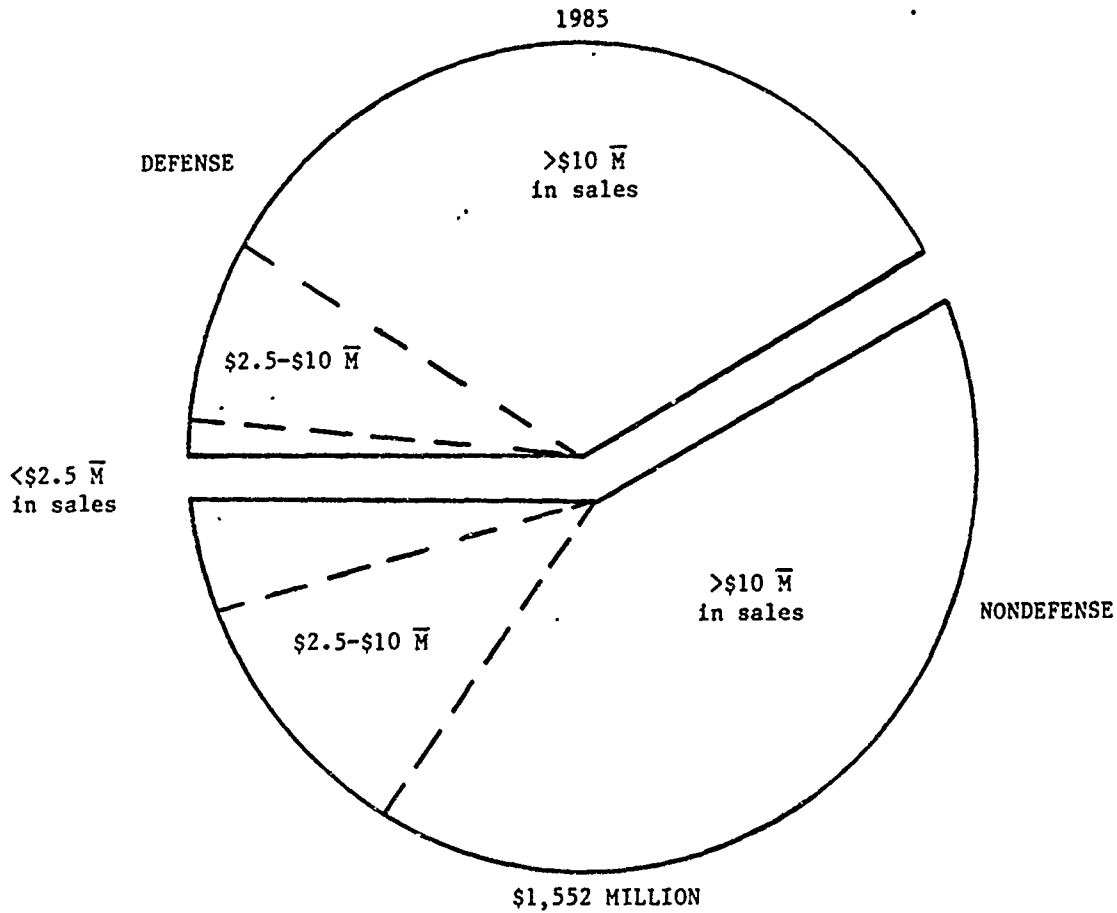


FIGURE 7. MARKET SHARE BY FIRM SIZE

The large companies, \$10 million or greater in sales, have 81 percent of the defense and 79 percent of the nondefense market. With 17 large companies out of 160 companies comprising the total, a sizeable portion of the industry sales are accounted for by a relatively small number of companies. There are 90 small firms, less than \$2.5 million in sales, sharing in a small percentage of the defense and non-defense markets - 2 and 8 percent, respectively.

Figure 8 is similar to Figure 7, but instead of breaking down the industry by sales volume, Figure 8 is by firm type.

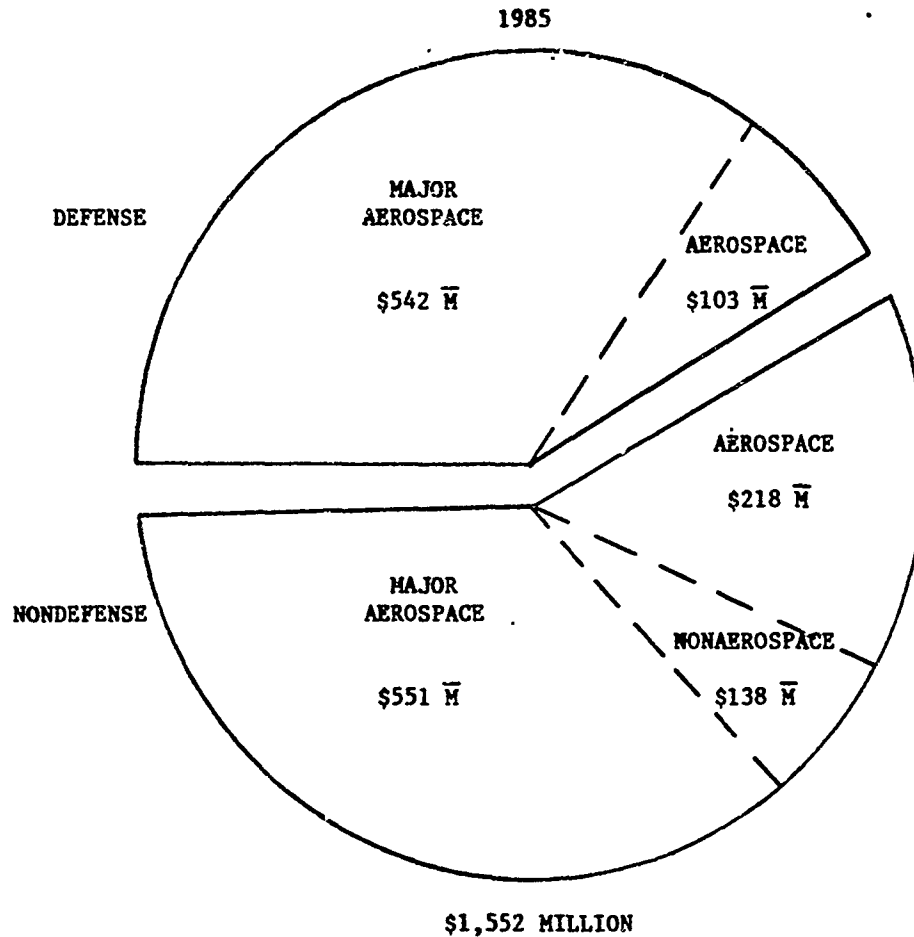
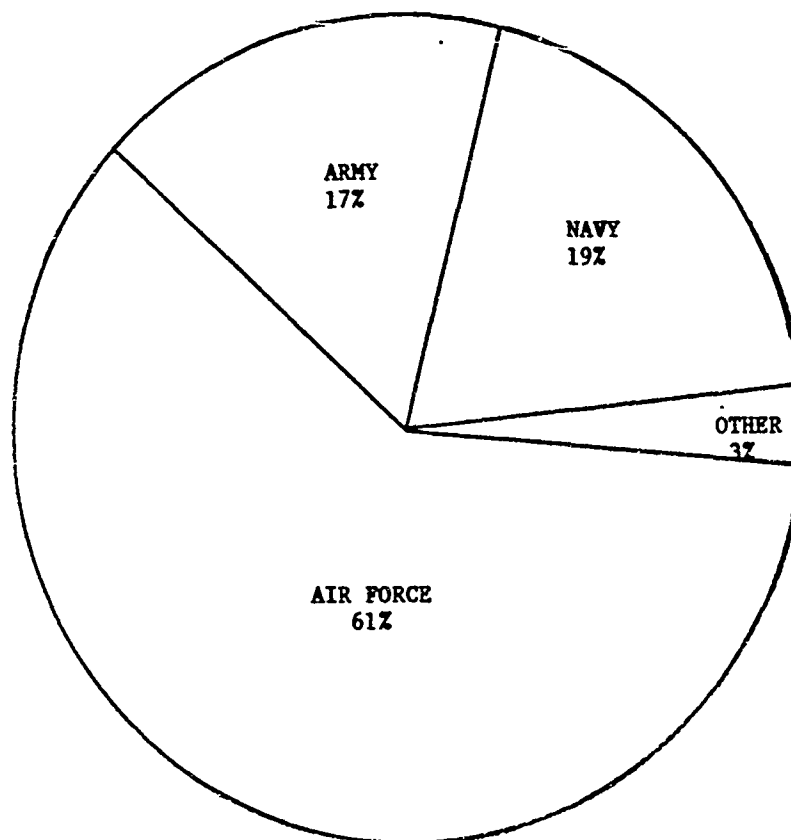


FIGURE 8. MARKET SHARE BY TYPE OF FIRM

The major aerospace companies clearly dominate both the defense and nondefense markets. Many major aerospace firms are also the firms with more than \$10 million in sales.

