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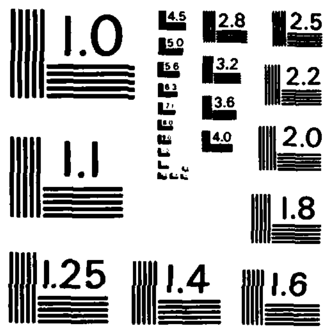

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AN ANALYSIS OF FOREIGN SOURCE DEPENDENCE FOR CRITICAL MICROCIRCUITS OF USAF AVIONICS COMPONENTS

THESIS

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AFIT/LS/GLM/85S-58

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THESIS

Presented to the Faculty of the School of Systems and Logistics

of the Air Force Institute of Technology

Air University

In Partial Fulfillment of the

Requirements for the Degree of

Master of Science in Logistics Management

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Preface

The exodus of microcircuit manufacturers to overseas locations where more favorable economic climates exist should be of concern to the federal government, especially the Department of Defense. This movement has created a dearth of onshore manufacturing capability which could have significant consequences if this country were to attempt to surge or mobilize production to wartime levels. This research attempted to investigate the Air Force's dependency on foreign sources for the procurement of microcircuits used in avionics systems.

The research was divided into two segments. Initially, a particular sample of microcircuits was analyzed to determine which microcircuits were procured directly from a foreign source and the criticality of those foreign manufactured microcircuits. The second segment of the research consisted of interviews with government officials, microcircuit suppliers/vendors, and manufacturing representatives to obtain their opinions as to the extent of U.S. dependency on foreign sources for the manufacture of ceramic dual-in-line microcircuits. It was determined that U.S. manufacturers are highly dependent on foreign facilities for the manufacture of U.S. microcircuits and on foreign sources, primarily Japan, for the component/piece parts which are used in the manufacture of microcircuits.

More effort should be expended by the Department of Defense to determine the actual capability of onshore manufacturers and to attempt to get manufacturers to move back onshore.

This research is significant in the fact that little has been done to uncover our dependence on foreign sources for electronic devices and components. However, because the research deals only with the cer-dip area, the findings may not be applicable to the entire industry. It does demonstrate a need that the authors feel should be brought to the attention of AFLC, AFSC, and DOD managers. Although the revelations may not be startling, the work accomplished should create concern within DOD for this crucial industry.

Several people were instrumental in getting us started on the right track. Although too numerous to single out, we will acknowledge as many as we can. First, thanks to Major Bill Cochran for giving us the idea for our research and allowing us the freedom to explore the files given him by the Cataloging and Standardization Center, and to the personnel at AFLC/MM who allowed us to use their computer resources for our information gathering. Other government personnel, Mr. Sam Miller and Major Harris Capps, also provided us insights we could not have obtained alone. Next, we certainly appreciate all the time given by members of the electronics industry for their candid remarks and for allowing us to use their testimonies and opinions in our research. Without them, this research would not have been possible in the depth obtained. Lastly, thanks to the personnel at the Defense Electronics Supply Center, Engineering Qualifications and Technical Support Branch, especially Mr. Stan Wadella, for allowing us to use DESC files and computer resources freely and opening several doors to us for the investigation. Without these people, the research would never have gotten started. For those that are not mentioned, we also give thanks for your help and support.

Final acknowledgements are due for the advisors, Major Tony Babiarz, who started us off, and Major Bruce Christensen and Dr. Robert Weaver, who helped us with the final product seen here. And special thanks to our wives, Sue and Nancy, and families, who tolerated our absences and long hours and offered their support and encouragement to complete the research.

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Abstract

The exodus of microcircuit manufacturers to overseas locations where more favorable economic climates exist should be of concern to the federal government, especially the Department of Defense. This movement has created a dearth of onshore manufacturing capability which could have significant consequences if this country were to attempt to surge or have to produce at wartime production levels. This research attempted to investigate the Air Force's dependency on foreign sources for the procurement of microcircuits used in avionic systems.

The research was divided into two segments. Initially, a particular sample of microcircuits was analyzed to determine which microcircuits were procured directly from a foreign source and then determine the criticality of those foreign manufactured microcircuits. The second segment of the research consisted of interviews with government officials, microcircuit suppliers/vendors, and manufacturing representatives to obtain their opinions as to the extent of U.S. dependency on foreign sources for the manufacture of ceramic dual-in-line microcircuits.

It was discovered that the current method used by the Defense Electronics Supply Center and AFLC's Cataloging and Standardizations Center to identify foreign manufactured microcircuits greatly understates this country's dependency

on foreign sources for microcircuits. No microcircuits from the sample were procured directly from a foreign manufacturer and only a small number of microcircuits, all of which were manufactured by U.S. corporations, were classified as foreign microcircuits. Through interviews, it was determined that U.S. manufacturers are highly dependent on foreign facilities for the manufacture of U.S. microcircuits and on foreign sources, primarily Japanese, for the component/piece parts which are used in the manufacture of microcircuits. It was concluded that other than JAN/MIL SPEC 38510 devices, which account for only 15 to 20 percent of military requirements, this industry relies exclusively on overseas facilities for assembling cer-dip microcircuits. This dependency is not restricted to the assembly level, but continues into the component/piece parts segment of this industry. Although there are onshore component manufacturers, each industry (ceramic package, leadframe, and sealing glass) is highly concentrated; both the ceramic package and sealing glass industries have only one major onshore producer. More effort should be expended by the Department of Defense to determine the actual capability of onshore manufacturers and to attempt to get manufacturers to move back onshore.

AN ANALYSIS OF

FOREIGN SOURCE DEPENDENCE FOR CRITICAL MICROCIRCUITS

OF USAF AVIONICS COMPONENTS

I. Introduction

Foreign source dependence for raw materials is well documented. However, few people realize the enormity of the dependence on foreign sources for manufactured military goods. In the Department of Defense, the number of items procured from foreign manufacturers and foreign-based U.S. manufacturers is well into the hundreds of thousands (18).

The causes for the increased procurement of foreign manufactured items are recent trade agreements, such as the General Agreement on Tariffs and Trade (GATT), and the cheaper costs and incentives offered in underdeveloped and developing contries. Trade agreements have benefited U.S. manufacturers, but they have also increased the number of imports into the U.S. As labor costs rise in the U.S., more and more industries are looking to overseas areas to reduce their production costs (55). As an added factor, the quality of manufactured goods from overseas sources has improved (14).

The dependence on foreign sources for the Department of Defense (DOD) items raises serious questions as to how widespread this dependency is and if the U.S industrial base possesses the capability to produce these foreign-procured items domestically. If a critical component of a USAF system is produced solely by a foreign manufacturer, the failure of that source could portend grave problems in the readiness of the U.S. armed forces.

Electronic components, such as integrated circuits, microcircuits, and semiconductors, are an area of overwhelming foreign source dependence. Over 90% of the integrated circuits stocked by DOD are obtained from foreign sources (18). Air Force Logistics Command's Cataloging and Standardization Center (CASC) lists over 1300 microcircuits with U.S. and foreign FSCMs (Federal Supply Code for Manufacturer) of which 13% are from foreign manufacturers with no U.S. involvement (41). Many U.S. electronic manufacturers are relocating their manufacturing, assembly, and testing facilities to foreign countries to reduce the costs of production through tax breaks and lower labor costs. Little else is known as to the basis of the agreements between the U.S. manufacturers and the foreign countries to which they are moving (18).

Background

Historically, U.S. industries have been skeptical of foreign-produced items. The "Buy American Act" was designed to keep low-priced foreign competitors out of U.S. markets because their items were of inferior quality and to assure U.S. businesses an active role in their own market. The

Federal Acquisition Regulation still prohibits procurement of foreign-produced items by government agencies, but exceptions now exist to allow their introduction into U.S. markets (25:25-1 to 25-2). Because of the Trade Agreements Act of 1979, DOD has had to change the wording of several clauses to include the "Buy American Act." As it stands now, ". . . non-tariff barriers . . . no longer exist to protect U.S. suppliers from competition from foreign signatory countries offering approved supplies" (9:31-32). Additionally, on 1 January 1981, Public Law 96-39, implementing the Government Procurement Code of the Multilateral Trade Negotiations (or Code), also allowed exceptions to foreign procurement based on GATT.

> . . .Section 30L of . . .[the] law empowers the President to waive the application of the Buy American Act and any other laws, regulations or procedures with respect to the products of a country which fits into any one of the following categories: (1) a major industrial country which is party to the Code and which provides reciprocal treatment to products from the U.S.; (2) a country, other than a major industrial country, which will assume the obligations of the Code and provide the opportunities of the Code through a bilateral arrangement with the U.S., rather than as a signatory of the Code; (3) a country other than a major industrial country which will provide the opportunities of the Code to the U.S., without assuming the procedural obligations of the Code or; (4) is a least developed country. (13:352)

More foreign-procurement was made legal for commercial industries.

Government-to-Government Agreements. Within DOD, two arrangements exist for foreign procurements: the Memoranda of Understanding (MOU) and offset agreements.

> Memoranda of understanding (MOU's) establish agreements between two or more countries to work toward an equitable equilibrium of purchases on defense programs. . . . The goal of the agreements is to achieve greater military capability at the lowest cost through a more rational use of the industrial, economic and technical resources of each country. . . . Offset agreements have more potential impact on DOD than the Memoranda of Understanding. These agreements call for specific percentage of sales offsets in return of the purchase by a foreign government of a U.S. weapons system. Although offsets can be met in a variety of ways, the most common methods used are coproduction of selected components overseas or direct purchase of foreign components for use in the United States. These purchased components can be either defense or non-defense related. (11:22)

Since offset agreement targets are ultimately the responsibility of DOD to assure compliance, this type of arrangement is discouraged except on a case-by-case basis (11:23).

Factors Influencing Offshore Procurement. Commercial buyers are now using foreign manufacturers because of several factors, the major reasons being price and quality (14:25; 11:43). "In the current economy, affordability and lower life cycle costs are increasingly important considerations that must receive a high degree of attention" (30:62). Concerning quality, Dr. Gordon Moore, Chairman of the Board and Chief Executive Officer of Intel Corporation, stated:

> . . .If you can really get the component with significantly higher performance overseas than you can get in the U.S., to be prohibited from using it would put you at a disadvantage, for the sake of an assured source. The technological advantage is very important for these systems. (37:55)

When doing business with NATO countries, ". . .it appeared that U.S. companies were buying components overseas when the cost and quality were favorable" (11:41).

> There have also been reports that Japanese companies are offering special deals to large defense contractors. Some of these contractors are stated to be accepting the task of qualifying large quantity lots of devices in return for free devices to run the qualifying tests. (42:67)

Industrial countries, though, are not the only countries interested in developing relations with U.S. industries or the Department of Defense.

> Increasingly, . . . political, military, and business leaders throughout the world are concluding that integrated circuit production is a strategic necessity, and they are looking for ways to establish such capabilities within their own borders. (75:62)

The Reagan administration's decision to rebuild the U.S. armed forces is another reason for the renewed interest by foreign and domestic industries to increase their capability to produce electronic components.

> Defense electronics contractors are enjoying high volume sales and a steady influx of new orders in the midst of

> the Reagan administration defense buildup . . . . (69:46)

Nearly all new weapons projects in the Pentagon are highly dependent on advanced electronics (69:48). Avionics, a large user of electronic components, will therefore command a larger percentage of the defense industry. Defense experts ". . . forecast that in 1985 avionics will account for $11.3 billion, or 25 percent of the aircraft market" (69:48).

Problems With Offshore Procurement. With such renewed interest in defense production, especially in the area of electronic components, the Department of Defense must beware of overzealousness in capturing a low price market.

> . . . care must be exercised to ensure that DOD does not become irreversibly committed to dependency on foreign sources for certain defense articles and that an adequate industrial base is maintained in the United States. (11:10)

Such care has not been taken, however, resulting in the situation currently experienced by the DOD. In fact, some relaxing of standards has occurred.

> While the JAN [Joint Army-Navy specification], or the circuits provided under the military's Quality Products List (QPL) program, must be constructed in the U.S. to Mil-M38510 specifications and tested to Mil-Std 883B requirements, the 883 designation may also be applied to any commercial device as long as it meets the military's 883 specifications in special tests, even if the parts are made, assembled and tested offshore. (54:6)

A recent white paper by the Engineering Qualifications

Section at the Defense Electronics Supply Center (DESC) highlighted the above problem.

> . . . claims of equivalency [between MIL-STD 883 microcircuits and commercial look-alikes] has lulled many equipment contractors and military program managers into a false sense of security that the components being used are MIL-SPEC items when in actuality they are not. . . . (28:3)

The problems do exist and will continue to exist until policies governing the use of offshore components prohibit the use of such component manufacturing facilities.

> . . . U.S. manufacturers tend to maintain only a token U.S. capability in order to maintain qualification status. In the complex microcircuit technology it would take years before even an efficient assembly operation could be re-established in the U.S. once off-shore assembled devices are no longer available. In addition, off-shore production of wafer fabrication, assembly, or testing tends to deplete the incentive for retention of U.S. based manufacturing sources thus jeopardizing the continuation of an adequate defense production base. (28:4)

Interviews and correspondence with persons in HQ AFLC (18), DESC (84), and the AFLC CASC (41) indicate that no formalized method exists to track foreign sourced items and procurements other than a manual review of each contract. Additionally, no studies have been done concerning the extent of the foreign dependency for microcircuits in the USAF.

Literature Review

Electronics is rapidly increasing its share of the costs in aerospace weapon systems, up from 10% in the 1950s to 30% at the present time (44:235). Annual budgeting for electronics is also increasing. "A review of . . .[CY] 1983 military outlays shows defense electronic spending at nearly $38 billion -- a 14 percent increase over the $32 billion spent in CY-82" (69:48).

> Defense electronics is expected to take a greater share of the defense budget over the 10-year period through 1993, with electronics projected to increase over 31 per cent while the defense budget is projected to increase approximately 16 per cent, according to Electronic Industries Association figures. (67:4)

The increase in budget outlays may lead one to believe that the military electronics market has been a boon to the U.S. electronics industry. This has not been the case. Feldbaum, et al. concluded in their 1980 report, Analysis of Critical Parts and Materials, that even though the DOD is spending more on electronics, the military's share of the integrated circuit market will decline as a percentage of the total market, while the private sector will be increasing its demand of electronic components (36:C-2,C-4). This decreasing percentage of the electronics market may help explain why commercial industries have been moving overseas.

The increasing number of electronics firms turning to the commercial market is indicative of the larger demand and profits available. The lack of profit from defense business has turned industries away from that market. The dual-use technology of integrated circuits and other electronic components allows all manufacturers to apply their technologies to both military and commercial markets (76:443). A 1977 study of the Defense Industrial Base (DIB) found that ". . . approximately 50% of the Defense hardware procurement dollar goes to . . . contractors" whose business is basically commercially oriented (12:4).

> Those companies, however, regard defense orders primarily as supplements to their principal markets. They are unlikely to adjust their business strategies significantly in response to changes in Defense procurement requirements and regulations. (12:4)

Since the defense market is not their mainstay, these companies can afford to be choosy about which contracts to pursue. Usually, the contracts sought are those that will produce the highest return on the investment.

> . . . commercially-oriented companies indicated they sought approximately 14% return on Defense sales before taxes -- just as they did for commercial business. In contrast, the high percent-Defense contractors anticipated no more than 10.5%. Actually, both groups achieved approximately the same result, 3.5% to 4% return on Defense sales. (12:7)

Defense business definitely has *not been profitable* for all industries.

Offshore Basing. As demand increases, electronic manufacturers are continually searching for ways to increase production and, at the same time, decrease costs.

Electronic industries have been looking to overseas areas for basing manufacturing, assembly, or testing facilities in order to decrease their costs.

> . . . the profit motive must be somewhere near the top of private industry's priorities when weighing the pros and cons of offshore purchasing. The cheaper labor and material prices available overseas. . . probably were the primary motivating factors in foreign purchasing decisions. (11:44)

Several foreign countries appeal to electronics companies by offering low tax rates, low wage rates, low interest loans, abundant labor and land, abundant raw materials, foreign (U.S.) ownership of facilities, and tax exemptions for several years (63:164-170). Intel, National Semiconductor, and Motorola, among others, ". . . have assembly and testing operations in or near Hong Kong" (56:66). "AMD [Advanced Micro Devices] has assembly and testing operations in Malaysia and the Philippines . . ." (56:66). Fairchild has assembly and test facilities in Singapore, Hong Kong, and Malaysia (10:55). Each of the manufacturers mentioned supplies several integrated circuits to the military (34:C-24).

Foreign governments are drawing electronics companies to their countries because of the strategic importance of electronics (75:62) and to ". . . promote technological development within the country, boost export earnings, and improve both the balance of payments and the skills of the native work force" (19:10). From the U.S. manufacturer's viewpoint, ". . . labor intensive costs . . . [are] lower in the developing countries, particularly Korea, Mexico, Taiwan, and Singapore (11:59). Fairchild recently invested $44 million to upgrade its assembly and test facility in Singapore (10:55). Usually companies will start out with a manufacturing capability in the U.S., and when volume production is required, ". . . they either contract for or build facilities for the volume overseas" (55:117). The eagerness to use foreign countries with lower labor costs may be detrimental to U.S. based industries. Some companies say that the lower labor costs in the developing countries will give those countries an edge in contracts, thus leading to a reduction of the domestic capability of the U.S. since those domestic sources are not used, and increased foreign dependence (6:584-585).

Another contributor to increased foreign dependence has been the ". . . declining federal and corporate investment in R&D at a time when other nations were stepping up their research efforts" (81:46).

