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DOMESTIC AND FOREIGN TRADE POSITION OF THE UNITED STATES AIRCRAFT TURBINE ENGINE INDUSTRY

TASK SIX

SHORT-TERM GAS TURBINE PROPULSION ANALYSIS AND ASSESSMENT

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U.S. aircraft engines and parts imports/exports are traced through the 70's and 80's, showing a trend that, if continued, will position the U.S. as a net importer of engines and parts by the turn of the century. New engine production between 1970 and 1988 is traced and comparisons made between the U.S. and other western world countries. The U.S. share in engine production eroded from 84% in 1970 to 62% in 1988, while the European Community (E.C.) more than doubled its share (15% to 32%). Changes in market character are reviewed (military/civil segments and coproduction growth). The machine tool industry's rise in Japan and its collapse in the U.S. is reviewed to identify conditions that also may characterize the U.S. engine industry. The U.S., E.C., and Japanese aircraft engine industries are briefly compared to highlight causes for the U.S. erosion and E.C. gain. Conclusions are drawn regarding the U.S. aircraft engine industry's trade position, and recommendations are offered for activity to assure that U.S. engines are produced with superior quality to lower cost than can be achieved by any of its international competitors for the foreseeable future.

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FOREWORD

A basic objective of the work this report summarizes was fact-finding. The search for facts, in terms of both statistical data and opinions generated by organizations and individuals with considerable experience in their respective areas, was limited to sources available to the general public. The authors draw conclusions and offer recommendations based on these facts. Government and industrial organizations involved in the various aspects of aircraft engine research, development, manufacturing, and marketing may possess information that substantiates, amplifies, reinterprets, or refutes these conclusions and recommendations. A purpose of this report is to generate a dialogue among the concerned organizations that will create a general consensus regarding the current outlook for the trade position of the U.S. aircraft engine industry and the collective actions needed to secure the industry's position as the world's primary supplier of aircraft engines into the foreseeable future.

The authors wish to acknowledge the work of Robert C. Sammons and Richard Whitney of The Innovators' Group, Inc., to identify and retrieve many of the documents that collectively comprise the background for the machine tool and engine industry comparisons. Also, the assistance of Tina Tietge and John Spatz of Universal Technology Corporation in developing the data bases and in researching and entering the voluminous material which made possible the displays of trends contained in the report.

Finally, the authors wish to recognize the foresight of Thomas J. Sims, Director, Turbine Engine Division, Aero Propulsion and Power Laboratory, who, in understanding the link between the industry's trade position and its capability to fulfill future military requirements, commissioned this work.

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SUMMARY

Over seven billion dollars of U.S. government and industry resources are planned to support aircraft turbine engine technology programs during the 1988 - 2003 time period under the auspices of the joint government/industry Integrated High Performance Turbine Engine Technology (IHPTET) initiative. Approximately half of these resources must be generated by the engine industry's Independent Research and Development (IR&D) and discretionary funded programs. Since IR&D and discretionary resources consist of income derived from both military and civil sales, maintenance of a healthy world-wide market for U.S.-produced engines is important to the health of the IHPTET initiative. The U.S. aircraft engines and parts sales activity in the world market is predominantly civil and probably will become more so during the nineties. Therefore, the Department of Defense has a substantial interest in the U.S. engine industry's ability to perform well in the international civil engine market.

The competitiveness of the foreign engine industry is increasing. Rising U.S. imports have resulted in U.S. domestic market penetration by foreign engine industries to over 20 percent in the mid and late eighties. In the late eighties, the engine parts and subassemblies trade segment rose to a dominating influence in both exports and imports, implying that increasing coproduction with foreign industry is becoming a dominant market force. Trade balance, as a fraction of total sales, in engines and parts sales declined throughout the seventies until the late eighties (except for short-lived surges). U.S. engines and parts trade surplus in terms of U.S. imports compared to total U.S. imports plus exports declined from 90 percent in the late sixties to 30 percent in the late eighties. If industry and government remain status quo with respect to their current policies, strategies, and tactics, the U.S. will become a net importer of aircraft turbine engines and parts by the turn of the century.

The western world aircraft turbine engine market, as reflected by estimates of the annual value of new engine production, has grown (between periods of temporary economic sluggishness) when measured with then-year dollars. But, when measured with now-year dollars, the market has been essentially static except for downturns in periods of economic sluggishness. In fact, the gradual decline in the military engine market would have resulted in an overall market contraction during the seventies and eighties had it not been for the growth in the civil market during the eighties.