The "Aerospace" category includes firms that do any business at all in aircraft, missiles, or other parts that meet military specifications. The "major aerospace" category includes those firms that do a majority of their business in parts that meet mil specs. It is interesting to note that of all investment casting sales, only about 9 percent are produced by firms that do not manufacture military grade parts.

Figure 9 represents the individual services share of defense shipments of investment castings for the years 1983-85.



TOTAL DOLLAR VALUE OF SHIPMENTS - \$1,483 BILLION

FIGURE 9. GOVERNMENT SHIPMENTS 1983-1985 (BY SERVICE)

The Air Force is by far the largest user of investment castings in DOD with the Army and Navy sharing about equally in the rest of the sales.

Figure 10 shows where defense investment castings are used.

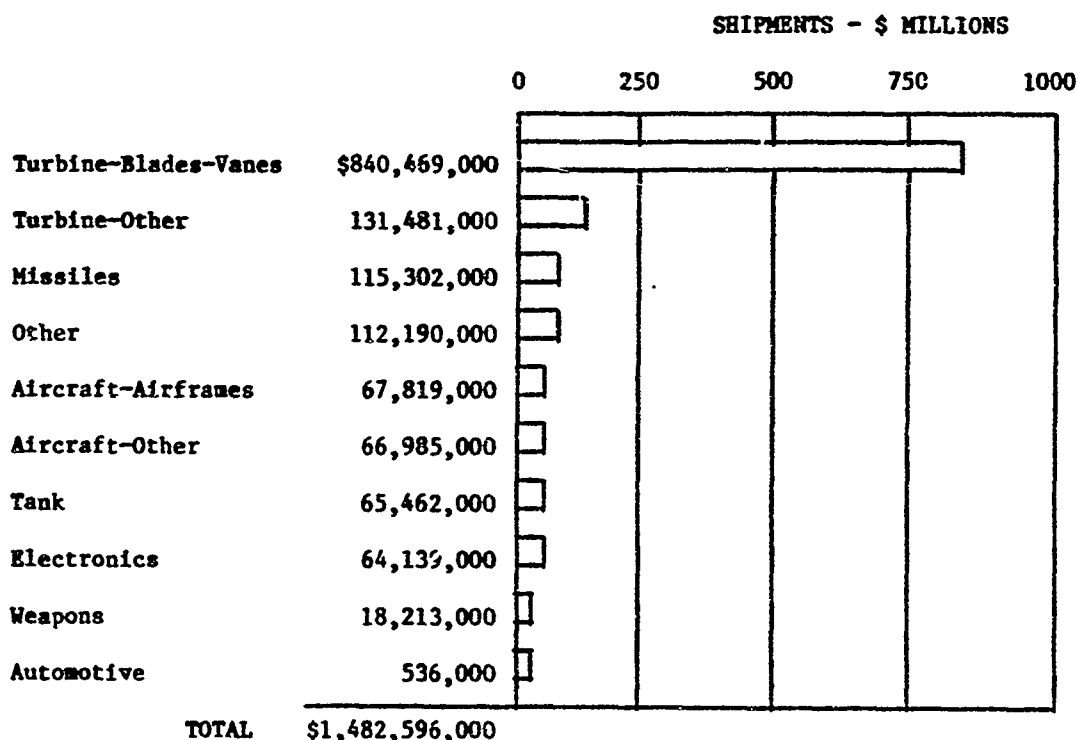


FIGURE 10. GOVERNMENT SHIPMENTS FOR 1983 THROUGH 1985 (BY PRODUCT AREA)

Turbine blades and vanes account for 57 percent of the dollar value of all investment castings shipped to DOD from 1983 to 1985. Blades and vanes also represent the state-of-the-art in investment casting. Only a few companies have the capability to produce single-crystal, directionally-solidified blades and vanes from exotic materials in a vacuum environment.

Blades are the small airfoils that run in a ring around jet engine turbine wheels. They are hollow for cooling, are made to very precise dimensions, and are made from high-alloy steels or superalloys to withstand high temperatures. They are usually cast individually and assembled to the turbine wheels. Vanes are similar to blades except that they are mounted on stationary disks between the turbine wheels. They are sometimes cast as a whole unit for the latter turbine stages.

The remaining products on the chart are typically complex parts made to precise, near-net-shape dimensions.

The figures below address lead times for investment castings.

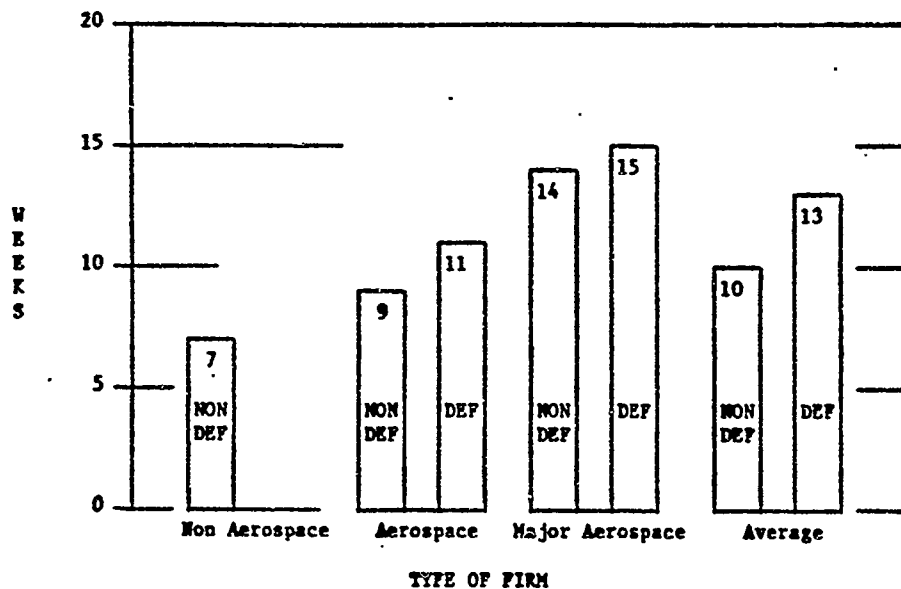


FIGURE 11. AVERAGE LEAD TIME IN WEEKS BY TYPE OF FIRM - 1985

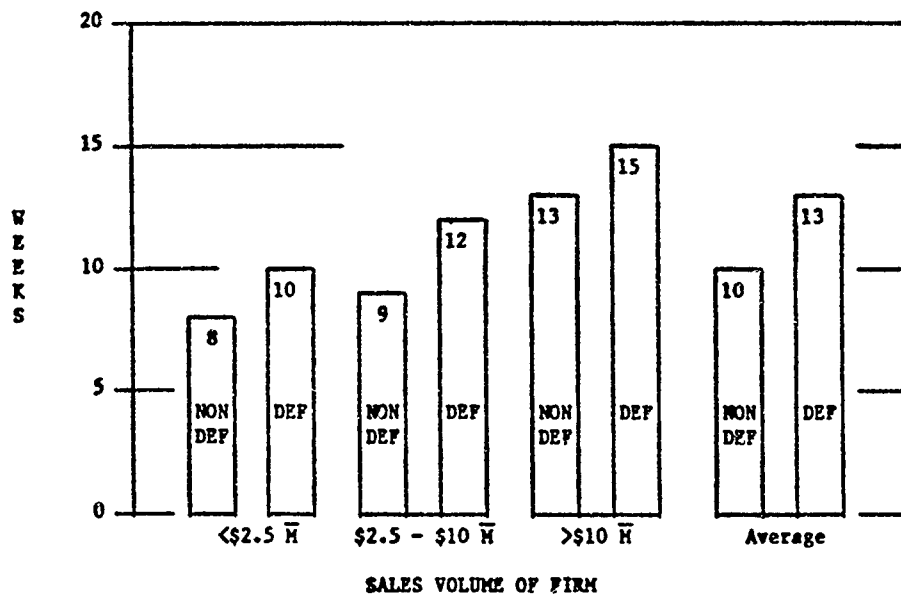


FIGURE 12. AVERAGE LEAD TIME IN WEEKS BY SALES VOLUME - 1985

Again, the breakouts by type of firm and sales volume do not differ significantly. The lead times for the major aerospace are higher than the others, but these companies are also operating at a higher utilization rate. Lead times may be longer under mobilization conditions, but the Government may be able to alleviate this through the Defense Priorities and Allocations System (DPAS). DPAS is also a very viable solution in the current peacetime

environment. While the average lead times, shown above, are not considered excessive, Special Priorities Assistance could be used to help resolve specific instances of long lead times. Figures 11 and 12 show average production lead time, or processing time, for the investment casting foundries themselves. They assume that production tooling exists, which if it does not, can add 10 to 38 weeks. Figure 19 shows the additional time required for procurement, transportation, and machining per the HQ AMC letters to the prime defense contractors.