> . . . since the mid-60's we have not invested in training researchers in science and math. [We do not] . . . even come close to approaching the needs we now have. And, the degree to which we can push an economic boon depends a lot on finding new approaches to using the talent we have produced. (70:126)

Foreign students stepped in to fill the gap created by the lack of U.S. students involved in science and math (70:126).

The investments by foreign governments in education and technology have allowed those countries to produce a higher quality product. In his study of acquisition of foreign-produced items, Bergquist discovered that ". . . most of the [U.S.] companies surveyed recognized that superior technology was available overseas . . . in both Europe and the Orient . . ." (11:57). Additionally, an interview with an aerospace company executive revealed that the feeling among some industries was that price and quality of a source should have no domestic boundaries. "The fact that the source is overseas should not bar its consideration as a supplier" (11:44). Another interviewee reported that "if a product is only available overseas sole sourcing may be the only alternative" (11:56). Currently, both U.S. sponsored and foreign-owned overseas sources are considered. "U.S. manufacturers and users can expect to see Japanese memories on the JAN [Joint Army-Navy] QPL [Qualified Products List] . . . [even] though JAN parts must be manufactured in the U.S. . . ." (42:67). In 1983, Japan exported $19 million in 256K Dynamic RAMs (Random Access Memory devices) to the U.S., a 70% increase over 1982 (64:46), although the total may have included some devices from Texas Instruments' Mihi plant (64:46). Additionally,

> A total of $10 million in 256K RAMs were imported after final assembly in the Philippines . . . . Sources believed they were from a Texas Instruments facility there. (64:46)

Competition is not only coming from Japan. Taiwan and

South Korea are also producing ". . . components for modern avionics, command, control, and communications equipment. The United States may never recapture this market" (32:132). In the FY 1983 DOD Program for Research, Development, and Acquisition, Richard DeLauer, USDR&E, stated

> . . . we are . . . experiencing a significant decrease in domestic capabilities to process and manufacture industrial products. We are exploring methods of restoring a domestic industrial capability in critical areas of foreign dependence. (26:IV-5)

As of the delivery of the FY 1984 report of the same name, no mention was made as to the progress of the methods being explored to restore the domestic industrial capability. In fact, concerning foreign dependence, the same statement was made as in the FY 1983 report (27:IX-3).

Trade Agreements. Increased trade with foreign countries may be one solution to bolster our domestic integrated circuit manufacturers. However, Trade Ambassador William Brock has blamed ". . . domestic industries for not fully capitalizing on offshore markets even when barriers have been reduced" for the decline of U.S. electronic component exports (68:P). Trade agreements must be reciprocated, and such was the idea of the General Agreements on Tariffs and Trade (GATT) and the International Government Procurement Code (Code). Part II of the Government Code under National Treatment and Non-Discrimination

> . . . requires foreign suppliers and products to be treated no less favorably than domestic products and suppliers except for "customs duties and charges of any kind imposed on or in connection with importation . . . ." This requirement of national treatment and non-discrimination applies to "products originating within the customs territories (including free zones) of the signatory countries." (13:347)

Contractors in the signatory nations shall not be discriminated against when competing for contracts in other participating countries (6:570). Additionally, developing countries are to be afforded special attention.

> Article III of the Code directs the participating countries to take into account the particular needs of developing countries in safeguarding their balance of payments position, in establishing and developing domestic industries, and in furthering economic development through mutual regional or global arrangements. The participating countries are instructed to facilitate increased imports from developing countries, and especially from the least-developed countries. (6:583)

The Trade Agreement Act of 1979 exempted ". . . from the operation of the Buy American Act contractors in countries which provide 'appropriate reciprocal competitive government procurement opportunities to the United States products and suppliers of such products'" (57:859). However, a 1982 Air Command and Staff College report stated that electrical and electronic equipment components were not included in the list of allowable products for foreign competition, probably since these components have a direct relation with U.S. defense capabilities (9:37).

Manufacturers, though, will use foreign sources if the technology they desire is available from that source (37:55). There is the fear that a fielded system dependent on a foreign-manufactured item that exceeds technology available in the U.S. could become unuseable if the source of the dependency was to disappear and no second source existed in the United States (37:55). As one industry executive stated, "It was a lot easier when we had a monopoly on the technology" (37:55).

Conclusion. Several articles have been written to help explain the causes of increased dependency of commercial industries on foreign sources. Three major factors, cost, quality of production, and trade legislation have had a large impact on the decision of U.S. electronic manufacturers to seek out foreign sources for procurement and manufacture of integrated circuits used in USAF. The extent to which this dependency exists and the exact motivation of U.S. manufacturers to trust in foreign sources will be explored in the remainder of this research.

Problem Identification

With the trend toward more high-technology in weapon systems, it is imperative that the U.S. Air Force, as well as DOD, be able to identify those electronic components obtained from foreign sources that are necessary to maintain critical avionics systems in Air Force aircraft in order to identify possible shortfalls.

Scope of Research

The main emphasis of this research was to identify those foreign-procured electronic components used in critical USAF aircraft avionics. Although some components may be common to other weapon systems, only those used by USAF were identified. Criticality of a microcircuit was determined by the criticality of the end item in which it is used. An analysis of contracts provided the names of manufacturers and suppliers dealing with foreign-produced microcircuits. Once identified, the individual manufacturers were contacted to determine: 1) the nature of any agreements between the U.S. manufacturer and his foreign producer, and 2) the U.S. manufacturer's capability to produce domestically what the foreign base supplies.

Investigative Questions

1. What microcircuits are obtained from foreign sources through suppliers in the U.S.? Which are obtained directly from foreign manufacturers?
2. Are any of these components used on critical hardware, such as the avionics systems in USAF aircraft? If so, can they be tracked?
3. What has been the trend in the past five years for procuring foreign-sourced microcircuits?
4. Does production capability exist in the U.S. for those particular items?
5. Does the U.S. industrial base possess the capability to

handle DOD requirements without foreign suppliers? If not, what must be done to improve that capability?

6. What is the basis for agreements between the U.S. manufacturer and his foreign source?

7. If items are obtained directly from a foreign manufacturer, what is the basis for that exchange?

Limitations

Although there may exist classified information concerning this subject, none was used in this research. Additionally, no specific avionics systems were mentioned along with the components required and the manufacturer, as this information considered together may result in classifying the report.

Limitations were also encountered in the gathering of data from the respective U.S. electronics manufacturers due to the degree to which they participated in releasing information concerning their foreign and stateside programs.

Summary

It is apparent that foreign dependence of electronic components, specifically microcircuits, is becoming a trend in the electronics industry. This research attempted to discover how deeply the Department of Defense is dependent on foreign sources for its supply of microcircuits. Chapter II explains the methodology, one that includes investigating records at the Defense Electronics Supply Center and Air

Force Logistics Command Headquarters and interviewing manufacturers and government personnel for information pertinent to the study. Chapter III reports the findings of the research and the changes that were necessary due to information uncovered in the data breakdown and interviews. Finally, Chapter IV answers the investigative questions, reports the authors' conclusions, and makes some recommendations for aiding the DOD's electronic sector and for further study.

II. Methodology

The methodology employed consisted of three phases: the data collection process, the data analysis to determine criticality and avionics use, and the interview process with personnel representing DOD, commercial suppliers, and manufacturers.

Data Collection

The first requirement was to enumerate those microcircuits obtained from a foreign source. The DO43 system provided the data needed to determine a sample from which to estimate foreign source dependence. A sample of over 1300 microcircuits, Federal Supply Class (FSC) 5962, with identified foreign sources was taken from over 10,000 Air Force-managed microcircuits. This list was obtained from the AFLC Cataloging and Standardization Center (CASC) at Battle Creek MI. A subsequent sample was taken from this list to afford a more thorough analysis within the time constraints given.

Four types of microcircuits were examined: digital microcircuits, linear microcircuits, integrated circuits, and microcircuit devices. Digital and linear microcircuits constituted the largest portion of the list obtained from the DO43 system; a systematic sample of those microcircuits was chosen to establish a number that could be handled in the given time. Random numbers were selected by roll of a die to determine the starting point; then every fifth digital and fourth linear microcircuit was selected to be included in the sample. Integrated circuits and microcircuit devices were evaluated in their entirety as their count was small. The final sample totalled 307, or approximately 24% of the entire listing. The sample population is listed in Appendix A, according to nomenclature.

After establishing the sample population of microcircuits, each microcircuit was crosschecked with the Total Item Record File (TIRF) at DESC to determine whether it was still a current or procurable device. Any "non-preferred" or "unauthorized for procurement" microcircuits were replaced by the identified preferred microcircuits. The replacement circuits were then analyzed.

Data Analysis

Analysis of the selected sample involved several steps: (1) identifying those microcircuits used in USAF weapon systems; (2) identifying those microcircuits listed as JAN/MIL SPEC 38510 and non-JAN or Commercial/Mil Std 883; (3) identifying, through contracts, those microcircuits manufactured offshore; (4) identifying the next higher assembly for the microcircuits to determine whether these devices are used in avionics systems; and (5) determining microcircuit criticality by inference from end item or next higher assembly criticality. All steps were performed manually as the information being extracted was located in files stored at different locations, such as DESC, Sacramento ALC, and Headquarters AFLC. No single computer resource was available for the extraction process. This analysis was intended to answer the investigative questions concerning which microcircuits were used in critical avionic systems (investigative question 1), which were produced offshore and their traceability (investigative question 2), and what has been the trend in procuring offshore manufactured microcircuits (investigative question 3).

After the microcircuit sample population was obtained, microfiche files at DESC's Technical Support Branch were referenced to determine which microcircuits were used in USAF major weapon systems, which microcircuits were JAN and non-JAN items, and the contract file numbers for the non-JAN devices. First, the Master Weapon Systems microfiche was referenced, using the microcircuit's National Stock Number (NSN), to eliminate from the sample population any microcircuits not used on USAF aircraft. Following this delineation, JAN and non-JAN microcircuits were distinguished; this was accomplished by referencing the Total Item Record File (TIRF). JAN items, according to the Qualified Products Listing (QPL), are required to be manufactured, assembled, and tested in the U.S.; therefore, foreign dependency of these manufactured items was not considered. Once the JAN/non-JAN microcircuits were identified, efforts were directed to the investigation of the non-JAN microcircuits.

The next step was to determine the microcircuits' country of origin. Using the Procurement Technical Data File (PTDF) or Contract Technical Data File (CTDF), along with retired contract files at DESC, non-JAN microcircuits' manufacture origin were determined. The PTDF and CTDF list by NSN the contract number, date of award, and the supplier awarded the contract for tne last three to five purchases. The contract numbers were then used to locate recently retired contracts in the DESC contract library to determine a microcircuit's country of origin. Information from the contracts pertaining to foreign/not foreign origin and manufacturer's FSCM were extracted to determine the number of microcircuits within the sample that could readily be identified as foreign-made. To analyze a trend in procurements of offshore manufactured items, contracts for the last five purchases, as identified by the PTDF and CTDF, were obtained. From these previous contracts the intent was to determine whether there has been an increase in the procurement of foreign-made microcircuits.

As a result of the data analysis, two types of dependencies were discovered -- direct dependency, that of total reliance on a foreign source for the end item, and indirect dependency, the dependency of U.S. manufacturers on foreign facilities or sources for production of microcircuits which may be classified as "Made in U.S." Interviews were used to verify and support the distinction between the two types of dependencies.

The microcircuits were then analyzed for use in avionics systems and criticality. The Component Item Review by Stock Number (D049) at Sacramento ALC was referenced to determine the next higher assembly or end item application for the microcircuits. The D049 lists end item NSN under the appropriate microcircuit NSN. These microcircuits were then examined on the D041 (Recoverable Consumption Item Requirement System) at Headquarters AFLC to obtain the Mission Item Essentiality Code (MIEC) for the component that uses a particular microcircuit. To infer criticality of the component microcircuits, those NSNs dealing with avionics were investigated on the D041 to determine usage and criticality. The highest MIEC listed in the D041 for uses of the particular end item were transferred to the microcircuit because the inavailability of the microcircuit would cause the greatest problem within the most critical system. MIEC codes are explained in Appendix B. The above process was required since AFLC does not assign essentiality codes to consumption items like microcircuits.

After isolating the microcircuits used in avionics systems, this data was compared to the data concerning the manufacture origin to determine the number of critical avionics microcircuits procured from offshore sources. The suppliers and manufacturers dealing with these parts, as well as the suppliers and manufacturers of the most recently awarded contracts, were contacted as part of the interview process.

Interview Process

Interviews with DOD personnel, commercial suppliers, and manufacturers were conducted to answer questions raised during the data collection process and the remaining investigative questions concerning the condition of the U.S. microcircuit industry and its capability. Interviews were free form and unstructured, with the authors asking general questions to initiate the interview and adding further questions as provoked by the interviewees' answers. Suppliers were chosen on the basis of the latest procurement award, those identified in a majority or the contracts, or a contract containing no information on the manufacture origin. The Sales or Military Sales section of each supplier's organization was contacted for the necessary information. Information required from these sources included total company business to determine the size of the company, the volume of military business, procedures for bidding on a government contract to include how the suppliers determine which manufacturer's product to bid and the basis for the choice, their estimate of the percentage of products supplied to the government that are manufactured offshore, and how the supplier determines the country of origin of the microcircuit.

Manufacturers were chosen based on the number of contracts that were filled using their parts. Contacts within the companies were obtained from DESC's Engineering Qualifications Branch (DESC/EQ). The contacts provided an opinion to the questions asked or directed the authors to individuals in their respective organizations who could answer the inquiries with more correct information. Departments contacted included Government Sales and Marketing. Information required from the manufacturers included their reasons for moving production overseas, their capabilities for increasing production, the share of production dedicated to JAN and non-JAN military components, and the industry's general condition with respect to capabilities of onshore production. The purpose was to determine how the manufacturers of military components perceived their industry's foreign dependency.

Concerning the indirect dependency issue, manufacturers of components/piece parts used in microcircuit production were also interviewed to obtain their perspectives on this sector of the electronics industry. Information relating to U.S. capabilities in this area, from a physical production capacity to a technological base, and the effects of world-wide competitors on the U.S. industry was requested from each manufacturer. The intent was to illustrate that the U.S. electronics industry is losing not only its end-item manufacturing capability to offshore facilities, but also the capability to support total domestic production of microcircuits.

Besides obtaining the manufacturers' opinions on the industrial situation, government offices were contacted to determine their perspectives on the industrial climate and the acquisition of offshore items. Government sources included the B-1B Systems Program Office (SPO) and HQ AFLC at Wright-Patterson AFB, Electronic Systems Division (ESD) at Hanscom AFB, and the office of the Assistant Secretary of Defense for Acquisition and Logistics (ASD/A&L), Washington DC (formerly UnderSecretary of Defense for Research and Engineering (USDR&E)).

Limitations

This research was limited to a specific population of microcircuits, specifically those of the ceramic dual-in-line (cer-dip) type, a fact which may prevent its generalization to the entire base of the electronic component industry. Cer-dip is only part of the entire industry, but it is used extensively by the military services. This research was designed to illustrate the changing nature of the electronics industry in the U.S. and point out some areas of possible improvement. Interviews were limited to those persons who deal directly with the military, so as to obtain as much information as possible, because it was unknown how some personnel unfamiliar with the military market may react to the questions, or how much information they would be willing to divulge.

With the exception of the government personnel and official company spokespersons, all interviews were conducted with the knowledge that the individuals interviewed may not be totally informed of their respective companies' policies. However, since all commercial manufacture personnel worked with the government in either sales or standardization, the authors expected them to be familiar with the subjects included in the interviews. All interviewees were assured that only their opinions were being solicited on topics where their expertise was lacking. The individuals were informed that the information given in the interviews was recorded as opinion and not necessarily their company's opinion. The authors felt that this information was still of benefit, in order to determine the feeling within the industry of the present situation. The intent of the research was to obtain candid and, when possible, accurate information from those individuals who work with the government in the acquisition of electronic components.

III. Findings

This chapter contains the findings of the investigation of foreign-source dependency for the sampled microcircuits. Before the findings are discussed the data collection process, problems encountered during the investigation, and changes to the methodology described in Chapter II will be addressed.

Data Breakdown

Although much effort was spent in the manual translation of the microfiche files, the number of microcircuits incorporating the characteristics required dwindled after each step. The original systematic sample of microcircuits yielded 169 digital microcircuits (19% of the total identified in the DO43), 95 linear microcircuits (25% of the total in the DO43), 14 integrated circuits (the entire number included in the DO43), and 29 microcircuit devices with no particular definition. The list of microcircuits in the original sample is contained in Appendix A. Subsequent searches that narrowed the requirements eliminated some microcircuits from consideration. The initial elimination of non-aircraft related microcircuits reduced the sample population to 99 digital, 40 linear, 2 integrated, and no microcircuits. Upon checking this sample against the Total Item Record File

(TIRF), the discovery was made that 60% of the microcircuits, 89 of 141 items, had been standardized and replaced with JAN/MIL SPEC 38510 items. The majority (73%) of the digital microcircuits were replaced accounting for the high percentage of circuits replaced. According to sources at DESC, this is not unusual, since non-JAN parts are used extensively in new weapon systems and over time these parts are systematically reviewed to determine where duplication exists and JAN standard parts can be substituted (43; 85). It was also discovered that some digital microcircuits were replaced by linear microcircuits, and some integrated circuits were replaced by digital or linear microcircuits. The microcircuits with no particular classification from the original sample must have been incomplete in their nomenclature, for all the devices used in major weapon systems were designated as digital or linear in the TIRF. The end sample consisted of 27 digital and 28 linear microcircuits.