The U.S. share in military engine production declined during the seventies, and its civil share eroded during both decades. The U.S. engine industry overall share declined from 84 percent in 1970 to 62 percent in 1988 as a consequence of a 22 percent loss in military share and 31 percent loss in civil share. During this same time period, the European Community (E.C.) almost doubled its military share (17 percent to 30 percent) and tripled its civil share (10 percent to almost 30 percent).

The character of the market has shifted significantly over the last decade. Formerly dominated by autonomous producers with corresponding engine development indigenous to each, the currently-prevailing condition (about 50 percent coproduced production value) verges on domination by coproduced engines. This shift is largely responsible for the E.C. civil market share gain during the eighties, and, after 1984, for maintaining the U.S. civil share in the range of 60-64 percent.

Although significant, the U.S. turbine engine industry trade decline during the last two decades is not nearly as catastrophic as the collapse of the U.S. machine tool industry trade. A comparison of U.S. and Japanese machine tool industrial policy, strategy, and support to highlight similarities and disparities points toward actions necessary in the U.S. to assure that the E.C.-caused trend in U.S.

engine market share will reverse in the next two decades. The comparison reviewed in the following material in no way infers an argument that the decline of U.S. preeminence in propulsion is analogous to that of the machine tool industry. The significantly increased depth and breadth of work from which to confirm or refute such an anology is beyond the scope of this report. The report does, however, compare elements of the domestic and foreign trade of each.

Japanese national policy regarding the machine tool industry was expressed in explicit *vision statements* by the Ministry for International Trade and Industry (MITI), with machine tool industry consensus, and implemented and enforced by a government with tight control of finance and trade actions. MITI employed its policy of *Developmental Capitalism* to nurture and support development of an internally-competitive machine tool industry, promoting inter-firm cooperation to develop the necessary product and process technology. It targeted the industry for *Technology Exploitation*, taking advantage of the technology linkages between machine tools and other industries, and ensuring long-term market share objectives.

The U.S., practicing its basic policy of mutual independence of government and industry and without the general public's recognition of the strategic importance of a powerful machine tool industry, depended upon the free enterprise system to maintain the industry's trade position. The U.S. policy was therefore forged by the financial pressures of stockholders unaware of or unwilling to recognize the strategic value of long-term market share objectives.

The strategies employed by the two machine tool industries were equally disparate. The Japanese employed their *infant industry* strategy, supporting technological development, entering the market with a price-competitive product to establish itself, following with share extension by technology upgrades, while protecting and stimulating its domestic market until the industry recovered its investment. The U.S. maximized its short-term profits. The U.S. industry set a low priority on productivity capitalization and product technology and stimulated subtier price competition which further suppressed innovation. It concentrated on high-volume products to cut costs and, when faced with a deteriorating market share, diversified into other businesses.

Both Japanese and U.S. machine tools moved toward conglomerate ownership, but while the Japanese rationalized (specialized) production across industry and took advantage of economies of scale, the U.S., with a low commitment to the machine tool divisions of the parent companies, diverted the machine tool boom-time profits to other uses rather than investing in product and process technology or productivity enhancements. Collaborative research occurred throughout the Japanese industry, with both private and government research coordinated toward common objectives. Low priority plus a fear of antitrust violations discouraged forming U.S. collaborations to advance technology and productivity.

Japanese government support consisted of low-cost loans and grants with shared results, a protected domestic market, "export cartels" to prevent excessive undercutting and to provide sales inducements to foreign buyers, and various forms of tax relief. U.S. government support, in addition to various forms of tax relief, was limited to the industry segment providing immediate defense needs in machine tools; its domestic markets were open, and no effective foreign sales inducements were forthcoming.

In short, the U.S. machine tool industry and its parent organizations, with their relative independence from the government, did not exercise the responsibility that accompanies this independence. Short-sighted motivations replaced long-term needs that should have become clear with strategic planning. The U.S. government did not revise the laws and regulations that could have assisted industry to gear up for the future machine tool market. Neither government nor industry provided the promotion necessary to alert the general public to the problem, thereby preventing machine tools from becoming a nationally-recognized issue in time to take effective action.

A cursory survey of the Japanese, E.C., and U.S. aircraft turbine engine industries reveals both similarities and disparities in policy, strategy, industrial infrastructure, and government support.

The underlying disparity in national policy between the U.S. and its primary competitors is its nonexistence in the U.S., compared to the obvious policies of the E.C. and Japan and the vigor with which they are being exercised. Japan continues to demonstrate pragmatic flexibility in applying *Developmental Capitalism* and *Technology Exploitation* to its engine industry as it progresses toward a position of importance in the world market. The E.C. governments, with their nationalized or otherwise heavily-subsidized engine industries, support their engine industries with tax income until they become profitable, and currently are leading them toward privatization and coalescence to position the E.C. engine industry for market leadership. The U.S. industry, with its free enterprise system relatively independent of the government, has not taken a leadership role in establishing a national policy to assure continued market leadership.