The survey asked for industry recommendations that would shorten defense leadtime (an overall average of 13 weeks vs 10 weeks for nondefense). The predominant responses were to relax Government specifications, to conduct less nondestructive testing, to hire more manpower, and to purchase more production equipment, especially automated equipment.

SURGE & MOBILIZATION ASPECTS

Figure 13 represents the response time of the investment casting industry to surge and mobilization conditions.

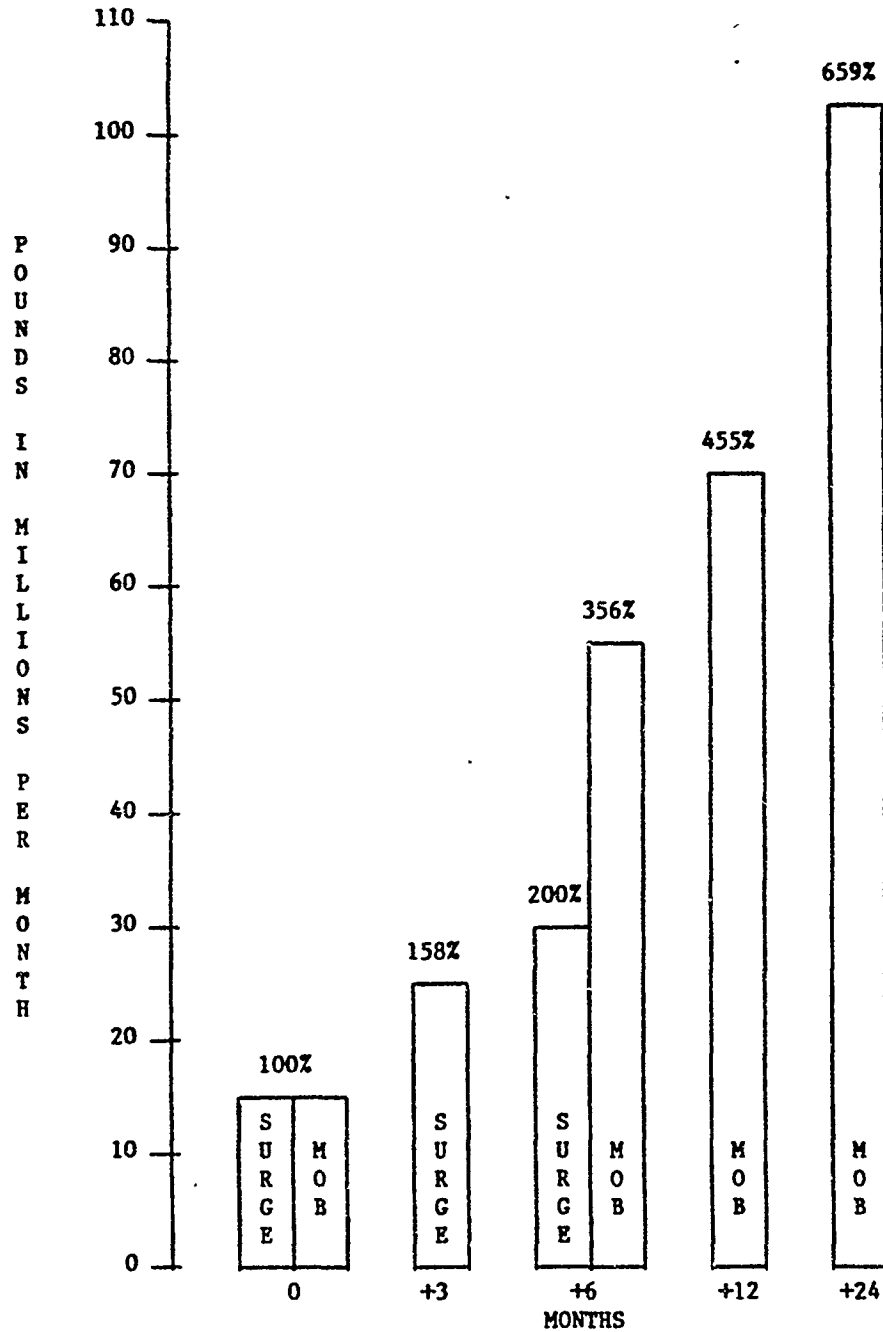


FIGURE 13. PRODUCTION INCREASE WITH SURGE AND MOBILIZATION

The production increases (using 1985 as a base year) will subsequently be compared to surge and mobilization estimates of the services requirements in Figures 15 through 17. Note that the second page of the survey form, Appendix A, contains the definitions of surge and mobilization.

The investment casters were asked to list and rank the bottlenecks that they envisioned for surge and mobilization. Figure 14 is a summary; it shows that shell forming and tool and die making are the chief concerns.

AEROSPACE

SURGE

1. Shell Forming
2. Die Tooling
3. Inspection

MOB

1. Die Tooling
2. Shell Forming
3. Pattern Production/Assembly

NONAEROSPACE

SURGE

1. Shell Forming
2. Finishing
3. Die Tooling

MOB

1. Shell Forming
2. Cast Melt
3. Die Tooling

FIGURE 14. MAJOR BOTTLENECKS WITH RESPECT TO SURGE AND MOBILIZATION

Experienced die toolers are in short supply, and the apprenticeship to fully train new die toolers can take as long as 48 months. Shell forming is an area where robots have had an impact on the investment casting industry. Some companies are using robots to dip the wax patterns into the refractory slurry. Drying time of the shell is also a limiting factor in the production.

The purpose of Figure 15 is to develop Army requirements for surge and mobilization.

End Item	End Item Requirements (per year - 1985 base)			Estimated Inv. Castings Per End Item	Inv. Casting Requirements (per year)		
	Peacetime	Surge	Mob		Peacetime	Surge	Mob
M712 Copperhead	5,250	21,000	249,192	12	63,000	252,000	2,990,000
MLRS Rkt	50,472	74,472	326,640	7	353,000	521,000	2,286,000
M1A1 Tank	840	1,440	8,592	262	220,000	377,000	2,251,000
CH-47 Helicopter	11	72	2,268	897	10,000	65,000	2,034,000
UH-60 Helicopter	104	264	3,168	414	43,000	109,000	1,312,000
M2/M3 Bradley	655	792	4,344	112	73,000	89,000	487,000
AH-64 Helicopter	138	216	360	622	86,000	134,000	224,000
AH-1S Helicopter	0	0	468	336	0	0	157,000
All Others	-	-	-	-	178,000	379,000	368,000
TOTAL					1,026,000	1,926,000 (1.9 Times)	12,109,000 (11.8 Times)

FIGURE 15. INVESTMENT CASTING REQUIREMENTS FOR THE ARMY

The Army end items shown are those that have the largest impact on requirements for investment castings. The peacetime production quantities are for 1985. The surge requirements represent maximum weapon system production capacity with existing facilities. The mobilization requirements are from the FY86 DA Critical Items List (DA CIL). The estimates of the number of investment castings per end item were made by IBEA using the responses to the HQ AMC letter to the prime defense contractors, Army project management personnel, and personnel at Wright-Patterson Air Force Base. The investment casting requirements, shown in the three right columns, are the result of multiplying the end item requirement numbers by the estimated number of castings per end item. It can be noted that surge is 1.9 times the peacetime rate, while mobilization is 11.8 times. Occasionally, surge requirements will be larger than the mobilization requirements. This can happen because surge involves current production capacity. On the other hand, mobilization requirements are completely independent of the surge requirements and are calculated based on scenarios, tactics, military doctrine, and war games.

Figure 16 summarizes the Army's surge and mobilization requirements from the previous figure and converts the numbers into multiples of peacetime production. The Navy and Air Force numbers are also added.

<u>Service</u>	<u>End Item</u>	<u>Surge</u>	<u>Mob</u>
Army	Copperhead	4.0	47.5
	MLRS Rocket	1.5	6.5
	MI1A1 (AGT1500)	1.7	10.2
	CH-47 (T55)	6.5	203.4
	UH-60 (T700)	2.5	30.5
	M2/M3	1.2	6.7
	AH-64 (T700)	1.6	2.6
	AH-1S (T53)	No Peacetime	No Peacetime
	Others	<u>2.1</u>	<u>2.1</u>
	Overall	1.9	11.8
	<u>End Item</u>	<u>Surge</u>	<u>Mob</u>
Navy	TF30 Engine (on F14)	1.5	3.0
	F404 Engine (on F18)	1.5	3.0
	F14 Airframe	1.5	3.0
	F18 Airframe	1.5	3.0
Air Force	F100 Engine (on F15 & F16)	1.5	3.0
	F15 Airframe	1.5	3.0
	F16 Airframe	<u>1.5</u>	<u>3.0</u>
Overall	1.5	3.0	

FIGURE 16. PEACETIME REQUIREMENTS INCREASE (TIMES)

Unlike the Army, the Navy and Air Force use flat rates for surge and mobilization production requirements. Surge is 1.5 times the peacetime production rate, mobilization is 3 times.