After referencing the PTDF, the contracts for the remaining microcircuits were examined to determine the microcircuits' country of origin. The NATO FSCMs, originally thought to identify foreign sources for microcircuits, were, in actuality, listed on the TIRF for use by NATO countries and only as information to DOD customers, not for procurement (83). Therefore, manual extraction of the required information from each contract was necessary. Some contracts were not available as the contract numbers were recorded incorrectly. Many contracts failed to identify the microcircuit as foreign or not foreign in origin, causing the authors to reevaluate the benefit of examining previous contracts. The authors also discovered that DESC retains previously awarded contracts for only one year (85). After that time, the contracts are retired to the Federal Records Center (FRC) for storage. Although these older contracts would be available from the FRC, DESC personnel indicated that it would require extensive manhours to retrieve them (85). In light of the number of more recent contracts which lacked information on the microcircuits' country of origin, the decision was made not to review the retired contracts at the FRC. Therefore, research into the procurement trends of specific microcircuits was not accomplished and this research question (number three) was not answerable in the terms of the original intent. The approach taken to this question was to include information from the interviews with the manufacturers and electronic industry experts and their opinions of the trend in offshore manufacturing.

After reviewing the microcircuits' information from the DO49, the sample was again reduced to 48 total, of which only 25 had uses in aircraft avionics. The avionics NSNs for the next higher assemblies or end items investigated on the DO41 were 1270, 1280, 4920, 5821, 5826, 5841, 5865, 6610, 6615, and 6930. Explanations of these NSNs is contained in Appendix D. Eighteen of the microcircuits had MIEC corresponding to a priority of 9 and above. Breakout of MIEC by numbers and priorities is contained in Appendix B. No connection is made directly between a particular NSN and the MIEC, as this may compromise the security of the part.

Following the identification of the criticality of the microcircuits, identified foreign manufactured microcircuits were cross-referenced to determine how many microcircuits of the final sample could be identified as critical, used in avionics systems, and produced offshore. Seven were procured offshore: three manufactured by National Semiconductor Corporation, two by Fairchild Semiconductor Corporation, and one each by Motorola and Texas Instruments. Of the seven, only five were found to satisfy all requirements of the research. Although a majority had a MIEC corresponding to a priority between 1 and 9, the five identified had priorities of 4 (three microcircuits), 8 (one microcircuit), and 14 (one microcircuit) indicating that these microcircuits were indeed critical. No foreign manufacturers were identified as a source for any microcircuits from the selected sample. The small number of foreign manufactured microcircuits may be deceiving as will be revealed later from the interviews with suppliers, manufacturers, and government personnel. Since only JAN items must be manufactured, assembled, and tested in the U.S. and no restrictions are placed on non-JAN items, the question of where these other parts identified as being "not foreign" were actually manufactured became foremost.

Interviews were conducted with supplier, manufacturer, and government personnel as stated in chapter two to uncover the reason for identification of so few microcircuits as offshore manufactured. Their testimonies and opinions led to the discovery of what the authors refer to as an indirect dependency. As an addition to the interviews initially proposed with the microcircuit manufacturers, other interviews with the electronic component piece-part manufacturers were accomplished. The companies and individuals contacted were obtained through interviews with government personnel and the microcircuit manufacturers. Information in this area was not covered in the literature but was deemed important by the authors for further investigation. The purpose was to determine how the piece-part manufacturers perceived their roles in the U.S. electronic industry and as world competitiors. Since most of the microcircuits used by DOD are of the ceramic dual-in-line package (cer-dip) type, ceramics and leadframe manufacturers were contacted to determine their position in the market and possible reasons for foreign dominance in both of these products. Findings in this area are discussed in the "Components/Piece Parts" section.

Supplier Interviews

A total of thirteen suppliers were interviewed to determine their knowledge of foreign manufacture of the products which they supplied to DESC. The names were taken from the contracts researched at DESC and represent the most widely awarded suppliers of contracts within the past year. The points of contact at each supplier were the sales or military sales sections. Some individuals wished to remain anonymous and, as such, will not be mentioned or specifically referenced within the text or appendices. The list of suppliers and sales persons interviewed is contained in Appendix C.

The suppliers varied in their total volume of business and percentage of business in military contracts from $200,000 to $38 million in government sales and 2 to 100 percent of the companies' business, the majority of the companies being in the 2 to 30 percent range.

All suppliers indicated that they were aware of offshore manufacturing of electronic components and that almost all commercial grade parts were manufactured overseas, but their estimate of offshore manufacture varied. One supplier, Kierulff, estimated between 30 to 40 percent of the microcircuits' manufacturing process, based on relations with Texas Instruments, was offshore (78). Another, from Micro-Mil, estimated that 80 to 85 percent of production was offshore (60). Other suppliers either mentioned a high percentage, but gave no exact figures (16; 20; 24; 38; 39; 45; 61), or could give no estimate (52; 83). The basis of the percentage of offshore manufacture depended on the sources that the supplier used in his contract bids. The most frequently mentioned manufacturers were National Semiconductor, Motorola, and Texas Instruments.

When requesting bids for purchases, DESC sends Invitations for Bid (IFB) or Automated Purchase Requests to all approved suppliers which list all approved manufacturers. When choosing a particular device to bid, the suppliers agreed that no preference was given to parts manufactured domestically over offshore manufactured parts except in the areas of delivery and price. In order to be competitive, price considerations are primary in determining which manufacturer's part the supplier will bid. Suppliers bid the lowest priced part that meets the technical standards and quality required by the QPL and DESC. Two of the thirteen suppliers, Hamilton/Avnet and Televox, stated that the lowest priced onshore and offshore parts are bid and they let DESC determine which part will be accepted (45; 86).

Determination of offshore manufacture was not always possible. Even though the supplier could obtain domestic/ offshore manufacture origin of the microcircuit from the manufacturer, this information could be biased. Manufacturers could list the part as "made in U.S." if at least 50% of the manufacture and value was domestic (25:25-1). It was later discovered through interviews with the component part manufacturers that materials for the microcircuits are obtained by the manufacturers before the "kit" is sent offshore for assembly and testing. As long as the component parts -- ceramic package, leadframe, and die -- are manufactured onshore, these pieces can be assembled offshore and the end device can be certified as an American product. The purpose of this procedure is to minimize customs charges because only the material and labor added offshore will be subjected to customs duty. How each microcircuit manufacturer splits his component parts business, whether onshore or offshore, will vary depending on his particular customs situation. Bill Everitt of Kyocera International, Inc,. world leading manufacturer of ceramic packages, stated that the microcircuit industry is very customs oriented which is one reason for Kyocera's original move to establish a ceramics plant in the United States (34). Since component parts are available from both onshore and offshore companies, the microcircuit manufacturer could produce one microcircuit as a foreign product in one lot and a domestic product in another, all depending on how the manufacturer decided to split his business and how he handled the customs. The assembly and testing phases of manufacture add little monetary value to the end device, enabling the manufacturer to market the microcircuit as "made in U.S." Therefore, the suppliers cannot be totally certain if the parts on which they are bidding are offshore or onshore manufactured parts. Pioneer-Standard was the only supplier to state that they purchased only U.S. made parts; however, it was unclear whether this meant onshore production or made by U.S. manufacturers (4). No further comment was obtained.

Information concerning a microcircuit's manufacturing origin which was not indicated in the DESC contracts was found through the suppliers' contracts, as the foreign/domestic production information was included in their paperwork. All suppliers agreed that the manufacturers do not usually provide the information concerning manufacturing location, but if requested by DESC, country of origin could be obtained by querying the manufacturer. In general, the suppliers would ordinarily provide foreign/domestic origin of parts if they knew, but sometimes, origin is not known and not a concern as (1) this information is not deemed critical by DESC, since they rarely ask for it, (2) the manufacturers may make the determination, as previously stated, that a part is U.S. manufactured when in actuality some manufacturing is offshore, and (3) the suppliers can usually guess if a part is manufactured offshore because most manufacturers from whom they buy have offshore plants. If any question exists as to origin, the majority of the suppliers agreed that the blocks would be left unmarked.

One supplier marked "not foreign" on the contracts if the part is obtained from a manufacturer listed on the QPL (78). These policies followed by the suppliers and manufacturers have created a tenuous situation in the determination of the actual manufacture country of origin of microcircuits. However, as interviews with microcircuit manufacturers revealed, the determination of foreign or not foreign with regard to a microcircuit's total origin is not an easy task.

Manufacturer Interviews

Six major manufacturers were interviewed concerning their operations of onshore and offshore production. Not surprising was the discovery that all manufacturers operated offshore facilities, but some to a greater degree than expected. Among those countries that have been able to attract the U.S. integrated circuit (IC) industry are the East Asian countries: Taiwan, Malaysia, Singapore, Hong Kong, South Korea, Philippines, and Thailand. However, several European countries were also mentioned: Italy, Germany, England, France, Portugal, Ireland, and Scotland. In only one case were South American countries mentioned: namely, Argentina and Brazil. Incentives to move offshore include those elements of cost mentioned throughout the literature (10; 14; 63), labor costs being the major consideration. Jack Kinn of the Electronic Industry Association (EIA) stated that the decision about where to move is based almost totally on labor costs (47). However, Arney Stensrud of Motorola, Dick Lambert of Signetics, and Richard Aria of AMD also cited facility costs as a reason for moving offshore (74; 50; 8). Other reasons given were construction costs, government subsidies, tax breaks, tax moratoriums, and worker productivity.

Because of the labor-intensive nature of microcircuit production and the availability of cheap labor overseas, offshore movement has been extensive. The general feeling among microcircuit manufacturers was that by automating facilities and reducing the amount of labor required, production could be brought back to the U.S., although the trend is not in that direction. Ralph Miller of Texas Instruments (TI) agrees in theory that automation could bring production back to the U.S. due to the decrease in labor required, but realistically sees automation expanding in offshore facilities (58). TI currently maintains several automated facilities overseas and is constantly updating the technology there. Richard Aria also supported the fact that the trend in automating facilities is in the direction of the offshore assembly facilities and not back onshore (7). Again, the reason is cost. Stensrud stated that Motorola maintains the most automated facility in the U.S. at Chandler, Arizona, yet offshore costs are still well below those of the Chandler plant; however, no cost figures were given (74). Therefore, automation may not be the only answer to returning microcircuit production to the U.S.

Other cost factors must be addressed.

The reduction of production costs was not the only consideration given for moving into a particular foreign country. Government stability, competition from indigenous and worldwide producers, and available labor talent were also noted. For example, based on Mexico's unstable government and unfavorable attitude toward the U.S., Motorola has elected not to manufacture military parts in those facilities. Additionally, Lambert stated that Mexican production is usually located close to the border and wage rates are comparable to those in the United States (50). Kinn stated that South American countries are also usually not sought for expanding production due to their instability and added that Scotland and Ireland are prime areas for expansion, as both of these countries have no indigenous microcircuit industries (47). In the area of talented labor, Susan Davis of National Semiconductor Corporation (NSC) stated that the countries of Southeast Asia offer more and better talent than either South America or Mexico (22). Richard Aria agreed with the contention that Southeast Asia is an excellent source of labor and added Ireland as another (8).

All manufacturers agreed that the majority of microcircuit production, over 80% of commercial and Mil Std 883B items (manufacture, assembly, and testing), is done offshore. JAN/MIL SPEC 38510 items are required to be manufactured, assembled, and tested in the U.S. according to the Qualified Products Listing published by DESC, so some manufacture is maintained onshore, but the percentage of total manufacture dedicated to JAN products is very small. Although the amount varies monthly, NSC manufactures approximately 1700 883B devices and only 140 JAN products (22). Susan Davis could not elaborate on what percentage of NSC's total production these items constituted, but judging from other manufacturers' testimonies, it is likely to be a small percentage. Richard Aria stated that his company devotes less than one percent of the company's total production capacity to JAN devices (8). Meanwhile, fifteen percent of their capability is devoted to the 883B devices. This capability is maintained both onshore and offshore. Aria also estimated that 98 percent of the company's assembly operations are offshore (8). Dick Lambert stated that of Signetics' onshore capability, 98 percent is dedicated to JAN production and two percent is set aside for developmental programs (50). He also estimated that 20 to 30 percent of the company's total production is in JAN devices, the balance being commercial products which are produced offshore (50).

While most companies may be drawing down their production of JAN devices or increasing their commercial production capability, Fairchild is increasing its onshore capability for JAN devices. Chandler Senate revealed that their plant in South Portland, Maine, has recently been upgraded in order to triple its production capacity, and expects to be producing ten times its capability of four years ago (73). Senate was very confident in Fairchild's capability to meet surge requirements in this respect. Other manufacturers were not as assured of their ability to meet surge requirements. Davis stated that the main obstacle to meeting surge requirements would be encountered with equipment restrictions, particularly the testing equipment (22). People are not a factor. However, she added that many of the larger manufacturers have the capability to convert their commercial lines over to military production if necessary (22). Dick Lambert's conception of the problems in a surge is totally opposite that of Davis. He saw the people problem, obtaining a properly trained force, as the major obstacle in surging (50). He stated that Signetics could easily acquire the equipment necessary for a surge, but would have difficulty maintaining production without adequate labor. As a final note, Lambert added that if the surge were necessary due to an overrun of the Far East by unfriendly forces, problems would be even greater, as most of the microcircuit assembly is located in that region. The loss of those facilities would affect the industry's capability to surge (50).

Although much of the production capability of U.S. microcircuit manufacturers has gone overseas, especially assembly and testing, certain aspects of production have remained onshore, particularly the manufacture of the die, the integrated circuit chip. Technology and proprietary rights rest with the manufacturers in the U.S. and they are reluctant to move that technology offshore for fear of proliferation of counterfeit items. However, even though the die is manufactured in the U.S., this piece, along with other parts of the microcircuit, is usually shipped overseas for assembly and testing. Richard Aria stated that his company receives all materials at its U.S. facility for testing prior to shipment overseas (7), but other companies, such as TI and Motorola, have testing capability at their offshore facilities (21; 58). According to the manufacturing sources, few parts other than the die are manufactured in the U.S. (7; 22; 50; 72; 74), which leads to a different and even greater foreign dependence than was first suspected. This indirect dependency will be discussed in a following section.

<u>Government Interviews</u>

Government sources were interviewed to determine any regulations or agreements used to govern the manufacture of microcircuits and to discover any attempts at decreasing foreign dependency and increasing U.S. IC capabilities. Conversations with the Engineering Qualifications Branch at DESC, the B-1 product assurance engineer, and the ASD/A&L Defense Materials Specifications Standards Office revealed that no controls were put on items other than JAN/MIL SPEC 38510 (17; 43; 59). Bob Knott, acting chief of DESC/EQ, stated that non-JAN microcircuits (883B or commercial-grade parts) could be produced offshore, and both JAN and non-JAN ICs could contain parts (ceramic base and lid, and leadframe) manufactured offshore if those parts were adequately tested before circuit assembly (49). Mil Std 883B covers testing procedures and documentation requirements of the microcircuits for specialized usage (e.g. heat, shock, or hardness testing). The use of offshore manufactured parts was also substantiated by Sam Miller, ASD/A&L (59). DESC considers the piece parts (ceramic, leadframe, wires, and die) as raw materials for the microcircuits, but requires documentation and testing of all parts in government-procured end items. Knott added that most of the back end assembly of non-JAN parts (fixing the ceramic base to the lead frame), and testing was done offshore due to labor costs (49).

Conferences with Darrel Hill, DESC/EQ, and Tom Cheung at the B-1 SPO revealed that weapon system acquisition is most vulnerable to offshore dependency (43; 17). Frequently, the contractor, or original equipment manufacturer (OEM), is able to tailor specific circuits to a weapon system using his own Specification Control Drawing (SCD) rather than DOD standard parts. Attempts have been made to provide the government more control over the parts used in new weapon systems by giving more control to DESC's Military Parts Control Advisory Group (MPCAG). Before 1983, DESC's MPCAG recommendations were considered only advisory in nature and, on average, only 20% of DESC's recommendations were followed (43). Secretary of Defense Caspar Weinberger and Deputy Secretary of Defense William Taft have issued memos to attempt to give the MPCAG more control in the standardization process before the weapon system is fielded, as opposed to replacing non-standard parts after fielding (29; 71). In Weinberger's memo, 29 August 1983, concerning spare parts acquisition, he directed in his near-term actions that all DOD agencies

> [Apply] the DOD Parts Control Program to enhance competition. The optimum use of standard military parts or commercially available parts in development of new systems will be mandatory. (29:1)

Darrell Hill also cited a 12 December 1984 memo from then UnderSecretary of Defense Wade stating that OEMs were using SCDs excessively and generally not complying with the DOD policy of using standard parts (43). The memo gave further guidance to this problem. The following requests were made:

> Direct Program Managers to require that contractors implement the DLA Military Parts Control Advisory Groups (MPCAG) recommendations unless a written waiver is obtained from the Program Manager for each contested recommendation. (29:1)

> Direct Program Managers to consult with MPCAGs prior to rendering a decision on contested recommendations and also to provide the MPCAGs with feedback on implementation of their recommendations. (29:1)

The intent of the efforts on the Parts Control Progr. and Spare Parts Acquisition was to reduce standardization problems and testing procedures, remedy spare parts acquisition problems, and increase compliance with the standard parts program. To determine the effects of the program, the product assurance engineer at the B-1 SPO was interviewed.

Tom Cheung revealed that control of parts is maintained by the SPO by the Program Parts Selection List (PPSL) (17). This list contains approved mil-standard and non-standard parts, and a section of inactive or disapproved parts. For mil-standard parts not on the list, the contractor need only seek approval from DESC for use and send a copy of the approval to the SPO. Non-standard parts require more review and approval.