The overall DOD surge requirement is 1.6 times the peacetime production rate. This was computed using a weighted average based on percent of Defense shipments (see Figure 9):

$$\begin{aligned} \text{DOD Surge Requirements} &= \\ & \frac{(\text{Army Surge} \times \text{Army \%}) + (\text{Navy Surge} \times \text{Navy \%}) + (\text{AF Surge} \times \text{AF \%})}{(\text{Army \%} + \text{Navy \%} + \text{AF \%})} \\ & \frac{(1.9 \times 17\%) + (1.5 \times 19\%) + (1.5 \times 61\%)}{97\%} = 1.6 \end{aligned}$$

From Figure 13, the study indicates that the investment casting industry could meet DOD surge requirements within 3 months. However, orders for castings that require new tooling could be affected by a 10 to 38 week wait for that tooling. What the study indicates is that the basic capacity is there, but new tooling could delay production for some items. Replacement tooling would similarly affect surge response.

An overall DOD mobilization requirement of 4.5 times the current peacetime rate for investment castings was similarly computed:

$$\begin{aligned} \text{DOD Mob Requirements} &= \\ & \frac{(\text{Army Mob} \times \text{Army \%}) + (\text{Navy Mob} \times \text{Navy \%}) + (\text{AF Mob} \times \text{AF \%})}{(\text{Army \%} + \text{Navy \%} + \text{AF \%})} \\ & \frac{(11.8 \times 17\%) + (3.0 \times 19\%) + (3.0 \times 61\%)}{97\%} = 4.5 \end{aligned}$$

Again from Figure 13, the investment casting industry could meet the overall DOD mobilization requirement within 12 months. However, if the Navy and Air Force mobilization requirements were actually as high as the Army's the industry would be overloaded. It could take several years to meet them. It should be noted that investment castings tend to be:

- a. Complex.
- b. Precise.
- c. Close to final dimensions.
- d. Difficult to produce any other way.

As a result, during mobilization, it may be difficult or undesirable to find substitutes for investment castings. The industrial base could, in fact, find itself substituting investment castings for machined parts as happened in World War II. Investment casting was used very little in industry prior to that war. However, as demands overtaxed the machine tool industry, investment casting provided a shortcut that reduced machining, welding, and assembly. It was a solution for many relatively small, complex,

undercut parts with smooth surfaces, accurate dimensions, and fine details. In addition, proper metal grain orientation is easy to control with investment casting. This is important for part strength.

An interesting observation is that industry survey definition of mobilization stated that casting production for nondefense use would be limited to 25 percent or less of peacetime levels. On the other hand, production for defense use would increase by a factor of 4.5. A question then arises: What would be the overall increase for the investment casting industry as a whole - defense and nondefense combined? The computation below answers the question.

1985 Peacetime Nondefense Share	= \$1,552 million x 58.5%	= \$908 million
1985 Peacetime Defense Share	= 1,552 million x 41.5%	= <u>644 million</u>
		\$1,552 million

and

Wartime Nondefense Share	= \$908 x 25%	= \$227 million
Wartime Defense Share	= 644 x 4.5	= <u>2,898 million</u>
		\$3,125 million

and, further,

Overall factor increase	= $\frac{\$3,125 \text{ million wartime}}{1,552 \text{ million peacetime}}$	= 2.0 times
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The 2.0 factor increase does not change the conclusion above that the investment casting industry could meet the overall DOD mobilization requirement within 12 months. Rather, it indicates a rather drastic change in product mix for mobilization.

FOREIGN SOURCING

Figure 17 is a breakout of materials used by the larger firms - more than 300 employees.

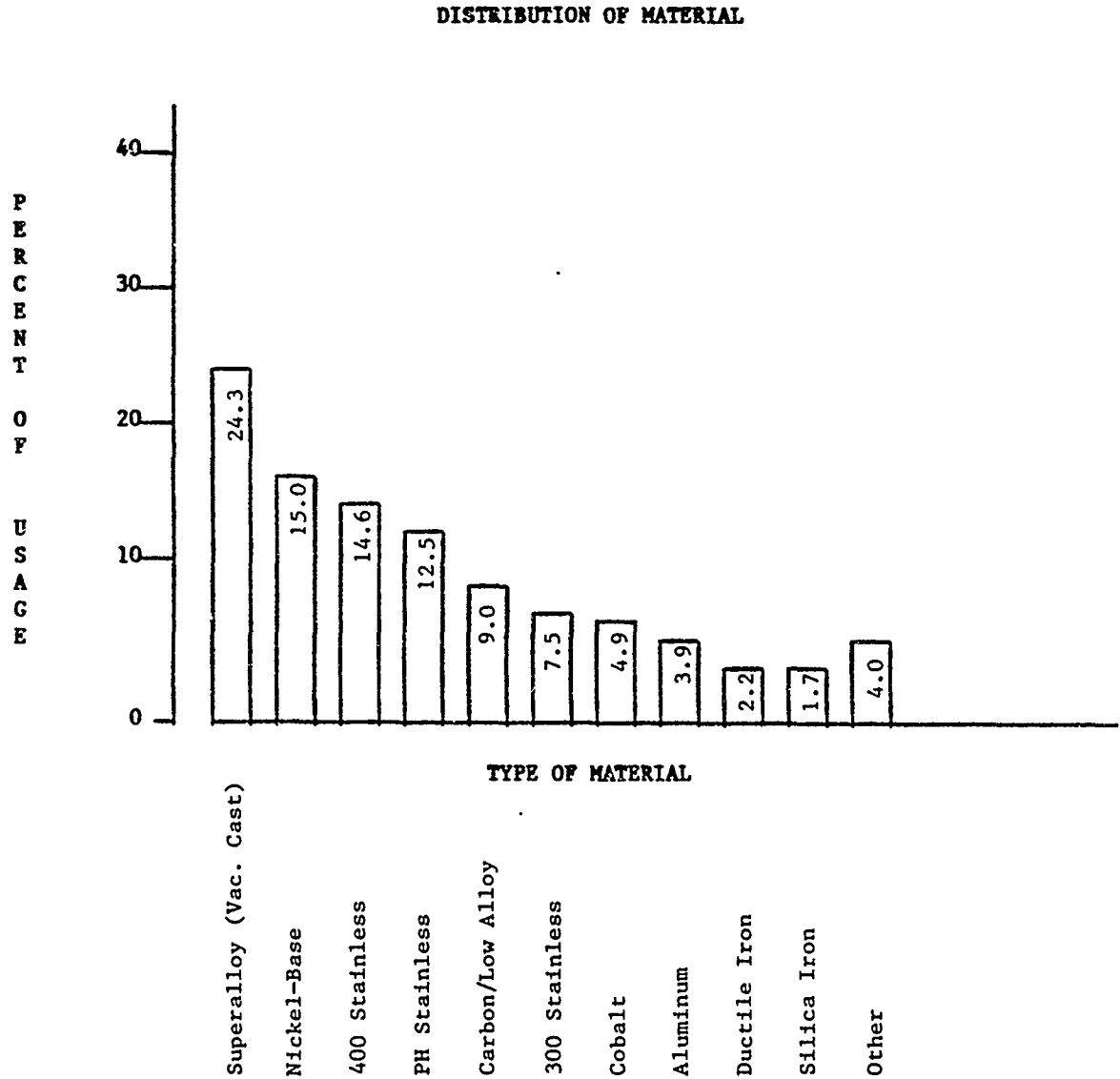


FIGURE 17. DISTRIBUTION OF MATERIAL

All of the materials shown can be considered as being high technology materials except for carbon/low alloy steel and silica iron. Three materials - superalloys, nickel-base alloys, and 400 series stainless - comprise over 50 percent of the total used.

To some degree the alloys used in investment casting depend on the availability of critical raw materials, the supply of which comes mostly from foreign countries. Figure 18 shows the import reliance for some of these raw materials.

<u>MATERIAL</u>	<u>IMPORT RELIANCE</u>	<u>MAJOR FOREIGN SOURCES (PERCENT)</u>
MANGANESE	99	SOUTH AFRICA (22), FRANCE (17), GABON (16), BRAZIL (15)
ALUMINA/BAUXITE	96	AUSTRALIA (31), GUINEA (19), JAMAICA (16), CANADA (15)
COBALT	95	ZAIRE (45), ZAMBIA (14), CANADA (11)
CHROMIUM	82	SOUTH AFRICA (55), ZIMBABWE (15), YUGOSLAVIA (9)
TIN	79	THAILAND (21), INDONESIA (17), BOLIVIA (17), BRAZIL (16)
NICKEL	74	CANADA (35), AUSTRALIA (16), BOTSWANA (16), NORWAY (11)
TUNGSTEN	71	BOLIVIA (16), CANADA (16), REPUBLIC OF KOREA (14)
ZINC	67	CANADA (48), MEXICO (12), PERU (8)
VANADIUM	41	CANADA (19), FINLAND (16)
SILICON	21	CANADA (24), BRAZIL (20), NORWAY (17), VENEZUELA (13)
COPPER	21	CHILE (45), CANADA (20), PERU (6), MEXICO (6)
IRON	19	JAPAN (25), CANADA (14), KOREA (10), BRAZIL (8)
TITANIUM	9	JAPAN (50), UNITED KINGDOM (25)

SOURCE: Mineral Facts and Problems, 1985, Bureau of Mines

FIGURE 18. NET IMPORT RELIANCE

There is no U.S. mine production for manganese, cobalt and chromium. Were it not for scrap reclamation reducing our dependency, the net reliance on foreign sources for these three materials would, in fact, be 100 percent. Manganese which is essential to all iron and steel production as a desulfurizing, deoxidizing, and/or alloying element, has no satisfactory substitute. Nickel is a substitute for cobalt and chromium in some applications, but with a loss of effectiveness.

The study team drew the following conclusions with regard to materials and foreign sourcing in general:

a. Only 17 percent of the firms required to respond indicated foreign sources for equipment, materials, or components.

b. Availability of strategic and critical materials is the only indicated serious foreign dependency problem.

c. The National Defense Stockpile of Strategic and Critical Materials is an important consideration.

(1) The stockpile is geared to a three-year war.

(2) The stockpile is intended to provide war reserves of raw materials, such as those shown in Figure 18.

(3) The stockpile goals represent the difference between demand and the level of assured supply.

(4) DOD currently has very little to do with the stockpile, however there has been legislative attempts to put DOD in charge.

USER SURVEY

In February 1986, HQ AMC sent a letter under the signature of the Commander, General Thompson, to 62 prime defense contractors (see Appendix B). The letter requested data on investment and other types of castings used by the contractors for military weapons systems. Basically, the letter asked the contractors to list their castings and identify type of casting, weapon system application, casting part name, lead time, and vendor name. The response was very good, with 6,600 investment castings reported by 53 contractors. The average lead time was 23.8 weeks, which is in contrast to 13 weeks reported by the investment casters themselves. However, Figure 19 will explain the difference. Army lead times averaged 21.6 weeks overall - 24.3 for aircraft, 16.3 weeks for missiles, 22.2 weeks for tank-automotive, and 18.0 weeks for electronics.

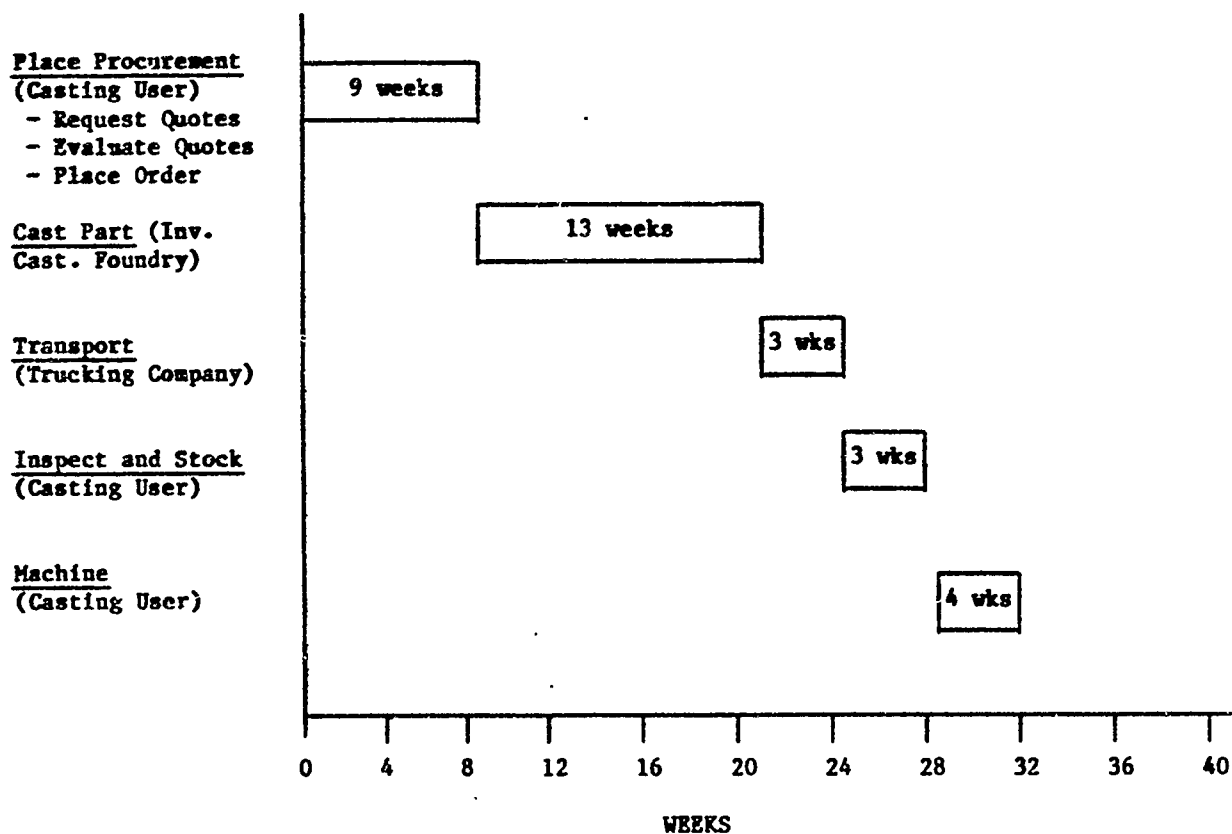


FIGURE 19. SAMPLE LEAD TIMES - DEFENSE INVESTMENT CASTING

The 13 week lead time for the casting effort itself is shown as a separate element in Figure 19. The complete figure illustrates that it can take 32 weeks from the time an order is started until a casting can be used in an assembly.

Die tooling used to make the wax or plastic patterns is a potential lead time element for new production items that was not covered in Figure 19. High part complexity and high production volumes tend to make the die tooling more complex and tend to make for longer tooling lead times. New die tooling could add from 10 to 38 weeks.

The HQ AMC letter also asked the prime contractors (casting users) to report lead times for other types of castings. Figure 20 is a summary of the significant returns.

**OTHER TYPES OF CASTINGS
(from user survey)**

<u>CASTING PROCESS</u>	<u>NUMBER OF OCCURENCES</u>	<u>AVERAGE LEADTIME (WEEKS)</u>
Die Casting	604	17
Permanent Mold	309	23
Sand Casting	278	<u>14</u>
		Average 18

FIGURE 20. OTHER TYPES OF CASTINGS

To reiterate, the comparable average for investment castings is 23.8 weeks, or about 6 weeks longer.

MEETING WITH THE AMERICAN FOUNDRYMEN'S SOCIETY

1. A meeting between representatives of IBEA and the American Foundrymen's Society Investment Casting Committee was held 10 Nov 86 in Des Plaines, IL. Investment casting companies represented were of the medium to small size in sales and employment. The most significant point made at the meeting was the recent influence imports were having on domestic firms. Yugoslavia, Spain, Brazil and Korea were named as countries recently increasing the volume of imported investment castings.

2. A preliminary analysis of the industry survey by the Department of Commerce (Figure 6) indicated that the industry could be a target for foreign firms with low cost labor. The meeting with industry representatives appeared to confirm the preliminary analysis. The representatives claimed that many of the small to medium sized firms are now in a survival mode. They are worried about staying in business, not expanding or investing in equipment. The representatives also claimed that low return on investment is not attractive for parent corporations to consider further investment casting capital expenditures.

CONCLUSIONS

The main purpose of this study was to assess the ability of the investment casting industry to support the Army and the other Services during peacetime, surge and mobilization. Many facts were brought out during the course of the study. It was determined that a substantial portion, i.e. 42 percent, of the investment casting industry supports DOD's needs with the single largest area of production being turbine blades and vanes. Furthermore, the DOD utilization of this industry is growing at a slightly larger rate than the overall projected growth rate of 5 to 10 percent. It was further determined that while the equipment of the investment casting industry is newer than U.S. industry as a whole, it is still comparatively speaking a more labor intensive industry.