Non-standard parts are considered by the contractor (OEM) for several reasons, to include:

1) if a mil-standard part is available, but the non-standard part is superior;
2) if a mil-standard part is not interchangeable, because of design requirements, even though the two parts are functionally the same; and
3) if demand for a mil-standard part is higher than forecasted, resulting in a shortage and possible leadtime and schedule problems, and a non-standard part is available with no delays

in production schedule (17).

Each of these cases will be reviewed by DESC, the SPO, or both.

In the first case, paperwork is sent to DESC and the SPO. DESC is the approval authority for all non-standard parts, and the SPO relies on their expertise because the SPO lacks the technical engineering manpower and computer data base for all parts. If disapproved, DESC must give reasons for their disapproval. If the part is approved, DESC may give limitations on its use in the system.

Occasionally, the OEM will design parts to be used in certain items that are functionally the same as a standard part, but may not be interchangeable with the standard part for design reasons, e.g., a 12-pin versus an 8-pin connection. Because re-engineering may cause scheduling problems, the contractor may ask the SPO to override a DESC disapproval decision. If overridden, DESC may recommend an alternate commercial part, but leadtime and scheduling problems may even prevent the use of the recommended part.

Maintaining production schedule is the major factor in the third instance. If the contractor cannot obtain the mil-standard part to meet the schedule, a request is made to the SPO for a one-time approval. This part, however, is not included in the Technical Order data, as it is only a one-time approval.

The efforts to standardize parts have been somewhat successful, but OEMs may still use parts of their own design for a new system, making new systems more susceptible to offshore dependency, and creating problems with standardization. If SCDs are used, the burden falls on DESC for standardization, which may require acquisition of the SCD and subsequently replacing the part with either a DESC drawing or JAN/MIL SPEC part.

Pursuit 2000, an electronics industry report compiled by USAF's Electronics Systems Division (ESD) in support of the 1985 Annual Production Base Analysis (APBA), makes the same inferences concerning standardization. The "Active Panel Report" states that "[most] of the products sold in the military marketplace are commercially developed items screened to military processes . . ." (2:I-3). Concerning standardization, the report indicated that

> . . .[there] is a lack of program enforcement for utilizing standardized microcircuits. There is much discussion at present regarding the JAN,Mil-M-38510, and the DESC programs; they are still not accepted by the prime contractors because they are generating source control drawings every day. At present, a product line of 60 products can result in more than 800 active source control drawings on file. (2:I-3)

Additionally, in Section 2.3, "Trends", the report states that "JAN . . . parts . . . account for only 15-20 percent of total DOD requirements, and therefore the bulk of military semiconductors have some form of off-shore fabrication process" (3:24). As was found in this research, PURSUIT 2000 discovered that foreign dependency reaches farther than just assembly of ICs, a finding that will be discussed in detail later.

Concerning surge capabilities of the industry, Major Harold Capps, ESD/ALMP, stated that, generally as a whole, the electronic circuit industry is not able to surge (15). Some segments may be able given small demands, but weak links do exist especially in the area of component parts for the end device. His contention is that the dependency on foreign sources for these components will severely hamper any attempt to increase production capacity, though DOD does not answer this question. Pursuit 2000 also indicates that the major constraint in a surge would be the acquisition of raw materials for the devices. It states that ". . . it could take one year or longer just to accumulate the parts necessary to begin manufacture" (2:I-8). Current onshore plant capacity and labor resources are also cited as obstacles to a surge, just as were mentioned by the manufacturers. The greatest threat, though, is perceived to be the dependence on foreign sources for the microcircuit components.

Components/Piece Parts Industry

As stated earlier, JAN/MIL SPEC 38510 items must be manufactured, assembled, and tested in the United States, but this requirement does not include the individual components/piece parts (ceramic bases and lids, leadframes, sealing glass, and wafer/chip) making up the microcircuit. These items are considered raw materials and can be produced in offshore facilities. Since a cut-off of raw materials would disrupt the production of the end item, an excessive reliance on offshore sources could be considered an indirect foreign source dependency in the context of reliance on foreign sources for manufactured items.

Another important point to understand concerning piece parts is that there is no distinction between those parts which go into JAN/MIL SPEC 38510 products and Commercial/Mil Std 883B products. Jon Ewanich, Staff Engineer in the Packaging Engineering Division of NSC, stated that piece parts are basically the same; they differ only in the amount of testing required for the device into which they will be included (35). Manufacturers will, therefore, use the same piece parts for either military or commercial products. Generally speaking, piece parts manufacturers have no idea whether they are producing for military or commercial specifications. Bill Everitt of Kyocera International, Inc. (KII), a major ceramic package manufacturer, said there have only been a couple of programs in the past, specifically the Trident projects, when Kyocera was aware that their packages were destined for a military program (33). Military requirements and specifications in these projects were passed directly to KII. Under normal circumstances, the component manufacturers build only to the customer's specifications and have no knowledge of their use after delivery (33).

The piece parts industry can be further divided into two main categories: low end technology and high or front end technology. Ceramic bases and lids, leadframes, and sealing glass, although extremely important to the industry, are characterized as the low end of the technology spectrum, while wafer/chip fabrication is characterized as the high/front end of the technology. As far as wafer/chip fabrication is concerned there was strong concensus that manufacturers are reluctant to move this technology offshore; security and the need for close customer contact were the primary reasons given for maintaining onshore production. Jack Kinn stressed that close customer contact will become more critical in the future, especially in the semi-custom microcircuit arena (47). He stressed the need for further integration of work stations between the original equipment manufacturers (OEMs), the ultimate designers of the system, and the manufacturers who have to supply the wafer/chip -- this will be done extensively through CAD-CAE-CAM (computer-assisted design/engineering/manufacturing)integration (47). A second factor preventing wafer fabrication from moving offshore, especially to the Far East, is a lack of raw materials used in the production process itself (51). Dick Lambert cited a lack of gases and chemicals at the purity levels needed for wafer fabrication as a major obstacle for many areas overseas. He said offshsore wafer fabrication, at the present time, tends to be restricted to Europe where the economic benefits are less apparent. The final explanation, closely related to the second factor, is that wafer fabrication is equipment and material intensive, which minimizes the economic advantages and pressures for moving to offshore facilities (51).

Microcircuit Manufacturers' Perspective. The overall view of the piece parts industry, ceramic packages, leadframes, and sealing glass, by those interviewed was that each of these industries is heavily dependent on foreign sources (7; 20; 47; 51; 58; 72; 74). Although no single segment of these piece parts industries was sole source to one particular company, the general feeling was that these industries were sole source to one country -- Japan (7; 21; 47; 51; 58; 72; 74). One of the most vocal individuals interviewed was Arney Stensrud who stated that Motorola gives no consideraton to the procurement of U.S. manufactured piece parts because there are no U.S. suppliers (74). Stensrud added that

> Being a qualified supplier means not only do you have the technology and competence, but you have the capacity to support the industry. If you are a lap guy, able to support a nominal amount, then you can go through qualification and prototype. That is one thing. But to sustain us as an industry, you are talking about 750 million to 650 billion units a year -- no onshore [manufacturer] can support that type of quantity. (74)

Although the above statement was directed toward the manufacturing of ceramic packages, Stensrud added that in the final analysis, 90 percent of all piece parts come from Japan (74).

For ceramic packages, three companies were cited as the major suppliers to the U.S. microcircuit industry, all three being Japanese companies: Kyocera, NTK, and Narumi (33; 35; 45; 48; 50; 65). As a general rule, the estimates for Kyocera's market share ranged between 40 and 60 percent, while the other two, NTK and Narumi, shared between 20 and 30 percent of the market. This left approximately 10 to 20 percent of the total market to the U.S. manufacturers. The Japanese concentration did vary somewhat depending on whether the ceramic package was a cer-dip or multi-layer ceramic package. Jon Ewanich stated there is more American representation in the cer-dip market. He identified Microelectronics Packaging Industries (MPI) and Dematron Technology Glass (DTG) as the two American companies currently producing cer-dip (35). In the multi-layer ceramic package arena, the market was described as almost totally Japanese with two American companies, MPI and GE, just beginning to enter this sector of the market (35; 65; 77). By far the largest supplier of ceramic packages, both cer-dip and multi-layer, is Kyocera (7; 22; 35; 46; 47; 50; 58; 72).

Most individuals interviewed were aware that Kyocera does have a plant located in San Diego, California, but were unable to offer information as to the plant's capability. Although its manufacturing capability was recognized, many felt that it was tied closely to its Japanese home offices and plants, Kyocera Corporation (45; 48; 51; 74). James Knight, Coors Ceramics, felt the San Diego plant was entirely dependent upon Japan for its ceramic powder technology (48). Jon Ewanich stated that most of NSC's ceramic packages for their Tucson plant which manufactures JAN/MIL SPEC 38510 products, come from Kyocera's San Diego plant, while NSC's overseas plants that deal with commercial and Mil Std 883 products receive their ceramic packages from Kyocera Corporation, Japan (35). No onshore manufacturing capability was cited for either Narumi or NTK.

More diversity prevailed in opinions concerning the dominance of the Japanese in the leadframe industry. Although two major suppliers of leadframes were identified as Japanese, Mitsui and Katsuda, several individuals interviewed agreed that their companies were not as dependent on the Japanese in this area (35; 45; 73). Texas Instruments (TI), Motorola, and Signetics officials cited heavy reliance upon Japanese suppliers, while AMD, Fairchild, and NSC officials stated a heavier usage of onshore manufacturing sources (35; 45; 51; 58; 73; 74). Dick Lambert and Ralph Miller claimed that the American leadframe manufacturers tended to be centered in the specialty, or niche, market and it was the Japanese who dominated the high volume, "jelly bean", market where pricing was the major factor (51; 58). Arney Stensrud argued that quality and reliability levels required for military products required that leadframes be purchased from Japanese sources because these factors could not be matched by the U.S. counterparts (74). Motorola is 98 percent dependent on Japanese leadframe suppliers for it JAN/MIL SPEC 38510 programs (74). The three U.S. manufacturers identified by AMD, Fairchild, and NSC were Stamping Technology, Oberg, and Plessey (later found to have been taken over by Handy and Harman) (35; 45; 73). Because of these onshore manufacturers, both Jon Ewanich and Jay Ju felt that microcircuit manufacturers had a much greater variety of leadframe suppliers from which to select and estimated their onshore market share was between 50 and 60 percent (35; 45).

The third segment of the component/piece part industry, sealing glass, appeared to be heavily concentrated and dependent on the Japanese (33; 35; 45; 65; 80). Only three manufacturers were cited by all interviewees: Nippon Electric Glass (NEG), Iwaki Glass, and Owens Illinois (33; 35; 65; 80). Both NEG and Iwaki are Japanese firms and command an estimated 80 to 85 percent of this market (80).

Ceramic Package Manufacturers. During several initial interviews, only two American manufacturing firms' names were consistently mentioned: Minnesota Mining and Manufacturing (3M) and Coors Ceramics (7; 31; 35; 47; 65). Further investigations revealed that both of these companies had left the ceramic package industry since late 1983 (48; 77). The first to go was 3M. Their plant in Chattanooga, dealing in multi-layered ceramic packages, was sold to General Electric (77). Coors, a manufacturer of cer-dip, sold their electronic packaging division to Microelectronic Packaging Industries in late 1983 (48; 65). Although Coors still manufactures technical ceramics, it no longer provides any mounted packages, gold and sealing glass applied, to any customers, but currently provides MPI with basic fired ceramic bases and lids (48). According to James Knight, the primary reason for Coors' departure from the industry was its inability to compete against the Japanese (48). Phil Rogren of MPI felt that a part of Coors' problem was that the company had a hard time deciding which market they wanted to be in. He felt that Coors was never properly motivated for this industry. He went on to add that 3M never made the required investment into the manufacturing side of the business; therefore, they experienced continuous problems with their multi-layered packages (65). Richard Aria and Jon Ewanich mentioned that their respective companies experienced numerous problems trying to qualify packages provided by 3M and Coors (7; 35).

Current onshore manufacturing capability for producing cer-dip consists of two American companies: Kyocera International, Inc., and Dematron Technology Glass. By far the largest of the two is KII, a U.S. corporation registered in California and wholly owned by Kyocera Corporation of Japan. The company began in 1969 as a small trading company in the San Francisco Bay-Silicon Valley area. In 1971, Kyocera bought a small ceramic packaging business (50 to 80 employees) from Fairchild Semiconductor in San Diego. KII has subsequently grown to over 1200 employees and moved from its original facility, but remained in San Diego (33).

Dematron Technology Glass is owned by Dematron, Inc., and like KII, is a U.S. corporation registered in California but is owned by a German corporation: Dematron GMVH. The corporation began as Technology Glass in 1973, initially manufacturing specialty glass for unique applications, catering to the specialty/niche market dealing in the area of higher lead counts. By 1977, Technology Glass found itself in the cer-dip business through one unique application. As the Japanese became more dominant in this market, Technology Glass began to integrate its operations downward into the lower lead count market -- the "jelly bean" market, where the normal lead count is between 14 and 16 -- eventually building both ceramic lids and matching bases. In July 1983, Technology Glass was acquired by Dematron, Inc., and in 1984, consolidated its San Diego and Sunnyvale operations into one facility in Union City, California (31). Although most individuals in the microcircuit industries interviewed associated KII with its parent company, Kyocera Corporation, no mention of the tie between Dematron Technology Glass and its parent, Dematron GMVH, was made. In fact, almost everyone interviewed still referred to Dematron Technology Glass as Technology Glass.

According to Bill Everitt, Vice President for Corporate Communications, KII's share of the U.S. market, cer-dip supplied to U.S. manufacturers, is approximately 65 percent (33). Kyocera's world-wide market share is estimated at 80 percent, making it the largest supplier of cer-dip products. He also estimated the percentage of offshore produced cer-dip at 85 percent, which includes Kyocera, Narumi, NTK, and MPI (33). These estimates are based on discussions between Everitt and his company's marketing specialist. Information concerning Kyocera's market share was provided by an outside marketing consultant firm employed by KII. Based on Kyocera's estimates of offshore production, it would appear that onshore production capability accounts for approximately 15 percent of the world market. Although, when asked to estimate the production split between KII and Kyocera Corporation going to U.S. manufacturers, regardless of the destination of the packages (i.e., onshore vs. offshore assembly plants), Everitt estimated the split at 50/50 for cer-dip (33). In other words, the San Diego facility is currently producing about half of the cer-dip destined for U.S. manufacturers. In addition, for the portion manufactured in Japan, KII acts as a wholesaler -- buying the items from Japan and reselling them to U.S. customers. Therefore, all U.S. package orders are handled by KII. This estimate holds for all types of cer-dip products, but the percentages differ for advanced packages, such as multi-layer. Another point Everitt stressed was that KII does possess all the modern, sophisticated equipment -- CAD, CAM, laser drilling, and computer-controlled machinery -- necessary to produce any package that is produced in Japan (33).

When asked about KII's capability to support military requirements if Japan were cut off, Everitt stated that KII does not know for sure what their products go into, so it was very difficult to estimate the military market, but based on the assumption that the military requirement is no more and is probably less than KII's total cer-dip manufacturing capability, he felt confident that the San Diego facility could handle it (33). This answer was also conditional on the assumption that the plant would be turned strictly into a military manufacturer, a questionable assumption short of total war mobilization (33). One of the major points stressed was KII's independence from Kyocera Corporation for its raw materials. Except for certain types of sealing glass which could be purchased from U.S. sources but are imported from Japan for financial reasons, all supplies are acquired from onshore sources (33).

The final point Everitt made concerning onshore capabiliy was KII's expansion efforts in Vancouver, Washington (34). KII has a 90,000 square foot multi-layer ceramic chip capacitor facility currently under construction and plans eventually call for approximately 550,000 square feet of manufacturing operations and office structure at the site. No decision has been made as to the product lines to be handled at this facility beyond the multi-layer ceramic chip capacitor to be housed in the plant currently under construction. Anything is possible, such as mechanical, application, industrial-type ceramics, or numerous other technical ceramics (34).

Whereas Kyocera International is an example of an offshore producer moving to the U.S., Dematron Technology Glass could best be described as a U.S. based manufacturer whose interests were bought by an overseas corporation. Theirs is a specialty operation, now attempting to expand its market share by moving into the high volume products. Although the consolidation of the San Diego and Sunnyvale operations into the Union City facility has doubled their facility size from 40,000 to 80,000 square feet, Will Eckert, Sales Manager, still estimated their market share at less than 10 percent (30). Michael Lemereis, Sales Engineer for DTG, estimated their share of the market at about five percent (53). Phil Rogren of MPI estimated his company's market share also at five percent, but estimated DTG's market share at about half of MPI's, or about two to three percent (65). Regardless of the estimates, DTG would have to be considered a minor producer in the cer-dip market.

The third American manufacturer of cer-dip is MPI, but currently it has no onshore production facility (48; 65). Although MPI claims to manufacture both commerical/Mil Std 883 and JAN/MIL SPEC 38510 products, it currently relies on Coors for its fired ceramic lids and bases which are then shipped to Singapore for bonding the sealing glass (65). In reality, MPI is an American offshore producer of ceramic packages. That is not to say MPI will not be a factor in the future, as the company is currently developing its own pressing capability in both Singapore and Scottsdale, Arizona. When these projects are completed, MPI's total production (pressing and glazing) will be split in the following manner: Scottsdale -- 20 to 25 percent, and Singapore -- 75 to 80 percent (65).