With tooling available, lead times, reported as 10-13 weeks at the casting foundry and 24 weeks overall from procurement to use, was not considered excessive. Potential problems which were identified are as follows:

- a. The high labor intensity of the investment casting industry could cause it to become a target for foreign firms with low cost labor.
- b. High part complexity, rigid specifications, and high production volumes make die tooling more complex and could result in unacceptable lead times.
- c. Critical materials, such as cobalt, chromium, manganese, and nickel, are used in the majority of the alloys used in the investment casting process. The U.S. is heavily dependent on foreign sources for these materials. This is no more of a problem for investment casting than for any other process which makes a product containing critical materials. However, it is nevertheless a major problem for the U.S. as a whole and bears being repeated here.

While some problems were identified and some trends bothersome, it was concluded overall that the state of the investment casting industry is adequate to meet defense requirements for peacetime, surge and mobilization.

RECOMMENDATIONS

Reaching the conclusion that the current investment casting industry can support DOD's current and mobilization requirement results in a further conclusion that "if it isn't broken, don't fix it."

Following that maxim, no specific recommendations are made. However, some comments are offered.

- a. Army work which is done to develop mobilization versions of weapon systems with reduced design specifications and reduced acceptance testing requirements would benefit the investment casting industry by reducing lead times.
- b. Making maximum use of the Special Priorities Assistance provision of DPAS can resolve an individual problem with a long lead time.
- c. Even with the conclusion that investment casting is a labor intensive process, some cases are made for it being a lower cost alternative to machining. Through the use of the Value Engineering process, the substitution of investment cast parts for machined parts should be explored both by prime contractors trying to reduce the cost of their weapon systems and by investment casters trying to sell their product and increase their facility utilization and efficiency.
- d. In approximately five years, this report should be used as a benchmark in a second study to determine the affects of foreign competition.

INVESTMENT CASTING INDUSTRY

THIS REPORT IS REQUIRED BY LAW

This report is required by law (50 U.S.C. App. Sec. 2155). Failure to report can result in a maximum fine of \$1,000 or imprisonment up to one year, or both. Information furnished herewith is deemed confidential and will not be published or disclosed except in accordance with Section 705 of the Defense Production Act of 1950, as amended (50 U.S.C. App. Sec. 2155).

General Instructions

1. It is not our desire to impose an unreasonable burden on any respondent. IF INFORMATION IS NOT READILY AVAILABLE FROM YOUR RECORDS IN EXACTLY THE FORM REQUESTED, FURNISH ESTIMATES AND DESIGNATE BY THE LETTER "E". Any necessary comments or explanations should be supplied in the space provided or on separate sheets attached to this questionnaire. Ensure that you reference the proper question if you use extra sheets. If any answer is "none", please indicate.
2. Report calendar year data, unless otherwise specified in a particular question. Parts II and III must be completed separately for each of your establishments that produce investment castings in the United States. Please make photocopies of forms if additional copies are needed. For Parts I and IV firms operating more than one establishment may combine the data for all establishments into a single report.
3. FIRMS WITH 50 EMPLOYEES OR LESS are required to answer ONLY the following questions: PART I—All, except that for questions four, five and six, report 1985 shipments only; PART II—All; PART III—Questions two, eight, nine, eleven, and thirteen only; PART IV—NONE.
4. In addition to the original report form to be returned to us, there is enclosed a file copy for your records. You are not legally required to fill out or retain this file copy. While it would be a convenience to the Government for a file copy to be made and retained for reference purposes, no assurances can be provided that file copies are exempt from compulsory examination pursuant to legal process.
5. Questions related to the questionnaire should be directed to Mr. Alex F. Evan, Industrial Specialist (202) 274-8225, Dr. Joel Morris, Industrial Specialist (202) 274-8209, Department of the Army, or Mr. John Tucker, Industry Analyst (202) 377-3795, Department of Commerce.
6. Before returning your completed questionnaire be sure to sign the certification and identify the person and phone number to contact your firm.
7. Return completed questionnaire by March 7, 1986 to:

U.S. Department of Commerce
International Trade Administration
Office of Industrial Resource Administration
Attn: Brad Botwin, Program Manager for
Industrial Capabilities, Room H3876
Washington, D.C. 20230

DEFINITIONS

BOTTLENECK—During a production expansion, the production process, operation or procedure, or material or labor requirement within your manufacturing establishment that would ultimately prevent or delay increased production.

CRITICAL OCCUPATIONS—Includes occupations for which you anticipate a potential shortage of qualified personnel during surge or mobilization. In general, this would include skilled occupations that require an extended training period.

ESTABLISHMENT—All facilities in which investment castings are produced includes auxiliary facilities operated in conjunction with (whether or not physically separate from) such production facilities. Does not include wholly owned distribution facilities.

FIRM—An individual proprietorship, partnership, joint venture, association, corporation (including any subsidiary corporation in which more than 50 percent of the outstanding voting stock is owned), business trust, cooperative, trustees in bankruptcy, or receivers under decree of any court, owning or controlling one or more establishments as defined above.

INVESTMENT CASTING—Production of industrial metal castings using expendable patterns and monolithic molds.

MOBILIZATION PRODUCTION CAPABILITY—The maximum realistic increase of sustainable defense production capability a manufacturing firm can achieve in the 24 month period following a declared national emergency. Report achievable increase in defense production at the end of 6 months, 12 months and 24 months in the mobilization capability section of Part II of the questionnaire. Non-Defense production limited to 25 percent or less of peacetime levels. Government financial assistance and prioritization of construction materials and outfitting equipment is available. Your existing manufacturing buildings may be enlarged, new buildings constructed or existing buildings currently used by you for non-manufacturing purposes may be converted into manufacturing facilities, and plant equipment acquired. Consider critical labor skills to operate at maximum sustained production levels. Minimum defense requirement is 4X your average monthly defense production in 1985.

OFFSET AGREEMENTS—A range of industrial and commercial compensation practices which include co-production, licensed production, subcontractor production, overseas investment, technology transfer, and countertrade.

PRACTICAL CAPACITY—Sometimes referred to as engineering or design capacity, this is the greatest level of output this plant can achieve within the framework of a realistic work pattern. In estimating practical capacity, please take into account the following considerations:

1. Assume a normal product mix. If the plant is subject to considerable short run variations in product mix, you may assume that the current pattern of production is normal unless it is unusually different because of a unique situation.
2. Consider only the machinery and equipment in place and ready to operate. Do not consider facilities which have been inoperative for a long period of time and, therefore, require extensive reconditioning before they can be made operative.
3. Take into account the additional downtime for maintenance, repair, or clean-up which would be required as you move from current operations to full capacity.
4. Do not consider overtime pay, added costs for materials, or other costs to be limiting factors in setting capacity.
5. Although it may be possible to expand plant output by using productive facilities outside of the plant, such as by contracting out subassembly work, do not assume the use of such outside facilities in greater proportion than has been characteristic of your operations.

PRODUCTION WORKERS—Persons, up through the line supervisor level, engaged in fabricating, processing, assembling, inspecting, receiving, storing, handling, packing, warehousing, or shipping investment castings. In addition, persons engaged in supporting activities such as maintenance, repair, product development, auxiliary production for your firm's own use, record keeping, and other services closely associated with production operations at your firm. Employees above the working supervisor level are excluded from this item.

SCIENTISTS AND ENGINEERS—Persons engaged in research and development work or production operations that have at least a four-year college education in the physical sciences or engineering.

SHIPMENTS—Report dollar value of domestically produced castings shipped from your plant during the reporting period for each category specified for questions 4, 5, and 6 in Part I. Report shipments for defense consumption separate from non-defense. Such shipments should exclude shipments of products produced by other manufacturers for resale under your brand name. Do not adjust for returned shipments. The defense portion of your business may be identified by those purchase orders bearing a DD or DX rating and/or a contract number from the Department of Defense, NRC, CIA, FAA, or NASA, as well as the orders of your customers whom you could identify as producing products for defense purposes, and items tested and certified to military specifications shipped to qualified distributors.

SINGLE SOURCE—An item currently being purchased from one source, other sources may be available, however, they may not be qualified or were not considered.

SOLE SOURCE—An item being purchased from one source, and no other production capability exists.

SURGE PRODUCTION CAPABILITY—The maximum sustainable level of defense production that can be achieved within an existing establishment by the end of the 6 month period immediately following surge day while maintaining non-defense deliveries. Report achievable defense production quantities at the end of 3 months and 6 months in the surge capability section of Part II of the questionnaire. Procurement actions for additional materials to sustain surge production levels will be initiated on surge day. Existing idle equipment may be activated as is, repaired, or upgraded and brought into service, or used equipment may be purchased and installed if possible within the 6 month time frame. Labor may be hired and trained in numbers sufficient to operate around the clock and week-ends allowing for necessary equipment maintenance and downtime. Minimum defense requirement is 2X your average monthly defense production in 1985.

UNITED STATES—The term "United States" includes the fifty States, Puerto Rico, the District of Columbia, and the Virgin Islands.

PART I - FIRM IDENTIFICATION

1. Name and address of your firm or corporate division.

If your firm is wholly or partly owned by another firm, indicate the name and address of the parent firm and extent of ownership.