Leadframe and Sealing Glass Manufacturers. While the ceramic package manufacturers, specifically Kyocera, described a somewhat better situation for their industry than the microcircuit manufacturers, the leadframe manufacturers described an even stronger, although guarded, position for onshore production capability of cer-dip leadframes. All three leadframe representatives maintained that American manufacturers have historically had a strong position in this industry, but certain economic factors have occurred within the last two years which may change their position, especially if the trend continues through 1986 (62; 67; 79). The two most critical concerns were the current recession within the microcircuit industry and the perceived artifically low yen valuation, relative to the dollar. These two factors have had a dramatic impact on the competitive capability of the American companies (62; 67; 79). Although the Japanese manufacturers have always enjoyed the advantage of being located closer to where most of the microcircuit products are assembled (Korea, Philippines, and Malaysia), a superior product and the ability to compete has in the past aided the American leadframe manufacturers. But lately the yen-dollar ratio has allowed the Japanese to price their leadframes so low that it has become far more attractive for U.S. microcircuit manufacturers to buy from them (62; 67). At the present time, according to James Otto of Stamping Technology, they can offer Motorola leadframes at about $18 per 1000; the Japanese manufacturers are able of offer equivalent parts at approximately $15 per 1000 (62). John Rosic, Oberg-Arizona, Inc., agreed with Otto, saying that the Japanese are currently selling their leadframes below what it is costing U.S. manufacturers just to obtain the raw materials (67). Since raw materials account for 60 percent of a cer-dip leadframe cost, Otto attributes the majority of the price differential to the yen-dollar ratio. He added that the differences in transportation costs brings the price differential to about $4 per 1000 (62). When the microcircuit industry was booming (1983 through the first half of 1984), the American manufacturers tended to tolerate this price difference. But when the market deteriorated, this additional cost began to be questioned by U.S. manufacturers. Some companies that previously had strong buy American policies began arguing for the world market and felt that they should buy from whoever is offering the lowest price (62). Lew Toth, Marketing Vice President for Handy & Harman, stated the Japanese stampers are out to dominate this industry and are currently buying business to keep their plants at a fairly good operating level (79). He said this was unfortunate because U.S. leadframe manufacturers provide the best quality, especially in the higher lead counts; the Japanese quality is good but tends to be more competitive in the lower lead counts (79). One way the Japanese are making a dent in the American share of the market is by giving away their tooling expense, a very expensive cost in the leadframe industry (79).

Prior to the current recession, Otto estimated the American manufacturers, in terms of dollar sales, commanded about 60 to 70 percent of the world market for cer-dip leadframes. Stamping Technology owned about 40 percent of that business. Today, Otto estimated, the American share of the world market has fallen to about 50 percent (62). Rosic, restricting his estimate to the U.S. manufacturer's market, estimated Oberg's share as 15 to 20 percent and Stamping Technology's share between 35 and 40 percent (67). Toth felt business was so depressed, down 60 to 70 percent depending upon product lines, that it was impossible to estimate overall market shares. He did feel the American manufacturers owned the larger share of the higher lead count frames (more sophisticated frames), while the Japanese probably dominated the lower lead counts (79).

These individuals confirmed Stamping Technology, Oberg-Arizona, Inc., and Handy & Harman Electronics Materials as the three major U.S. manufacturers of cer-dip leadframes (62; 67; 79). Stamping Technology is a private corporation, located in Milpitas, California, whose specialty is in the lower lead counts and whose volume is the largest of the three American producers (62). Handy & Harman Electronics Materials is owned by Handy & Harman, a large precise metals company, who entered the cer-dip leadframe industry two years ago by buying Plessey Montevale, the oldest and at one time the largest cer-dip leadframe manufacturer. They are now one of two fully integrated suppliers in the world, the other being a Japanese company. Total integration refers to the capability to manufacture the leadframe material as well as the parts themselves (79). Oberg-Arizona, Inc. is a subsidiary of Oberg Manufacturing, Inc., an old line high technology stamping company, whose leadframe facility is located in Chandler, Arizona (67). Otto described Oberg-Arizona as an "up-and-coming" cer-dip manufacturer, while Toth rated Oberg-Arizona as a distant second or third in both manufacturing volume and dollar sales (62; 79).

As stated earlier, the third segment of the piece parts industry, sealing glass, is heavily dependent on Japanese sources. The only American company mentioned was Owens Illinois. Donald Towse, Manager of Marketing and Sales for Technical Products, emphasized that Owens was strictly a minor force in that market. He estimated their market share between 15 and 2Ø percent (8Ø). Since each microcircuit manufacturer decides how it will split its business, Owens attempts to work with U.S. manufacturers to specify their products -- to the extent Owens is able to do this, they can have an involvement. Towse stated Owens Illinois has adequate excessive capacity to fill the gap if the Japanese suppliers were cut off (8Ø).

JAN/MIL SPEC 3851Ø Offshore Issue

Government Perspective. On 13 February 1985, then UnderSecretary of Defense James P. Wade issued a memorandum of understanding clearing Australia, Canada, and Ireland for reciprocal qualification on the U.S. JAN/MIL SPEC 3851Ø QPL (82). These negotiations had been going on for some time and ended in a settlement which may have profound ramifications for this country's last area of onshore assembly capability. According to Darrell Hill, DESC's position throughout the negotiations was to allow foreign manufacturers to be listed on the JAN/MIL SPEC 38510 QPL, but they would be listed according to that country's standard. Although listed on the QPL, the foreign device could not be purchased if a JAN/MIL SPEC 38510 device is preferred and a U.S. manufacturer is able to supply the device. DESC's intent was to offer an alternative source if a JAN device was not required or not available. When this issue was settled, the MOU went beyond DESC's position; it stated there would be no distinction in the method of listing on the U.S. QPL or product on the basis of country of origin. For the first time, the door had been opened so foreign produced devices can be listed as equivalent devices on the JAN/MIL SPEC 38510 QPL (43).

The U.S. government does not actively seek agreements with other countries, but will approach a country's reperesentative when advised by microcircuit manufacturers and it appears to be of benefit to those manufacturers. Sam Miller stated that some manufacturers had approached him concerning an agreement with Mexico because of the amount of work being done there for the U.S. manufacturers (59). Mexico's representative expressed no interest at that time and has not been approached since. Currently another agreement with Israel, started higher than the USD office, is being considered, but no other details were available (59).

DESC's primary concern with this agreement centers on three issues: auditing and certification, traceability, and the competitive position of U.S. facilities. DESC's auditing program, both initial production qualification and on-going conformance inspections, is critical to the JAN program. Hill stated it takes approximately five years to train a DESC engineer in understanding the intricacies of the JAN standards and, in many cases, DESC inspectors act more as consultants to the maufacturers than inspectors (43). Because of this close scrutiny and coordination, DESC claims JAN devices have a 3 to 35 times greater reliability over non-JAN devices (29). With overseas production, DESC's auditing and certification powers will be lost or at least diluted. Reasons for this center on budgetary constraints for overseas travel and manufacturers' concerns about having foreign agencies inspecting their processes which may lead to technology transfer. For the offshore facilities, DESC will have to rely on each country's quality assurance agencies; DESC's role will be more advisory than enforcement. Hill feels the end result will be devices made to the particular country's standard, but will be marked as a JAN device and be able to compete on an equal footing against onshore devices whose manufacturers must meet all of DESC's qualification standards (43).

Hill's second concern is traceability, the ability to determine whether a particular device is truly a JAN equivalent item and not merely a commercial device packaged as a JAN device. By relying on indigenous inspectors, he feels there is a greater potential for counterfeit devices to be passed off as JAN products (43). Sam Miller, ASD/A&L, played this aspect down since the MOU gives all countries involved the right to retest any item that enters their country. If deficiencies are found, the manufacturer can be denied listing on the QPL (59).

The ability of U.S. onshore manufacturers to compete with offshore manufacturers is of great concern to the manufacturers, but also to the government, in terms of readily available supplies and technologies. Hill cited the Irish government's offerring of tax breaks, land, and other benefits to manufacturers to aid them in setting up production facilities in Ireland (43). It is presumed that these benefits will give unfair economic advantages to offshore facilities, as is currently seen in the production of non-JAN microcircuits. These attractive benefits may also draw down the number of facilities in the U.S. if not checked. Miller indicated that U.S. manufacturers are not prohibited from moving a facility overseas as long as the facility moving is not the last onshore producer of a particular item (59). If it is, the only recourse is not to qualify the new plant. He stated:

> If there are alternative sources for the device in the United States . . . we cannot prohibit him [the manufacturer] from applying for qualification in a foreign plant. But, if he shuts down the only source that we have in the United States for manufacturing that particular device . . . unless there are peculiar circumstances . . . we would not extend qualification to his foreign plant. (59)

Hill argued that this country is in danger of losing what manufacturing capability we still have and not receiving much in return (43).

Microcircuit Manufacturers' Perspectives. It became apparent that the opening of the JAN QPL to foreign countries is an extremely emotional issue within the microcircuit industry. Interviewees indicated that one of the reasons for this is the fact that many issues are still being negotiated and little information is available to the industry (23; 58; 74). Several individuals interviewed were unwilling to discuss the offshore movement of JAN other than to admit they were aware that agreements between the U.S. and Australia, Canada, and Ireland were being negotiated. Of those individuals willing to discuss the agreements, the competitive issue, the ability of onshore facilities to remain competitive with the foreign producers, was considered the critical one. Susan Davis felt that onshore plants were much more compliance oriented than offshore plants, which may work against the U.S. manufacturer. She stated that NSC had just completed a $2 million program to have its Tucson plant JAN-certified and another company could spend half that amount offshore and be fully certified on the QPL (22). Dick Lambert stated that their strategy, if JAN moves offshore, is to use the facilities of their parent company, N.V. Phillips, to manufacture offshore JAN parts. He claimed that application had been submitted to the U.S. government for such action (51). Ralph Miller stated the TI will stay competitive and, if it requires moving offshore to do so, they will act accordingly. He felt it was possible that more production capability would go overseas, but he was not sure the potential was there because it has been opened only to the NATO countries and Australia, and most of the high volume comes from the Far East, not Europe. Although he felt these agreements would have limited impact, he did stress that it represented "a hole in the dike" (58). This response was echoed by Lambert (50). He felt that the European threat was only temporary, but eventually the MOUs would be expanded to the Far East (51). Pressure to demonstrate good faith to our Far East allies, Thailand, South Korea, and the Philippines, may cause the U.S. to open the doors further or the current MOUs may be construed as discriminatory by these countries, an accusation that could be detrimental to U.S. foreign policy. In the end this issue will issue will be decided in

Congress, as the decision will be settled on political not technical grounds.

Summary

Foreign dependence in the microcircuit area does exist and could potentially become a greater problem if conditions are allowed to continue as in the recent past. The problems of limited manufacturing capability in the U.S. are currently the most important problems facing the DOD should a surge or mobilization capability be necessary. Economics is a major reason for this lack of onshore capability in both manufacturing and raw materials for microcircuits. Although DOD is not dependent on foreign manufacturers for finished, manufactured microcircuits as yet, the opening of the JAN market to other countries may change that situation. These problems need to be addressed, and the effects of the industry's condition on military logistics need to be studied in order to adequately assess U.S. capability in this area.

IV. Conclusions and Recommendations

Chapter III revealed the variety of opinions and perceptions of the microcircuit industry's and the electronic component industry's capability to produce onshore. DOD's dependency on foreign sources for manufactured microcircuits was observed as more of an indirect dependency. Reliance on foreign sources is largely due to the movement of the U.S. manufacturers' assembly and testing facilities to offshore locations. However, with the opening of JAN production to offshore locations, the dependence on foreign sources for manufactured microcircuits may increase. These issues will be addressed in this chapter through the answering of the investigative questions, the authors' conclusions, and suggested recommendations for improving the state of the microcircuit industry and further research in this area.

Investigative Questions

Investigative Question One. What microcircuits are obtained from foreign sources through suppliers in the U.S.? Which are obtained directly from foreign manufacturers?

As was stated in Chapter III, only seven microcircuits from a sample size of 307 could be clearly identified as foreign products and, of those seven, none were procured directly from any foreign manufacturers. All were procured from U.S. manufacturers but were devices which, for one reason or another, could not be certified as an American product. The authors surmise the primary reason for these seven devices being categorized as foreign would be the number or percentage of foreign procured piece parts which went into the manufacturing of these devices. Depending on how the manufacturers procured their piece parts for a subsequent lot, the same type of device could very well be certified as a U.S. product after the next production. Because DESC either does not require or enforce the requirement that suppliers identify a microcircuit's country of origin, these findings could be understated; but based on this sample analysis and interviews, the conclusion was made that there is little indication of direct dependency on foreign devices or foreign manufacturers for microcircuits used in Air Force avionic components. As was also stated earlier, the NATO/foreign FSCMs (Federal Supply Code for Manufacturers) which were listed on the Total Item Record are actually included therein for informational purposes only and do not indicate that these sources were or would be used for the procurement of these devices; these foreign sources could be used for items which were not JAN/MIL SPEC 38510 devices, but in this research, none were so identified.

The foreign dependency that was noted in this research was in the form of indirect dependency, a case which the authors suggest is much more dangerous from a military perspective because it is not as apparent as direct dependency to the ultimate user. The most noticeable form of indirect dependency centers around U.S. microcircuit manufacturers' reliance on offshore facilities for the assembly phase of the microcircuit manufacturing process. As was pointed out in the interviews, each major U.S. microcircuit manufacturer will maintain only one onshore production facility, generally dedicated to manufacture of JAN/MIL SPEC 38510 devices and development of new devices, but will operate numerous offshore assembly plants manufacturing commercial and Mil Std 883 devices. As long as these devices have an acceptable level of component parts manufactured in the U.S., these devices can be certified as U.S. products. While commercial devices may not have obvious uses in military weapon systems, these devices, in some form, are extensively used in military systems, especially during the weapon system acquisition phase when avoiding cost overrun and maintaining production schedule are the primary considerations. JAN/MIL SPEC 38510 devices contribute only 15 to 20 percent of the Air Forces's microcircuit requirements -- although they did turn out to represent about half of the sample after the original sample was adjusted for non-preferred microcircuits -- leaving 80 to 85 percent of the Air Force's microcircuit requirements as Commercial/Mil Std 883 devices. These items are dependent on some form of offshore assembly, of which most is done in the Far East, creating a potential logistics problem during a major conflict or mobilization.

The second form of indirect dependency noted in this research was the reliance on foreign sources for the component/piece parts, which are considered raw materials in the microcircuit devices. This dependency can impact both Commercial/Mil Std 883 and JAN/MIL SPEC 38510 devices because there are no restrictions placed on manufacturers in obtaining their raw materials for either product. Although the interviews with the microcircuit manufacturers described a rather gloomy picture within the piece part industries for American producers, interviews with representatives within these industries did paint a somewhat better picture. There appears to be some American representation within each of these industries (ceramic packaging, lead frames, and sealing glass) although it did appear to be somewhat concentrated in one company or at best three major companies. The degree to which there is American involvement within the ceramic package and leadframe industries may explain why there were so few foreign microcircuits identified from the sample. By using ceramic packages manufactured by Kyocera International Inc. in San Diego, which most microcircuit maufacturers identified as a Japanese company, and leadframes from any of the onshore producers, Stamping Technology, Oberg, or Handy & Harman, U.S. microcircuit manufacturers can certify their commercial devices as U.S. products, even though all parts are shipped overseas for assembly. Given KII's capability to handle approximately 35 percent of the U.S. manufacturers' cer-dip demand, the U.S. leadframe manufacturers' market share of approximately 50 percent, and the military's share of the entire microcircuit market accounting for only seven percent of the total market value, most microcircuits destined for military applications could retain the "Made in U.S." marking, even though the industry is heavily dependent upon foreign sources for assembly. In conclusion, identifying specific microcircuits as being foreign procured does not accurately indicate this country's dependency on foreign sources for meeting its microcircuit requirements.

Investigative Question Two. Are any of these components used on critical hardware, such as the avionics systems in USAF aircraft? If so, can they be tracked?

Only five microcircuits of the total sample were identified as both foreign manufactured and critical in Air Force avionics systems. As pointed out in question one, investigation of the data considered only direct dependency; if indirect dependency were considered, the number of critical components dependent upon foreign sources or facilities would increase because of U.S. microcircuit manufacturers' dependency on offshore assembly facilities and raw materials (ceramic packages, leadframes, and sealing glass) used in the manufacture of Commercial/Mil Std 883 devices.

It is important to realize that the JAN/MIL SPEC 38510 program is a standardization program designed to assure quality and reliability of microcircuits; devices chosen to be produced under this program are not selected because they are tied to critical weapon system components, such as fire control systems, electronic countermeasure equipment, airborne navigation systems, or others. JAN/MIL SPEC 38510 devices are not correlated with MIEC codes of 1 or 2; Commercial/Mil Std 883 devices could just as easily be used in critical components as JAN devices. The decision whether to use or not use JAN devices centers more on the availability of the JAN device, the OEM's design of the system using the microcircuit, and a weapon systems' potential production delays rather than on whether the device is part of a critical component. Once the weapon system has been deployed and item management has been turned over to DESC, commercial devices are periodically reviewed to determine whether a JAN device or another commercial device is available that could aid in standardizing components; but once again, this process is not tied to any criticality issue any more than when the weapon system was first deployed. In fact, Darrell Hill, DESC/EQ, emphasized that the B-1B weapon system was relying heavily on Commercial/Mil Std 883 devices for both production scheduling reasons and program cost considerations; such devices are very reliant on offshore assembly and possibly raw materials, and many will be used in critical components as defined by this research.

It was determined that it would be extremely difficult to track these components. Taken individually, these items or devices constitute small purchases; contracts reviewed averaged about $6,000 per award, and DESC personnel are concerned with the expeditious handling of these contracts, not the determination of the microcircuit's country of origin. It is not cost effective to ensure that the suppliers and manufacturers are supplying all the information to determine whether a device is foreign procured or not foreign procured. Even when a commercial device qualifies as a U.S. product, the manufacturer must still rely on a foreign facility for a critical phase of its manufacturing -- assembly. Therefore, tracking country of origin would not aid in identifying the extent to which military weapon systems rely on foreign sources for the procurement of microcircuits.

<u>Investigative</u> <u>Question</u> <u>Three</u>. What has been the trend in the past five years for procuring foreign-sourced microcircuits?

This question could not be answered because DESC's contract records tended to be incomplete in identifying country of origin. General information from the literature and interviews were used to determine the direction that microcircuit manufacturers are moving in the use of offshore sources. This movement offshore has not been a recent phenomenon. Foreign assembly is well ingrained in the U.S. microcircuit manufacturer's operations. Although two manufacturing representatives, National Semiconductor and Fairchild Semiconductor, did mention recent investments in their JAN/MIL SPEC 38510 lines, the lion's share of this industry's investments has been and continues to be channelled towards the offshore facilities. Most manufacturers acknowledged that automation did hold potential for onshore development, but stated that automation has already been incorporated into many of their offshore facilities. Left to their own volition, manufacturers will incorporate automation into their onshore JAN/MIL SPEC 38510 lines because the newer and more advanced microcircuits require automated production. But automation has not caused and will not cause manufacturers to move any of their offshore production back to the U.S. Total cost -- labor, construction, operating and maintenance -- has caused and will continue to cause manufacturers to move their operations offshore. The concern expressed over the issue of allowing offshore manufacture of JAN/MIL SPEC 38510 devices supports the notion that there is a natural movement to offshore facilities. The interviewees agreed that if one or more manufacturers can obtain an economic advantage by producing offshore, then other manufacturers must follow suit. The present MOUs may appear to be directed towards three countries -- Australia, Canada, and Ireland -- which do not have distinct economic advantages over onshore sources, but they represent a new hole in the dike to U.S. manufacturers, a dike which was protecting the last remaining onshore manufacturing capability for microcircuits. The authors agree with Dick Lambert's statement that it would be just a matter of time before this agreement is opened to other countries where there are definite economic advantages. Therefore, the trend toward offshore manufacturing appears to be continuing.

The past five years have been a period of turmoil for the U.S. component/piece parts industry. During this period two large U.S. firms have elected to leave the industry -- Coors and 3M -- and smaller firms have been acquired by larger ones. Much of the reason has been the inability of the American manufacturers to compete against the marketing strategies of the Japanese. Their companies have been able to acquire a larger share of these markets because of their manufacturing volume capability, their customer service philosophy, and their cut-rate pricing strategies. Some interviewees felt that Japan has purposely followed an aggressive policy in an attempt to capture a dominant share of the electronic industry. These same individuals argue that the U.S. manufacturers, in an effort to maximize short-term corporate performance, are playing into the Japanese strategy. James Otto of Stamping Technology cited Texas Instruments' joint venture with Japanese leadframe manufacturers as an example of an American company strengthening its ties with offshore sources and closing its doors to American onshore manufacturers. He argued the end result will be fewer American manufacturers and higher prices once the Japanese have a controlling position within this industry. This shake-out appears to have already taken place within ceramics and sealing glass (although this research makes no inference of the impact that this shake-out has had on prices), and is currently occurring in the leadframe industry, in which it appears that the Japanese have made some inroads. The U.S. component industry, just as the microcircuit industry, is in danger of losing all its capabilites to offshore sources.

Investigative Question Four. Does production capability exist in the U.S. for those particular items?

At the present time, U.S. microcircuit manufacturers possess the technology for producing both JAN and non-JAN microcircuits onshore, but have retained the capability to manufacture, assemble, and test only JAN items onshore. Once a non-JAN product has been designed and its production process developed and thoroughly tested onshore, the manufacturing knowledge and procedures for that product are exported to offshore assembly facilities, where the actual production takes place. It was emphasized by all interviewees that the knowledge and technology is American, but economic competition has forced all U.S. manufacturers offshore for the large-scale production phase. Pursuit 2000 estimated the military share of the total U.S. market at only seven percent, and the microcircuit manufacturer representatives estimated JAN production at 15 to 20 percent of the total military production; therefore, an estimate of the total onshore cer-dip capability would be approximately two percent. This is an extremely rough estimate of U.S. manufacturing capability, but, based on interviews, it does give an indication of how dependent U.S. manufacturers are on their offshore assembly facilities and how lacking this country is in its capability for manufacturing microcircuits.

U.S. microcircuit manufacturers are highly dependent on foreign sources for their component parts, but not as dependent as initially suspected. The most dependent area appears to be sealing glass, where the only onshore producer of any quantity is Owens Illinois, a company that was described by its own representative as a producer of marginal quantities compared with the two major Japanese producers. The ceramic package area turned out to be in better shape than first indicated, although it is highly concentrated. If Kyocera International Inc. is as independent of their parent company as their representative indicated, then the U.S. microcircuit manufacturers do have available a major supplier of cer-dip packages onshore. The only problem would be the dominance of one manufacturer, but in some respects it appears that a monopoly already exists within this industry. Other indications of the health of this sector are Dematron Technology Glass' attempt to move into the "jelly bean" market and MPI's efforts to build an onshore plant; these additions should enhance the U.S. ceramic package manufacturing capability. By far the best U.S. capability lies within the leadframe industry; it appears that all three U.S. manufacturers identified -- Stamping Technology, Oberg, and Handy & Harman -- are major producers of cer-dip leadframes. However, a future concern is the potential effect that the current recession, mentioned by the leadframe and sealing glass manufacturers, will have on this segment on the U.S. piece parts industry. In the final analysis, the U.S. has the technology to produce microcircuits without any reliance on foreign sources, but at present it lacks the capability to do so. For economic reasons, the U.S. manufacturers have become reliant on offshore facilities and sources.

Investigative Question Five. Does the U.S. industrial base possess the capability to handle DOD requirements without foreign suppliers? If not, what must be done to improve that capability?

The authors can come to no other conclusion than U.S.

microcircuit manufacturers lack the capability to support DOD requirements without some form of foreign support. By far, the weakest link in the U.S. manufacturing process is its over reliance on foreign assembly of commercial devices. Since 80 to 85 percent of the current military microcircuit requirements are classified as commercial devices, which are assembled overseas, and U.S. microcircuit manufacturers maintain onshore facilities only for the production of JAN/MIL SPEC 38510 devices, the authors have concluded that onshore manufacturers could not supply enough devices to meet military requirements if all foreign facilities were cut off. There is no doubt that the onshore JAN/MIL SPEC 38510 facilities could pick up some of the military production, but not enough to replace the loss of all the overseas assembly facilities. Based on the interviews, there also appears to be little concern on the part of the U.S. manufacturers about this country's lack of manufacturing capability; most individuals felt that since the assembly plants are not located in one country but are scattered throughout a multitude of countries and these countries are more or less friendly toward the U.S., this dispersal offers adequate protection against a total loss of assembly capability. A loss of one country may impact an individual company or several companies, but it would not dramatically affect the total industry.

In the area of component/piece parts, certain items could be handled with the loss of a foreign source, but not all. Ceramics, an industry thought to be totally Japanese controlled by most microcircuit manufacturers, can be produced in sufficient quantities onshore to satisfy all military needs given a cutoff of Japanese sources, but not without a significant impact on commercial production -- a proposition in the opinion of the authors to be totally unacceptable for both political and economic reasons. Leadframe producers, given this country's three major manufacturers, appear to be best capable of handling a complete cut off of foreign suppliers. In the area of sealing glass, although the Owens Illinois representative felt confident that Owens would have the capacity to meet the U.S. manufacturer's demands if Japanese sources were cut off, the authors concluded that Owens' capability would be similar to Kyocera International Inc.'s: it could support military requirements, but not both military and commercial demands simultaneously.

An additional problem existing in the component/piece parts industry is the degree of concentration to one country: Japan. Dispersal of assembly facilities over numerous countries was considered by several manufacturers as protection against possible cut off; however, U.S. manufacturers could experience major supply problems if Japan were isolated. Given this degree of concentration and, therefore, vulnerability, the authors would argue that existing onshore capacity should be protected and more capability, especially within ceramics and sealing glass, should be encouraged.

Two things must be done to correct the lack of onshore production capability: (1) pressure must be placed on the U.S. microcircuit industry to move more of its assembly facilities back onshore, and (2) U.S. microcircuit manufacturers must be encouraged to procure their component/piece parts from onshore producers. Getting microcircuit manufacturers to move back onshore may not be difficult as several interviewees expressed the view that the industry does not care where it produces the devices. Each company's concern centers primarily on its ability to compete. If one manufacturer can cut his costs by moving offshore, then all manufacturers must follow or face extinction. The current tendency of allowing some military devices to be built offshore and requiring other military devices to be built onshore was also viewed by some manufacturers as part of the problem. A possible solution would be to require all military components, both JAN/MIL SPEC 38510 and Commercial/Mil Std 883 devices, to be manufactured onshore. No doubt this would raise the cost of these devices, but automation and special tax incentives could be incorporated to offset some of these negative factors.

In piece parts, although some U.S. capability exists,

AD-A161 311 AN ANALYSIS OF FOREIGN SOURCE DEPENDENCE FOR CRITICAL MICROCIRCUITS OF US..(U) AIR FORCE INST OF TECH WRIGHT-PATTERSON AFB OH SCHOOL OF SYST.. 2/2

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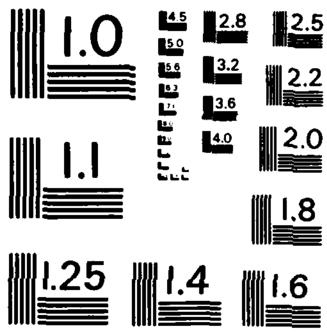
1.0
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Japan holds the edge in volume of production; therefore, economic sanctions against Japanese and assistance towards U.S. companies could be levied to create an artificial market in favor of U.S. producers. If sanctions were considered too drastic, DOD could fall back on the exclusion clause of the GATT to allow procurement of critical technologies only through onshore manufacturers. Also, the DOD and the military services should play a more active role by requiring primary contractors and subcontractors to procure subsystems and components from onshore producers.

Investigative Question Six. What is the basis for agreements between the U.S. manufacturer and his foreign source?

As discovered in the literature, the U.S. manufacturers' offshore facilities are founded and maintained on the basis of costs, the availablity of a talented and trainable labor force, and the stability/friendliness of the country's government. Naturally, the manufacturer will attempt to work the situation to his advantage and not risk such large investments without guarantees. Nationalization of the industries within a country is always a possibility no matter how stable or friendly a government may be.

All manufacturers stated that their companies had established offshore facilities many years ago due to the absence of competition in the foreign countries and the ability to produce at lower costs making their prices more competitive; they could not recall other reasons for moving to those areas. At present, no restrictions exist as to non-JAN manufacture or the obtaining of pieces for use in the end-item microcircuit from overseas areas. No government-to-government agreements exist in the area of commercial microcircuit production.

Component manufacturers operate under the same trade rules as the microcircuit manufacturers, except that no components are specified as JAN items; the only requirement is that the components meet certain standards before their inclusion into military parts. Foreign sources are used as freely as costs allow and their use depends largely on the microcircuit manufacturers' policy towards customs. Foreign sources may be used for several reasons: cost, quality, quantity available, and service. Ceramic packages and leadframes are available from U.S. sources, but sealing glass is almost totally foreign sourced. This sector of the industry, as the microcircuit industry, is driven by economics.

Investigative Question Seven. If items are obtained directly from a foreign manufacturer, what is the basis for that exchange?

Presently, the U.S. has negotiated and approved MOUs with Australia, Canada, and Ireland for the production of JAN microcircuits, but only Ireland possesses the capability for immediate entry into the JAN microcircuit market. The U.S. government does not actively seek nations with which to formalize contracts, but does so only at the suggestion of interested parties. No action would be taken if it was considered detrimental to U.S. capabilities. If something of this nature does occur, under the General Agreements on Trade and Tariffs (GATT), the U.S. would be allowed to exclude certain items from the MOU. Several persons agree that the GATT has provided more opportunities for foreign countries to enter U.S. markets and vice-versa, but they criticize U.S. manufacturers for failing to exploit foreign markets with their technology as other countries have freely entered competition with the U.S.

Pressure from the Commerce and State Departments has necessitated the agreements with other countries for DOD items and opened the door for further encroachment on U.S. military markets. Although DOD can put restrictions on the movement of critical technologies offshore, there is no guarantee that industrial capabilities will remain in the U.S. if competition from offshore sources increases. As seen in the component/piece part industry, the proliferation and use of non-U.S. manufacturers has increased due to economic reasons, giving a good indication of the future if more MOUs are created in the name of politics and economics.

Conclusions

The United States is extremely dependent on foreign sources for the manufacture of cerdip microcircuits, but not in the manner that was first suspected. When this research began, it was anticipated that direct dependency would constitute a major factor since each microcircuit in the original list from CASC had at least one NATO FSCM. But, as was indicated in Chapter III, this was not the case. Initially, the lack of identified foreign-procured microcircuits created confusion because of the amount of information written pertaining to the use of foreign sources. Through interviews, it was determined that indirect dependency was the problem, not direct dependency. However, due to recent agreements with other countries, the degree of direct dependency may change as JAN competition moves offshore.

Indirect dependency can take two forms. The first form of indirect dependency is U.S. microcircuits manufactured by U.S. corporations, but assembled in offshore facilities owned by the same manufacturer. This form of dependency has reached the point at which this country's commercial and military cer-dip requirements are almost totally reliant on these offshore manufacturing facilities. In fact, the remaining onshore facilities could not even meet the military needs if these offshore facilities were isolated. The U.S. microcircuit manufacturers' reliance on offshore assembly has been caused by economic factors, minimizing production cost, with little concern for military logistics factors, probably due to the limited share the military has of the overall microcircuit market. Although the U.S. offshore facilities are dispersed over a number of countries, which provides some measure of protection from isolation, the DOD must become more concerned about the length and vulnerabliity of the supply line that is created by this method of manufacturing. Raw materials are generally shipped from either Japan or the U.S. to these offshore facilities, which are primarily located in the Far East. The finished device is then shipped to the U.S. This procedure may make good economic sense in a peacetime environment, but during wartime, when transportation assets are not only scarce but extremely vulnerable, these distant offshore assembly facilities may not be able to supply this country's microcircuit requirements.

A second type of indirect dependency is the reliance on offshore sources, notably Japanese, for the component/piece parts which comprise cer-dip microcircuits. These parts can be used in both JAN and non-JAN microcircuits. The degree to which U.S. maufacturers use offshore sources will depend on economic factors, customer service issues, production capability, and finally the quality of onshore components. Although it was discovered that onshore manufacturers exist within each industry (ceramics, leadframe, and sealing glass), onshore representation is not only highly concentrated, but taken as a whole, could not meet the demands of the U.S. cerdip manufacturers. It appears that there is enough potential manufacturing capability to meet the military needs, primarily because the military represents such a small portion of the entire microcircuit market, but only at the expense of the commercial market. In the final analysis, these two types of indirect dependency on foreign sources for the manufacture of microcircuits place the U.S. in a very precarious position especially as military weapon systems become more dependent on sophisticated electronic equipment.

Recommendations

There are no quick fixes to reverse this country's dependency on offshore manufacturing facilities and foreign sources for component/piece parts used in the manufacture of cer-dip microcircuits. This dependency has existed for a long time and has become an accepted business practice within the industry. Since it has contributed to low cost microcircuits, it has been ignored by the government. To reverse this dependency will require changes in priorities, perceptions, and philosophies within both government and business. Recognizing the need for any change -- the need for more onshore manufacturing capability -- must come from the government, in particular the Department of Defense. Once the need is recognized, proper corrective action must be determined by joint cooperation between business and government sectors.

The initial step has to be problem recognition. The Department of Defense should accomplish a complete audit of all onshore microcircuit manufacturing capability. This audit should determine all onshore capability under the following three scenarios: peace, surge, and war. An additional goal should be to determine the ability of onshore facilities to manufacture both commercial and JAN/MIL SPEC 38510 devices in quantities to make up for the isolation of one or more key manufacturing countries under each of the three scenarios. Although this research project concerned itself with only cer-dip devices, the DOD audit should include all types of microcircuits which have potential use in military weapon systems.

In conjunction with determining onshore capability, the Department of Defense should analyze the location of the major offshore assembly facilities to determine the host countries' vulnerability to political turmoil and different war scenarios, and the facilities' responsiveness to U.S. surge and wartime requirements. This analysis should determine the effects of losing a particular country or multiple countries on the capability of this industry to support its U.S. commercial and military markets. Since most of the major assembly facilities are located in the Far East, special attention should be directed to assessing logistics problems associated with this area which could occur during crises and conflicts.

Once these two audits have been accomplished, the Department of Defense would be better able to estimate the desired level of onshore manufacturing capability that could assure military requirements be met under surge or mobilization conditions. Government and industry representatives must work together to determine an appropriate strategy to create this capability with minimum impact on industry competition and microcircuit pricing. Automation, combined with industrial incentives, tax breaks and subsidies could be instrumental in aiding some offshore production to be brought back onshore.