2. If your firm did not produce investment castings in the United States during the period January, 1981 to the present, check here (), then sign the certification at the end of this questionnaire and promptly return to the U.S. Department of Commerce.
3. Identify the location of your investment casting manufacturing establishment(s) in the United States.

	Locality	State	Zip Code
(a)	_____	_____	_____
(b)	_____	_____	_____
(c)	_____	_____	_____
(d)	_____	_____	_____

4. Enter total Non-Defense shipments of castings (all manufacturing establishments). See definition of shipments.

	(In thousands of dollars)				
	1981	1982	1983	1984	1985
o Investment	_____	_____	_____	_____	_____
o Die	_____	_____	_____	_____	_____
o Sand	_____	_____	_____	_____	_____
o Permanent Mold	_____	_____	_____	_____	_____
o Other (specify)	_____	_____	_____	_____	_____

5. Enter total Defense shipments of castings (all manufacturing establishments). See definition of shipments.

	(In thousands of dollars)				
	1981	1982	1983	1984	1985
o Investment	_____	_____	_____	_____	_____
o Die	_____	_____	_____	_____	_____
o Sand	_____	_____	_____	_____	_____
o Permanent Mold	_____	_____	_____	_____	_____
o Other (specify)	_____	_____	_____	_____	_____

6. During the three year period 1983 thru 1985, estimate the total dollar value of your investment casting shipments for the following military product areas.

	Army	Navy	Air Force	Other Govt
	(In thousands of dollars)			
o Gas Turbine Engines Blades and Vanes	_____	_____	_____	_____
Other	_____	_____	_____	_____
o Aircraft Airframes	_____	_____	_____	_____
o Aircraft, Other	_____	_____	_____	_____
o Automotive	_____	_____	_____	_____
o Electronics	_____	_____	_____	_____
o Tanks	_____	_____	_____	_____
o Missiles	_____	_____	_____	_____
o Ammunition	_____	_____	_____	_____
o Weapons, other	_____	_____	_____	_____
o Other (specify)	_____	_____	_____	_____

7. Identify all military systems for which you partially or fully supply investment castings. (e.g., TOW missile, M1 Tank)

8. List your top five Non-Defense markets/product areas.

PART II - PEACETIME CAPACITY, SURGE AND MOBILIZATION CAPABILITIES

INSTRUCTIONS

- o Complete Part II for each establishment that manufactures investment castings.
- o Report calendar year data, unless otherwise specified.
- o If information is not readily available from your records in exactly the form requested, furnish estimates and designate by the letter "E".
- o Do not leave questions unanswered. Enter "none" where appropriate.

ESTABLISHMENT IDENTIFICATION

(Locality) (State) (Zip Code)

PEACETIME CAPACITY

1. What is this establishment's investment casting production capability expressed in size range?

pounds/ounces _____ to _____

linear dimension _____ to _____

2. What is your annual practical capacity for producing investment castings? (See definition of practical capacity.)

Size Range (lbs)	# of castings
under 1 lb	_____
1 - 5 lbs	_____
6 - 10 lbs	_____
11 - 20 lbs	_____
21 - 50 lbs	_____
over 50 lbs	_____
Total	_____

Enter below factors which would increase/decrease figures given above. (e.g. material, shape, tolerances)

3. What was this establishment's practical capacity utilization rate in percent during the last six months of 1985?

Practical Capacity Utilization _____%

How long would it take to reach practical capacity from the rate indicated? (in weeks)

_____ weeks

4. Enter workforce shift information below.

Operation	Average shifts Last Six Months, 1985			Number shifts if at practical capacity		
	# shifts	man hours/ shift	days/wk	# shifts	man hours/ shift	days/wk
Die Tooling	_____	_____	_____	_____	_____	_____
Pattern Production /Assembly	_____	_____	_____	_____	_____	_____
Shell Forming	_____	_____	_____	_____	_____	_____
Casting/Melt	_____	_____	_____	_____	_____	_____
Finishing	_____	_____	_____	_____	_____	_____
Inspection	_____	_____	_____	_____	_____	_____
Other	_____	_____	_____	_____	_____	_____

5. Briefly discuss the convertibility of your non-defense production operations to defense production and the problems that might arise in the conversion.

6. During 1985, what was your average leadtime (in weeks) for:

Non-Defense Orders _____ weeks Defense Orders _____ weeks

Regarding your longest leadtime defense items, list the investment casting, the defense system it supports, the average leadtime during 1985, and describe how that leadtime could be significantly shortened.

Casting Product	Defense System	Average Leadtime	How to Shorten Leadtime
_____	_____	_____	_____
_____	_____	_____	_____
_____	_____	_____	_____
_____	_____	_____	_____
_____	_____	_____	_____
_____	_____	_____	_____
_____	_____	_____	_____

SURGE CAPABILITY

1. What is your investment casting surge capability? (See definitions of surge capability and shipments. Assume 1985's defense product mix.)

Size Range	(\$ of castings)		
	1985's average monthly defense production rate	Surge rate at 3 months	Surge rate at 6 months
under 1 lb	_____	_____	_____
1 - 5 lbs	_____	_____	_____
6 - 10 lbs	_____	_____	_____
11 - 20 lbs	_____	_____	_____
21 - 50 lbs	_____	_____	_____
over 50 lbs	_____	_____	_____

2. List and rank the bottlenecks you envision would be encountered during a surge and the time and cost to correct. Refer to definition of BOTTLENECKS. Rank bottlenecks in order of occurrence. If the answer is "none", please indicate.

<u>Operation</u>	<u>Bottlenecks</u>	<u>Rank</u>	<u>Time and Cost to Correct</u>
Die Tooling	_____	_____	_____
Pattern Production /Assembly	_____	_____	_____
Shell Forming	_____	_____	_____
Casting/Melt	_____	_____	_____
Finishing	_____	_____	_____
Inspection	_____	_____	_____
<u>Other areas</u>			
Raw Material Inventory	_____	_____	_____
Government Regulations	_____	_____	_____
Other (specify)	_____	_____	_____

3. What can the government do to help reduce or eliminate bottlenecks?

MOBILIZATION CAPABILITY

1. What is your mobilization capability for investment castings? (See definitions of mobilization capability and shipments. Assume 1985's defense product mix.)

Size Range	1985's average monthly defense production rate	(% of castings)		
		Mobilization rate at 6 months	Mobilization rate at 12 months	Mobilization rate at 24 months
under 1 lb	_____	_____	_____	_____
1 - 5 lbs	_____	_____	_____	_____
6 - 10 lbs	_____	_____	_____	_____
11 - 20 lbs	_____	_____	_____	_____
21 - 50 lbs	_____	_____	_____	_____
over 50 lbs	_____	_____	_____	_____

2. List and rank the bottlenecks you envision would be encountered during a mobilization and the time and cost to correct. Refer to definition of BOTTLENECKS. Rank bottlenecks in order of occurrence. If the answer is "none", please indicate.

<u>Operation</u>	<u>Bottlenecks</u>	<u>Rank</u>	<u>Time and Cost to correct</u>
Die Tooling	_____	_____	_____
Pattern Production /Assembly	_____	_____	_____
Shell Forming	_____	_____	_____
Casting/Melt	_____	_____	_____
Finishing	_____	_____	_____
Inspection	_____	_____	_____
<u>Other areas</u>			
Raw Material Inventory	_____	_____	_____
Government Regulations	_____	_____	_____
Other (specify)	_____	_____	_____

3. What can the government do to help reduce or eliminate bottlenecks?

PART III - EMPLOYMENT, RESEARCH AND DEVELOPMENT, INVESTMENT AND INVENTORIES.

INSTRUCTIONS

- o Complete Part III for each establishment that manufactures investment castings.
- o If information is not readily available from your records in exactly the form requested, furnish estimates and designate by the letter "E".
- o Enter "none" where appropriate.

ESTABLISHMENT IDENTIFICATION

(Locality)

(State)

(Zip Code)

1. Investment: Enter expenditures for new plant, machinery, and equipment from 1981 through 1985 as requested below. Enter any government investment expenditures at your establishment separately.