Similar analysis of the component/piece parts industry is needed. The Department of Defense could assist this industry by mandating domestic components be used in military microcircuits. An issue consistently averred was the quality of Japanese versus U.S. products in the piece parts area. While the manufacturers of these parts, particularly the leadframe manufacturers, felt that their quality was as good as that of the Japanese, the historical impression of poor American quality still remains among the microcircuit manufacturers. Time and education would help alleviate the present inconsistencies of thought in this sector of the industry. After educating the microcircuit manufacturers, the piece parts industry must strive to maintain a better image which may help curb the incursion of Japanese components.

Another possibility would be to increase the customs duty on the foreign content of manufactured microcircuits shipped into the U.S. This would artificially enhance the competitive position of onshore component suppliers and allow them to compete on a more equal footing but may also cause more consternation and calls of government interference in free trade. However, it would create for domestic suppliers a larger share of the microcircuit market since it would affect both military and commercial markets.

The Department of Defense can also assist domestic manufacturing by increasing the emphasis on the use of JAN/MIL SPEC 38510 microcircuits in all weapon systems. As was stated earlier, contractors and OEMs can tailor their specific systems to avoid the use of JAN/MIL SPEC 38510 devices forcing the government to buy SCDs from these same manufacturers. Therefore, the DOD must increase its emphasis on the use of DESC's Military Parts Control Advisory Group during the acquisition of new weapon systems and educate its program managers on the benefit of the DOD standardized parts program. At the same time, the Department of Defense must monitor the pressures to open manufacturing of JAN/MIL SPEC 38510 to offshore facilities to determine whether this program is having or will have a detrimental impact on domestic manufacturing capability.

Finally, although the current method of determining a microcircuit's country of origin understates this country's dependency on foreign sources, more emphasis should be placed on DESC's procurement personnel to ensure that country of origin information is provided on each contract. Besides country of origin, DESC should require suppliers of all non-JAN/MIL SPEC 38510 devices which qualify as U.S. products to identify the location by country of the assembly facility in which the microcircuit they are submitting for bid was manufactured. This information should be computerized and included in the PTDF or CTDF. This would increase accessibility to historical data and aid in tracking this country's dependency on foreign sources.

Recommendations For Further Study

Electronics do and will continue to play an important role in the weapon systems of the future. The U.S. needs to be aware that this industry will become increasingly critical to the support of the armed forces as well as the sustenance of the civilian sector. Several other areas exist for investigation into the electronics industry sector. This research has covered only a very small part of that sector. Pursuit 2000 gives an overall picture of the industry, but more detail is required. The following areas are recommended for further research:

1. Cer-dip constitutes the majority of the type of devices used in USAF weapon systems and other major systems. Advances are being made, though, in the area of multi-layer and other advanced package types. This area

should be considered for research into foreign dependency.

2. Some of the microcircuit manufacturers mentioned the increasing dependence on silicon from foreign sources. Currently the U.S. is the major producer of silicon, but will it continue to hold this position?

3. How does DOD initiate new systems engineering to be included in a new major weapon system or other major system? Is the interface between the SPO and the contractors sufficient to create a more favorable parts control program for the government?

4. Based on the electronics industry's move to offshore locations for manufacture of commercial devices, how will the opening of JAN to other countries and possibly East Asia affect the production capabilities within the U.S. and the logistics lines for increased requirements? And how will DOD handle the competitive situation between the new manufacturers overseas and those established in the U.S.?

5. Two alternatives have been mentioned to replace the cer-dip microcircuit -- plastic and epoxy. How will the introduction and eventual use of these products impact the nature of the component industry and the dominance of foreign suppliers? Will manufacturers be able to handle these changes in their production? Does the U.S. possess any advantage in these two products?

Concluding Remarks

Dependency on foreign sources exists in two major areas of the microcircuit sector, but the potential for a third area also exists: (1) dependence on offshore facilities for assembly of microcircuits; (2) dependence on foreign sources for components/piece parts used in microcircuits; and (3) the possible dependence on foreign facilities for manufactured end-item JAN microcircuits. The U.S. currently lacks capability in the first two areas, which could severely affect any surge or mobilization requirements of DOD. The third area is potentially a problem because negotiations are continuing between the U.S. and several foreign governments. Presently JAN has been opened only to European countries, but consideration of opening JAN to East Asian countries, where price competition is much more threatening to U.S. companies, could greatly deteriorate the U.S. electronics industry.

This research has covered only a small part of the entire electronics sector of the U.S. and DOD. It has shown that the U.S. electronics industrial base is lacking in capability to manufacture microcircuits and the components used in their manufacture. The industry needs rebuilding onshore in order to improve the vitality and responsiveness to DOD requirements.

DOD cannot afford to be pushed into situations that may compromise the readiness capability of the armed forces. As electronics become more important in major weapon systems, the shortfall being created by current conditions will become more apparent. New technologies requiring less dependence on foreign sources are definitely an alternative to be considered, among others. But DOD must also know where and how much capability exists before any action can be taken. An action must be taken soon, before the U.S. finds itself in a compromising political situation.

Appendix A. List of Microcircuits (FSC 5962)

This appendix lists all microcircuits (FSC 5962), by nomenclature, in the original sample from the DO43 and those that replaced the outdated ones from the original sample. From the updated list of replacement and original NSNs, the microcircuits were then checked for use in a USAF Major Weapon System (USAF MWS) and further delimited by extracting those microcircuits identified as JAN/MIL SPEC 38510 (MIL-SPEC). From the final sample of non-JAN microcircuits, those procured from a foreign source were investigated. The far right column (NATO FSCM) indicates the number of NATO sources listed as sources on the Total Item Record File. Underline indicates avionics related NSNs (Appendix D).

<u>Digital</u> <u>Microcircuits</u>

ORIGINAL NSN*	REPLACEMENT NSN**	USAF MWS	MIL-SPEC	NATO FSCM
00 001 6011	01 052 2957	Y	Y	0
00 011 2600	00 361 8732	Y	Y	1
00 024 0653		Y	Y	2
00 053 6929		N		
00 102 7520	00 365 5728	Y	Y	0
00 106 4282	00 369 7621	Y	Y	0
00 110 6424	00 436 0821	Y	Y	0
00 118 3867	00 348 2715	Y	Y	0
00 118 7084	00 341 0544	Y	Y	1
00 120 9199	00 333 8323	Y	Y	0
00 139 2880	00 429 5774	Y	Y	0
00 148 2863	01 026 2494	Y	Y	0
00 156 0982	01 052 2957(R)	Y	Y	0
00 160 5028	00 369 7621(R)	Y	Y	0
00 162 7435	00 495 8160	Y	Y	0
00 163 0134	00 369 7642	Y	Y	0
00 166 7961	00 341 0545	Y	Y	0
00 168 8330		N		
00 170 6734		N		
00 172 5569	01 005 5529	Y	N	0
00 172 9346	01 130 2432	N		
00 184 8226	00 386 8211	Y	Y	0
00 190 4072	00 017 3919	Y	N	0
00 193 7555	00 361 8649	Y	Y	0
00 197 3536		Y	N	1
00 200 1987	01 032 7950	Y	Y	0
00 216 4137	01 090 7524	Y	N	0

ORIGINAL NSN*	REPLACEMENT NSN**	USAF MWS	MIL-SPEC	NATO FSCM
ØØ 236 8179	ØØ 428 7318	Y	Y	1
ØØ 244 4198	ØØ 43Ø 26ØØ	Y	Y	Ø
ØØ 245 5337	ØØ 428 6377	Y	Y	Ø
ØØ 247 3396	ØØ 348 2541	Y	Y	Ø
ØØ 25Ø 9266	ØØ 348 2719	Y	Y	1
ØØ 256 Ø343	ØØ 365 572Ø	Y	Y	Ø
ØØ 264 3566		Y	Y	1
ØØ 276 9935	Ø1 Ø15 5998	Y	Y	Ø
ØØ 277 Ø188	ØØ 43Ø 2641	Y	Y	Ø
ØØ 284 1934	ØØ 372 Ø476	Y	Y	Ø
ØØ 3Ø8 9782	Ø1 Ø21 5875	Y	Y	1
ØØ 318 2224		Y	Y	1
ØØ 321 8117	ØØ 593 72Ø1	Y	Y	Ø
ØØ 338 9742	ØØ 365 5728(R)	Y	Y	Ø
ØØ 342 938Ø	Ø1 Ø15 5998(R)	Y	Y	Ø
ØØ 35Ø 8387	ØØ 361 9145	Y	Y	Ø
ØØ 358 552Ø	Ø1 Ø12 65Ø7	Y	Y	Ø
ØØ 369 77Ø6		Y	Y	1
ØØ 374 8874	Ø1 Ø7Ø 6595	Y	N	Ø
ØØ 39Ø 797Ø		Y	Y	1
ØØ 4ØØ 899Ø	Ø1 Ø19 6671	Y	Y	2
ØØ 4Ø2 9335	Ø1 144 1523	N		
ØØ 4Ø3 4536	ØØ 361 8648	Y	Y	Ø
ØØ 4Ø5 3149	ØØ 348 2715(R)	Y	Y	Ø
ØØ 4Ø5 3157(O)	ØØ 329 5ØØ6	Y(O)	N(O)	2(O)
ØØ 41Ø 2396	ØØ 43Ø 26ØØ(R)	Y	Y	Ø
ØØ 421 Ø113	ØØ 369 7831	Y	Y	2
ØØ 428 2494		Y	N	3
ØØ 43Ø 72Ø7	ØØ 341 Ø545(R)	Y	Y	Ø
ØØ 431 472Ø		N		
ØØ 436 Ø111		N		
ØØ 446 62Ø1	ØØ 264 356Ø	Y	Y	Ø
ØØ 451 5831	ØØ 39Ø 8Ø13	Y	Y	Ø
ØØ 455 3527	ØØ 595 85Ø4	Y	Y	Ø
ØØ 459 73Ø1		Y	N	1
ØØ 47Ø 1632	ØØ 331 9837	Y	Y	Ø
ØØ 479 9Ø9Ø	Ø1 Ø24 5756	N		
ØØ 488 4857	ØØ 369 7641	Y	Y	Ø
ØØ 495 497Ø	ØØ 378 Ø22Ø	Y	Y	Ø
ØØ 5Ø9 1888		N		
ØØ 52Ø 5924		Y	Y	1
ØØ 532 Ø575	Ø1 Ø26 2491	Y	Y	Ø
ØØ 539 Ø683		N		
ØØ 543 2296	Ø1 Ø3Ø 2Ø98	Y	Y	Ø
ØØ 565 99Ø4	Ø1 Ø34 9829	Y	Y	Ø
ØØ 568 7416	Ø1 Ø94 961Ø	N		
ØØ 595 8253	Ø1 Ø57 3455	Y	Y	Ø
ØØ 7Ø3 Ø892	ØØ ØØ5 512Ø	N		

ORIGINAL NSN*	REPLACEMENT NSN**	USAF MWS	MIL-SPEC	NATO FSCM
00 760 2486	00 469 4661	N		
00 762 0617	00 632 5205	Y	N	0
00 850 8756	00 428 8070(L)	Y	Y	0
00 865 4631	00 436 0889	Y	Y	0
00 927 1749	00 503 8672	Y	Y	0
00 936 4963	01 097 8663	Y	Y	0
01 003 2228		Y	N	2
01 003 4113	01 032 7950(R)	Y	Y	0
01 004 1274	01 027 6863	Y	Y	5
01 004 9341	01 006 0180	Y	N	0
01 008 5276	01 120 4001	Y	N	0
01 009 1115	01 015 0281	N		
01 009 6126		N		
01 010 7819	01 041 3214	Y	Y	0
01 011 7814	01 003 4417	Y	N	0
01 013 8539		N		
01 015 0271	01 063 6658	N		
01 015 5314	01 012 5828	Y	Y	1
01 016 5308	01 058 7980	Y	Y	0
01 019 1415		N		
01 019 8649	01 089 6786	N		
01 020 5885	00 361 8672(L)	Y	N	0
01 025 2594		Y	Y	1
01 026 6622	01 043 3940	Y	Y	0
01 027 9236	01 058 5777	N		
01 029 0311	00 361 8649(R)	Y	Y	0
01 029 0316	00 371 8959	N		
01 029 0327	01 084 7401	Y	N	0
01 029 0335	00 024 0653(R)	Y	Y	2
01 029 0340		N		
01 029 0348	01 052 2957(R)	Y	Y	0
01 029 0623	01 035 5801	N		
01 029 8536	00 348 2717	Y	Y	2
01 030 3141		N		
01 030 8282	00 542 9418(L)	Y	Y	0
01 032 0364		N		
01 032 7187		N		
01 033 2283		Y	N	1
01 035 5409	01 050 0918	Y	Y	0
01 037 6408	01 124 9258	Y	Y	0
01 038 1016	00 361 8732(R)	Y	Y	1
01 038 3362	01 014 9631(L)	Y	N	0
01 041 2309		N		
01 042 4184	01 125 6014(L)	Y	Y	0
01 043 0977		N		
01 044 0208		N		
01 045 8493	01 070 8432	Y	Y	0
01 046 9461	01 119 3881	Y	N	0

ORIGINAL NSN*	REPLACEMENT NSN**	USAF MWS	MIL-SPEC	NATO FSCM
Ø1 Ø48 1Ø61	Ø1 Ø34 3875	Y	N	Ø
Ø1 Ø48 3764		Y	N	1
Ø1 Ø49 2599	Ø1 Ø5Ø Ø921	Y	Y	Ø
Ø1 Ø5Ø ØØ76	Ø1 ØØ9 5492	N		
Ø1 Ø5Ø 55Ø8	Ø1 111 Ø9Ø2	N		
Ø1 Ø52 8124	Ø1 Ø98 6584	Y	N	Ø
Ø1 Ø53 5183		Y	N	1
Ø1 Ø55 496Ø		N		
Ø1 Ø55 8212	Ø1 Ø58 1539	Y	Y	Ø
Ø1 Ø58 5172		Y	Y	3
Ø1 Ø61 7695		Y	N	1
Ø1 Ø63 1966		Y	N	6
Ø1 Ø64 6366	Ø1 1Ø7 2511	N		
Ø1 Ø66 115Ø	Ø1 Ø33 2286	Y	N	Ø
Ø1 Ø73 4892		N		
Ø1 Ø74 8167		N		
Ø1 Ø75 7598		N		
Ø1 Ø75 9783		N		
Ø1 Ø76 2632		N		
Ø1 Ø77 2243	Ø1 Ø82 4225	N		
Ø1 Ø78 4624		N		
Ø1 Ø79 9238	Ø1 Ø65 Ø88Ø	Y	N	Ø
Ø1 Ø8Ø Ø432		Y	N	1
Ø1 Ø82 5268	Ø1 Ø33 2277	Y	N	Ø
Ø1 Ø86 2515		N		
Ø1 Ø87 5969	Ø1 145 8652	N		
Ø1 Ø87 777Ø		N		
Ø1 Ø89 1Ø34		N		
Ø1 Ø9Ø 75Ø7		N		
Ø1 Ø91 819Ø	Ø1 Ø67 3Ø73	Y	Y	Ø
Ø1 Ø92 3869		N		
Ø1 Ø92 5778		N		
Ø1 Ø92 5783		N		
Ø1 Ø93 2233		N		
Ø1 Ø93 9287		N		
Ø1 Ø97 75ØØ		N		
Ø1 Ø98 8876		N		
Ø1 Ø99 923Ø	Ø1 Ø86 7Ø29	Y	Y	2
Ø1 1Ø1 7978		Y	N	1
Ø1 1Ø3 7364	Ø1 Ø83 5992	Y	Y	Ø
Ø1 112 2Ø72		N		
Ø1 115 6137		N		
Ø1 124 2251		N		
Ø1 128 3Ø37		N		
Ø1 135 5724		N		
Ø1 144 9479		N		

Linear Microcircuits

ORIGINAL NSN*	REPLACEMENT NSN**	USAF MWS	MIL-SPEC	NATO FSCM
00 003 4440		N		
00 009 7214		N		
00 024 0482		N		
00 086 7280	01 040 8819	Y	N	0
00 106 0836		Y	N	2
00 112 2468		N		
00 118 9012		N		
00 130 0344	01 034 2145	Y	N	0
00 139 2824	00 167 6330	Y	Y	1
00 148 2858	01 064 9568	Y	N	0
00 160 6530		N		
00 163 0163		N		
00 166 8277	01 010 7808	Y	Y	0
00 170 9731		N		
00 172 9243	00 459 7301	N		
00 189 1038	01 064 9568(R)	Y	N	0
00 197 2361	00 274 0200	Y	Y	1
00 200 1990		Y	N	2
00 231 9995	01 112 7196	Y	Y	0
00 235 7324		N		
00 240 5856		N		
00 249 7909		Y	N	1
00 263 2193	00 161 4518	Y	N	0
00 277 0237		Y	N	2
00 299 8041	00 378 0077	Y	N	0
00 319 2530	01 010 78(R)	Y	Y	0
00 333 9256		N		
00 365 5977		Y	N	3
00 386 5122		N		
00 400 4853	01 064 9568(R)	Y	N	0
00 403 2694	01 073 9544	Y	N	0
00 409 2766	00 172 8266	Y	N	1
00 412 1021		Y	N	1
00 425 2895		N		
00 427 0803		N		
00 431 3295		N		
00 442 2823	01 064 9568(R)	Y	N	0
00 449 4334	01 073 9544(R)	Y	N	0
00 453 7715	01 167 6330(R)	N		
00 455 3510	00 428 8070	Y	Y	0
00 470 9516	01 078 6998	Y	Y	0
00 476 4344		N		
00 482 7349		N		
00 488 6920		N		
00 494 1153		N		
00 497 5853	01 082 7432	N		

ORIGINAL NSN*	REPLACEMENT NSN**	USAF MWS	MIL-SPEC	NATO FSCM
ØØ 539 Ø86Ø		N		
ØØ 557 1645		N		
ØØ 579 7737		Y	N	2
ØØ 592 6Ø2Ø	Ø1 Ø62 2739	Y	N	Ø
ØØ 615 5Ø17	Ø1 112 5675	Y	N	Ø
ØØ 759 Ø771	ØØ 37Ø 2637	Y	N	Ø
ØØ 781 Ø876		Y	N	1
ØØ 869 4ØØ7		N		
ØØ 985 1755	Ø1 Ø1Ø 78Ø8(R)	Y	Y	Ø
Ø1 ØØ6 Ø987	Ø1 ØØ3 2215	Y	N	Ø
Ø1 ØØ8 4827	Ø1 Ø88 3862	Y	Y	Ø
Ø1 ØØ9 9277	Ø1 Ø11 9Ø48	Y	N	Ø
Ø1 Ø12 4871		Y	N	1
Ø1 Ø16 7253		N		
Ø1 Ø21 5884	ØØ 417 1Ø8Ø	Y	Y	Ø
Ø1 Ø26 8813	Ø1 Ø39 73Ø3	Y	N	Ø
Ø1 Ø29 8Ø13		N		
Ø1 Ø32 6832		N		
Ø1 Ø35 3849		N		
Ø1 Ø39 7934		N		
Ø1 Ø4Ø 5667	ØØ 482 9758	Y	N	Ø
Ø1 Ø41 378Ø		N		
Ø1 Ø46 5774		N		
Ø1 Ø47 8234	Ø1 Ø55 9927	Y	N	Ø
Ø1 Ø49 4669	ØØ 197 3361	Y	Y	1
Ø1 Ø5Ø 4693	Ø1 128 389Ø	Y	Y	Ø
Ø1 Ø51 5698		N		
Ø1 Ø55 8199		Y	N	2
Ø1 Ø58 4413		N		
Ø1 Ø62 ØØ27		N		
Ø1 Ø64 8Ø74	Ø1 Ø24 9529	N		
Ø1 Ø71 749Ø		N		
Ø1 Ø74 7751		N		
Ø1 Ø75 5829		Y	N	2
Ø1 Ø75 9776		N		
Ø1 Ø76 Ø576		N		
Ø1 Ø78 6994	Ø1 168 Ø96Ø	Y	Y	Ø
Ø1 Ø79 8489		N		
Ø1 Ø83 8751		N		
Ø1 Ø87 6727		N		
Ø1 Ø91 Ø533		N		
Ø1 Ø92 3864	Ø1 ØØ9 5492	Y	N	Ø
Ø1 Ø93 33Ø2		N		
Ø1 Ø97 2444		N		
Ø1 1Ø1 2386		N		
Ø1 1Ø8 4Ø92		N		
Ø1 119 296Ø		N		
Ø1 122 8659		N		
Ø1 155 7879		N		

Integrated Circuits

ORIGINAL NSN*	REPLACEMENT NSN**	USAF MWS	MIL-SPEC	NATO FSCM
ØØ ØØ8 Ø726	ØØ 341 Ø544(D)	Y	Y	1
ØØ Ø67 4Ø6Ø		Y	N	1
ØØ 1Ø1 97Ø2		N		
ØØ 249 791Ø		Y	N	1
ØØ 481 9332	Ø1 Ø16 8738(D)	Y	Y	Ø
ØØ 476 9897		N		
ØØ 762 Ø593	ØØ 259 43Ø8	N		
ØØ 777 3375	ØØ 369 7739(D)	Y	Y	Ø
ØØ 933 9735	Ø1 Ø51 5ØØ5(D)	Y	Y	Ø
ØØ 985 1614		N		
Ø1 Ø83 1316		N		
Ø1 Ø83 6747		N		
Ø1 Ø83 69Ø6		N		
Ø1 1Ø8 6Ø16		N		

Microcircuits

ORIGINAL NSN*	REPLACEMENT NSN**	USAF MWS	MIL-SPEC	NATO FSCM
Ø1 Ø2Ø 5679		N		
Ø1 Ø34 ØØ49		N		
Ø1 Ø34 ØØ5Ø	ØØ 429 5638(L)	Y	N	1
Ø1 Ø38 61Ø6	Ø1 128 389Ø(L)	Y	Y	Ø
Ø1 Ø67 Ø5Ø6		N		
Ø1 Ø67 Ø5Ø7		N		
Ø1 Ø61 Ø5Ø8		N		
Ø1 Ø67 Ø5Ø9		N		
Ø1 Ø67 Ø51Ø		N		
Ø1 Ø67 Ø511		N		
Ø1 Ø67 Ø512		N		
Ø1 Ø67 Ø513		N		
Ø1 Ø67 Ø514		N		
Ø1 Ø67 Ø515		N		
Ø1 Ø67 Ø516		N		
Ø1 Ø67 Ø517		N		
Ø1 Ø67 Ø518		N		
Ø1 Ø67 Ø519		N		
Ø1 Ø67 Ø52Ø		N		
Ø1 Ø84 3951	Ø1 Ø7Ø Ø689(D)	Y	N	1
Ø1 Ø93 Ø11Ø		N		
Ø1 Ø93 Ø111		N		
Ø1 Ø93 Ø112		N		
Ø1 Ø93 91Ø4		N		

ORIGINAL NSN*	REPLACEMENT NSN**	USAF MWS	MIL-SPEC	NATO FSCM
Ø1 Ø93 91Ø5		N		
Ø1 Ø93 91Ø6		N		
Ø1 Ø93 91Ø7		N		
Ø1 Ø93 91Ø8		N		
Ø1 Ø97 91Ø9		N		

Key
(R) -- Repeat Entry
(L) -- Replaced by Linear Microcircuit
(D) -- Replaced by Digital Microcircuit
(O) -- Original Microcircuit still in USAF inventory. Replacement is not used by USAF.

*--SOURCE: DO43 EXTRACT LIST, FSC 5962, CATALOGING AND STANDARDIZATION CENTER, BATTLE CREEK, MI. 5 MAY 1984.
**--SOURCE: DESC TOTAL ITEM RECORD FILE (TIRF), DEFENSE ELECTRONICS SUPPLY CENTER, DAYTON, OHIO. 28 JANUARY 1985.

Appendix B. Mission Item Essentiality Code (MIEC)

"The MIEC is a three-position code designed to accommodate the allocation of resources based on weapon system importance" (1:Ø5-32). It is composed of the System Essentiality Code (SEC), a number from one to seven indicating Logistics Support Priorites (1:Ø5-136); a Subsystem Essentiality Code (SSEC) representing ". . . the criticality of the subsystem to the performance of the systems' assigned mission. Valid codes are A, B, C, D, and M " (1:Ø5-137); and in the third position, the Item Essentiality Code (IEC), correlating to ". . . the relationship of the individual items to operation of the subsystem . . ." and represented by ". . . E - Critical for Operation; F - Impairs Operation; G - Not Critical for Operation; and M - FMS Peculiar Application" (1:Ø5-138).

The MIEC ranking table assigns priorities to the various combinations of SECs, SSECs, and IECs. The MIEC ranking table is reproduced on the next page (1:Ø5-33).

PRIORITY	CODE	PRIORITY	CODE	PRIORITY	CODE
1.	1AE	26.	6BE	51.	3CG
2.	1BE	27.	6CE	52.	4CG
3.	1CE	28.	4AF	53.	5CG
4.	2AE	29.	4BF	54.	6CG
5.	2BE	3Ø.	4CF	55.	1DE
6.	2CE	31.	5AF	56.	2DE
7.	3AE	32.	5BF	57.	3DE
8.	3BE	33.	5CF	58.	4DE
9.	3CE	34.	6AF	59.	5DE
1Ø.	1AF	35.	6BF	6Ø.	6DE
11.	1BF	36.	6CF	61.	1DF
12.	1CF	37.	1AG	62.	2DF
13.	2AF	38.	2AG	63.	3DF
14.	2BF	39.	3AG	64.	4DF
15.	2CF	4Ø.	4AG	65.	5DF
16.	3AF	41.	5AG	66.	6DF
17.	3BF	42.	6AG	67.	1DG
18.	3CF	43.	1BG	68.	2DG
19.	4AE	44.	2BG	69.	3DG
2Ø.	4BE	45.	3BG	7Ø.	4DG
21.	4CE	46.	4BG	71.	5DG
22.	5AE	47.	5BG	72.	6DG
23.	5BE	48.	6BG	73.	7MM
24.	5CE	49.	1CG		
25.	6AE	5Ø.	2CG		

Appendix C. List of Interviewees

The following is a list of the suppliers, manufacturers, and government personnel interviewed in the course of the research. The companies and individuals are listed separately to provide anonymity to those individuals desiring such.

Suppliers

Arrow Electronic	Dayton, Ohio
Esco Electronics	Dayton, Ohio
Exotics, Inc.	Dayton, Ohio
G & A, Inc.	Cincinnati, Ohio
Graham Electronics	Cincinnati, Ohio
Hamilton/Avnet Electroincs	Dayton, Ohio
IPAC Company	Dayton, Ohio
Kierulff Electronics, Inc.	Centerville, Ohio
Micro-Mil Inc.	Dayton, Ohio
Pioneer-Standard Electronics	Dayton, Ohio
Ram Technology Inc.	Levittown, New York
Televox Inc.	Dayton, Ohio
Zeus Components, Inc.	Port Chester, New York

Altick, Barbara	DESC Sales Supervisor
Carmichael, Danny	Sales
Colker, Fred	Sales
DeCesare, Michelle	Sales
Frost, Jack	Sales
Giesting, Chip	Sales
Giesting, Mary	Sales
Gould, Willis	Sales
Jett-Smith, Ginger	Government Sales
Lehrner, Harvey	Government Sales
Moore, Ronald	Sales
O'Donnell, Jack	Government Sales
Tokar, Diane	Sales
Varielo, Donna	Sales
Wickeline, Linda	Government Sales

Manufacturers

Advanced Micro Devices	Sunnyvale, California
Coors Ceramics	Golden, Colorado
Dematron Technology Glass	Union City, California
Fairchild Semiconductor Corp.	South Portland, Maine

General Electric Corporation	Chattanooga, Tennessee
Handy & Harman Electronics Materials	North Attleboro, Mass.
Kyocera International Inc.	San Diego, California
Microelectronics Packaging Industries	Santa Clara, California
Motorola, Inc.	Mesa, Arizona
National Semiconductor Corp.	Santa Clara, California
Oberg-Arizona, Inc.	Chandler, Arizona
Owens Illinois	Toledo, Ohio
Signetics	Sacramento, California
Stamping Technology	Milpitas, California
Texas Instruments	Midland, Texas

Aria, Richard	Military Programs Manager
Daugherty, Chuck	JAN Components
Davis, Susan	Mil-Aero Components
Eckert, Will	Sales Manager
Everitt, Bill	Vice President for Corporate Communications
Ewanich, Jon	Packaging Engineer
Ju, Jay	Packaging Engineer
Knight, James	Senior Sales Engineer
Lambert, Dick	Quality & Reliability Assurance Manager, Military Products
Lemereis, Michael	Sales Engineer
Miller, Ralph	Military Sales
Otto, James	Vice President, Marketing & Sales
Rogren, Phil	District Sales Manager
Rosic, John	Vice President and Plant Manager
Senate, Chandler,	Military Sales
Stensrud, Arney	Director of Military Market
Theobald, Paul	Application Engineer
Toth, Lew	Vice President, Marketing

Industrial Organizations

Kinn, Jack	Electronics Industry Association
Lambert, Dick	Chairman, JEDEC 13.2

Government Personnel

Capps, Harris T., Major	Director, Electronics Sector Management Center, ESD/ALMP, Electronics Systems Division. Hanscom AFB, Mass.
Cheung, Tom	Product Assurance Engineer, B-1B System Program Office, Aeronautical Systems Division. Wright-Patterson AFB, Ohio
Cochran, William, Major	Chairman, Joint Oversight Foreign Dependency Committee, AFLC/XRP, HQ AFLC. Wright-Patterson AFB, Ohio
Hill, Darrell	Branch Chief, Engineering Qualifications/Microcircuits, DESC/EQM, Defense Electronics Supply Center. Dayton, Ohio
Knott, Robert	Acting Branch Chief, Engineering Qualifications/Microcircuits, DESC/EQM, Defense Electronics Supply Center. Dayton, Ohio
Miller, Sam	Assistant Director for International Standardization, Defense Materiel Specification Standards Office, Assistant Secretary of Defense for Acquisition, ASD/A&L (formerly USDR&E), OSD. Washington DC

Wadella, Stan	Branch Chief, Technical Support Branch, Defense Electronics Supply Center. Dayton, Ohio

Appendix D. Avionics Federal Supply Classification

Group 12 Fire Control Equipment

1270 Aircraft Gunnery Fire Control Components
Includes Turrets, Aircraft; Computers, specifically designed; Complete Gyro Mechanisms.
Excludes Gun Chargers; Ammunition Boxes; Gun Heaters; Field and Link Chutes; Ammunition Boosters; Gyro Components; Complete Fire Control Systems.

1280 Aircraft Bombing Fire Control Components
Includes Computers, specifically designed; Complete Gyro Mechanisms; Optical Devices for Bombing Fire Control.
Excludes Gyro Components.

Group 49 Maintenance and Repair Shop Equipment

4920 Aircraft Maintenance and Repair Shop Specialized Equipment
Includes Maintenance stands designed for support of aircraft assemblies during repair or overhaul; Test Stands and Test Equipment specifically designed for maintenance and repair of aircraft components such as: engines, generators, hydraulic systems, armament, automatic pilot, fire control, flight control and navigational systems.
Excludes Hand Tools; Airfield Maintenance Platforms; Basic types of electrical and electronic test instruments, including those specially designed, such as ammeters, voltmeters, ohmmeters, multimeters, and similar instruments, as shown in the indexes to the FSC; Test Apparatus used for both communications and other electrical and electronic equipment.

Group 58 Communication, Detection, and Coherent Radiation Equipment

5821 Radio and Television Communication Equipment, Airborne
Includes Telemetering Equipment.

5826 Radio Navigation Equipment, Airborne
Includes Loran Equipment; Shoran Equipment; Direction Finding Equipment.

5841 Radar Equipment, Airborne
NOTE: Radar assemblies and subassemblies designed specifically for use with fire control equipment or guided missiles are excluded from this class and are included in the appropriate classes of group 12 or group 14.

5865 Electronic Countermeasures, Counter-Countermeasures and Quick Reaction Capability Equipment
NOTE: This class includes, and is restricted to, passive and active electronic equipment, systems, and subsystems designed to prevent or reduce an enemy's effective use of radiated electromagnetic energy or designed to insure our own effective use of radiated electromagnetic energy. Includes Electronic Countermeasures, Electronic Counter-Countermeasures, Electronic Support Measures, and Quick Reaction Capability Equipment and components specially designed therefore which are not classifiable elsewhere in the FSC structure. Excluded from this class are nonelectronic items which are properly classified in more specific classes in accordance with the FSC structure and indexes.

Group 66 Instruments and Laboratory Equipment

6610 Flight Instruments
Includes Air Speed Indicators; Rate of Climb Indicators; Bank and Turn Indicators; Pitot Tubes; Gyro Horizon Indicators; Attitude Gyro Indicators.
Excludes Navigational Instruments.

6615 Automatic Pilot Mechanisms and Airborne Gyro Components
NOTE: Included in this class are gyro components of guided missiles. Excluded are complete gyro mechanisms and nonairborne gyro components, both of which are classified in the same classes as their next higher assemblies.
Includes Automatic Pilot Regulators; Directional, Vertical, Bank and Turn, and Hydraulic Surface Gyro Controls; Airborne and Shipborne Automatic Pilot Mechanisms; Helicopter Automatic Stabilization Equipment.
Excludes Automatic Pilot Training Devices; Automatic Pilot Mechanisms, Guided Missile.

Group 69 Training Aids and Devices

6930 Operation Training Devices
Includes Link Trainers; Automatic Pilot Training Devices; Drift Meter Training Devices; Celestial Navigation Trainers; Dead Reckoning Navigation Trainers; Instrument Flying and Landing Trainers; Terrain Projection Trainers; All operational training devices except communication and armament. Excludes Training Aids.

Source: Defense Logistics Agency. Cataloging Handbook H 2-1, Federal Supply Classification, Part 1, Groups and Classes. Battle Creek MI: Defense Logistics Service Center, May 1982.

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This ~~research~~ attempted to investigate the Air Force's dependency on foreign sources for the procurement of microcircuits used in avionics systems. The research was divided into two segments: a particular sample of microcircuits was analyzed to determine which microcircuits were procured directly from a foreign source and then determine the criticality of those foreign manufactured microcircuits; the second segment consisted of interviews with government officials, microcircuit suppliers/vendors, and manufacturing representatives to obtain their opinions as to the extent of U.S. dependency on foreign sources for the manufacture of ceramic dual-in-line microcircuits.

It was discovered that the current method used by the Defense Electronics Supply Center and AFLC's Cataloging and Standardizations Center to identify foreign manufactured microcircuits greatly understates this country's dependency on foreign sources for microcircuits. Through interviews, it was determined that U.S. manufacturers are highly dependent on foreign facilities for the manufacture of U.S. microcircuits and on foreign sources, primarily Japanese, for the component/piece parts which are used in the manufacture of microcircuits. It was concluded that more effort should be expended by the Department of Defense to determine the actual capability of onshore manufacturers and to attempt to get manufacturers to move back onshore.

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