Private Investment Expenditures
(in thousands of dollars)

	1981	1982	1983	1984	1985
Plant	_____	_____	_____	_____	_____
Machinery and Equipment	_____	_____	_____	_____	_____
Total:					

Government Investment Expenditures
(in thousands of dollars)

	1981	1982	1983	1984	1985
Plant	_____	_____	_____	_____	_____
Machinery and Equipment	_____	_____	_____	_____	_____
Total:					

2. Planned expansion: Enter percentage increase(+)/decrease(-) in practical capacity planned for in the next five years.

_____ § Reason for increase/decrease _____

3. What is the average age of your capital equipment?

Die tooling	_____	Pattern Production	_____
Shell forming	_____	/Assembly	_____
Finishing	_____	Inspection	_____
Casting/Melt	_____	Other (specify)	_____

4. Enter the square footage used for the following operations.

Die Tooling	_____	Finishing	_____
Pattern Production	_____	Inspection	_____
/Assembly	_____	Other (specify)	_____
Shell Forming	_____		
Casting/Melt	_____		

5. Place a check mark next to those test procedures for which you have in-house capabilities to perform.

<input type="checkbox"/> Magnetic particle	<input type="checkbox"/> Fluorescent penetrant
<input type="checkbox"/> Dye penetrant	<input type="checkbox"/> Radiographic

6. Estimate the percent by Grade, as established by radiographic inspection, of your 1985 investment casting production.

Grade A	_____ %	Grade D	_____ %
Grade B	_____ %	Grade E	_____ %
Grade C	_____ %		

7. Has this establishment been approved/qualified to any of the following military inspection standards?

<input type="checkbox"/> Mil-I-45208
<input type="checkbox"/> Mil-Q-9858
<input type="checkbox"/> Mil-C-45662

8. In 1985, what was the percent (in value) of total materials used in your investment casting production for:

_____ Aluminum alloys	_____ Nickel base alloys	_____ Copper
_____ Carbon/low alloy steels	_____ Titanium	_____ Copper base alloys
_____ Ductile iron	_____ 300 series stainless	_____ Vacuum cast superalloys
_____ Silicon iron	_____ Tool steels	_____ Magnesium alloys
_____ 400 series stainless	_____ Cobalt steels	_____ Other (specify)
	Total:	100 %

9. Employment: Enter the number of employees from 1981 through 1985 as requested below. (See definition of Scientists and Engineers, and Production Workers)

	1981	1982	1983	1984	1985
Scientists and Engineers	_____	_____	_____	_____	_____
Production Workers	_____	_____	_____	_____	_____
Administration and Others	_____	_____	_____	_____	_____
Total:					

Critical Occupations: List below. (See definition of Critical Occupations)

Job Title	Number Employed	Training Period (in months)
_____	_____	_____
_____	_____	_____
_____	_____	_____
_____	_____	_____

10. Research and Development: Enter research and development expenditures from 1981 through 1985 as requested below. Enter any Government funded expenditures separately.

Private Funded Research and Development Expenditures
(in thousands of dollars)

	1981	1982	1983	1984	1985
On Materials	_____	_____	_____	_____	_____
On Processes	_____	_____	_____	_____	_____
Other	_____	_____	_____	_____	_____
Total:					

Government Funded Research and Development Expenditures
(in thousands of dollars)

	1981	1982	1983	1984	1985
On Materials	_____	_____	_____	_____	_____
On Processes	_____	_____	_____	_____	_____
Other	_____	_____	_____	_____	_____
Total:					

11. In which of the following areas do you consider the application of new technologies to be most critical? Number from one to seven.

- | | |
|--|---|
| <input type="checkbox"/> Die Tooling | <input type="checkbox"/> Finishing |
| <input type="checkbox"/> Pattern production/Assembly | <input type="checkbox"/> Inspection |
| <input type="checkbox"/> Shell forming | <input type="checkbox"/> Other _____
(specify) |
| <input type="checkbox"/> Casting/Melt | |

List and rank new technologies you would be most interested in acquiring.

12. Inventory: In the space provided below, briefly discuss your inventory policies for materials and supplies. Cite the average number of days supply you normally have in house for your materials and supplies.

13. Have you in the past five years experienced shortages or extended leadtimes in obtaining any material or supply, machinery, equipment, or additional labor that forced you to modify or curtail your operations?

_____ yes _____ no

If yes, list below. Identify the nature and duration of the problem on your operation and the action you took to resolve the situation.

14. What percent of your work did you subcontract out/off load in the past five years?

1981	1982	1983	1984	1985
_____	_____	_____	_____	_____

Specify the operations most frequently subcontracted.

15. Do you assemble components/castings into subassemblies, or larger castings?

_____yes _____no

If yes, indicate percent of direct labor hours utilized in assembly, and briefly describe the types of products assembled.

16. a.) Are you considered a sole source or single source producer for any defense related casting, assembly, or component?

_____yes _____no

If yes, specify and provide the basis for such a position. (See definitions of sole and single source.)

b.) Do you have any sole source or single source suppliers for manufacturing equipment/parts/components/materials?

_____yes _____no

If yes, specify the equipment/part/component/material, the name of the supplier, and how the loss of that supplier would effect your operations.

PART IV - FOREIGN RELATIONSHIPS / FOREIGN SOURCING
(Part IV may be completed for your firm as a whole)

1. Enter the location and primary activity of any establishment outside the United States your firm wholly or partly owns or controls or is affiliated with or has license agreements with that manufactures investment castings.

Name	Country	Primary Activity

2. If any of the foreign establishments you listed above are integrated with your U.S. operations on a normal basis, please briefly specify the nature of that integration in the space provided below.

3. If the foreign establishments that you interact with suddenly ceased operations for an indefinite period, what adjustments would you need to make in your U.S. operations to counteract this interruption?

4. Complete the following table addressing which foreign made manufacturing equipment/parts/components/materials you use in your manufacturing operations. Use the following coded reasons why a foreign source is used in completing the table:

- A. No known domestic source
- B. Domestic source not available or inadequate
- C. Offset Agreement
- D. Lower cost
- E. Quicker delivery
- F. Better quality
- G. Other (specify)

<u>Item</u>	<u>Country of Origin</u>	<u>Are spare parts/maintenance available only from a foreign source?</u>	<u>Reason why foreign source</u>
-------------	--------------------------	--	----------------------------------

5. If the foreign sourced items identified in question 4 are lost, what is your contingency plan (i.e. qualified domestic source, alternate material) and does this impact your ability to surge or mobilize?

6. In recent years, have offset agreements affected your firm?

_____ yes _____ no

If yes, how? _____

CERTIFICATION

The undersigned certifies that the information herein supplied in response to this questionnaire is complete and correct. The U.S. Code, title 18 (Crimes and Criminal Procedure), Section 1001, makes it a criminal offense to willfully make a false statement or representation to any department or agency of the United States as to any matter within its jurisdiction.

(Date)

(Signature of Authorized Official)

Area Code and Telephone Number

(Type or Print Name and Title of Authorized Official)

Area Code and Telephone Number

(Type or Print Name and Title of Person to Contact
Regarding this Report)

Comments: If you wish to add anything not covered in the questionnaire that, in your judgment might be useful to, or that should be brought to the attention of this assessment, please use the space below. Topics of special interest include international competition, government regulations, technology advancement in machinery and equipment and/or material formulations, and possibilities for improving defense productivity and costs.



DEPARTMENT OF THE ARMY
HEADQUARTERS, U. S. ARMY MATERIEL COMMAND
5001 EISENHOWER AVENUE, ALEXANDRIA, VA 22333-0001

February 11, 1986

Industrial Preparedness
Division

Dear Mr.

The ability of the U.S. industrial base to support the requirements of the Defense Department in a national emergency is of critical concern to the military departments. To obtain a better understanding of our Nation's capability and the measures necessary to address shortfalls, the Army services are analyzing specific industrial sectors, focusing primarily on subcontractors.

The Army is finding that our peacetime production rates are constrained by very long leadtimes for precision/investment castings. Extrapolating this condition to an emergency suggests even greater, perhaps crippling deficiencies. This situation leads us to a closer examination of the precision/investment castings sector.

The purpose of this study is to assess the ability of the U.S. precision/investment castings industry to support significant and rapid increases in production required by DOD to meet a national emergency. Recommendations will be developed to address shortfalls.

To enable a comprehensive study, your assistance is requested in providing data about the precision/investment castings you use for DOD products. The information and format requested is noted in the example below:

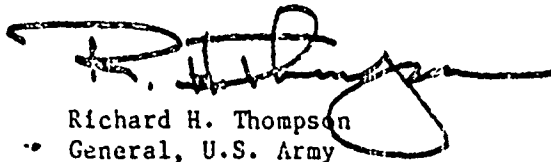
EXAMPLE

End Item	Component	Part Name	Leadtime	Type of Casting	Manufacturer
Tow Missile	Motor	Bracket	12 Months	Investment	ABC Casting Co
		Housing	6 Months	Die	XYZ Company

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Your assistance in providing data to help the Army evaluate this sector of the subtier supplier base is greatly appreciated. If the above information could be provided to the Industrial Preparedness Division (AMCPD-I) by March 17, 1986 it will allow timely input for other aspects of the study. Any questions may be directed to Dr. JoeI Morris at (202) 274-8225.

Sincerely,

A handwritten signature in black ink, appearing to read "R. H. Thompson", with a large, stylized flourish at the end.

Richard H. Thompson
• General, U.S. Army
Commanding