With the failure of Japan's *infant industry* strategy to provide a competitive indigenous engine development position, it shifted to *technology imitation* via coproduction agreements with foreign engine companies to gain a foothold in the large high bypass engine market segment. Evidence of the success of this strategy appeared in the late eighties, when coproduced engines became an important part of Japan's total new engine production value. By the mid eighties codevelopment was becoming an integral part of its agreements with U.S. and E.C. engine companies. *Technology innovation* to improve codevelopment leverage, thereby increasing its production share (rather than market penetration with indigenously developed and produced engines), appears to be Japan's current primary strategy. As the East Asian civil market expands, with attendent coproduction granted to the developing nations, Japan may attempt to lead such a "trade bloc" to a regional indigenous development/production capability, thus achieving its MITI-stated vision as a primary competitor in the international civil engine market early in the next century.

The successful growth of the E.C. engine industry to 30 percent of total new engine production value in 1988 was largely due to its strategy of codevelopment/coproduction with U.S. industry. By 1988, coproduced engines comprised over 70 percent of the E.C. total new engine production value. Strategy evident recently throughout the E.C. engine-producing nations is that of increasing the presence of its engine industry in the U.S. to accelerate penetration of the U.S. market. Local offices of E.C. firms, heavy advertising, local service facilities, acquisition of U.S. subsidiaries, and collaborations of all types make evident the E.C.'s drive for U.S. market expansion. A strategy for the immediate future appears to be to position the E.C. engine industry to command an increased equity share in cooperative development and production programs with the U.S. As the E.C. engine industry continues to grow, the strategy may involve increasing protection of its domestic civil market to a level now existing with its military market and decreasing its collaborations with the U.S. industry so as to employ a more unilateral approach in a drive to dominate the growing East Asian and East European market sectors.

By the early seventies, the U.S. engine industry had matured into a highly-competitive group of seven prime contractors. Operating as independent, intercompetitive entities, the U.S. industry dominated world production. By the late eighties, its share of new engine production value had eroded to 62 percent;

nevertheless, U.S. engine manufacturers continue today in essentially the same competitive rather than cooperative mode of operation with their domestic counterparts. The U.S. engine industry has become increasingly global, with U.S. manufacturers trading U.S. process and product technology, production share, and U.S. market share to foreign producers for development risk abatement and access to foreign markets. As with the E.C. in the U.S., the U.S. engine industry is increasing its presence in the European countries by means of local service organizations, local marketing offices, and acquisition of foreign subsidiaries. Almost without exception, the seven U.S. engine prime manufacturers are divisions of large holding companies, where, without significant government assistance, each competes with its "sister" divisions for productivity capitalization.

The Japanese engine industry consists of elements of three large "Heavy Industry" conglomerates. Domestic collaborations, "forced" by the government, promote cooperative technology generation, rationalized elements of design and production among the collaborators, and more efficient economies of scale. Conglomerate ownership of the engine manufacturers makes available private capital, which, with massive injections of government-backed or forgiven long-term productivity and development loans, positions them as lucrative prospects for international codevelopment and coproduction collaborations.

Seventeen companies comprise the bulk of the E.C. prime contractor base, with Rolls-Royce and SNECMA the largest developer-producers. Intra-E.C. collaborations are the norm, capitalizing on rationalized design and development efficiencies and promoting internal competition for specific parts of development and production programs. The current trend is toward increased conglomerate ownership which will provide the capital resources necessary to replace government subsidies as the industry progresses toward privatization.

The operating strategies of the U.S. engine industry have forged its infrastructure to a group of seven independent, inter-competitive prime manufacturers supported by a large subtier supplier network. The few domestic collaborations among these seven have produced negligible product/process technology rationalization and inconsequential development risk abatement. Production rationalization is more evident within the international collaborations than within the domestic. Without government-furnished productivity capital or guaranteed loans, and unwilling or unable to spread productivity risk among themselves, each U.S. engine company is forced to compete for productivity capital within its own conglomerate, often competing with divisions offering attractive short-term returns on their capital investment proposals. Opportunities for economies of scale benefits at the parts and subassembly levels that characterize Japanese and E.C. domestic collaborations are for the most part lost to the U.S. industry. U.S. industry has been forced to trade away technology during the last decade to gain positions in foreign markets, but shrinking government support and restricted industry discretionary funds have slowed acquisition of new technology. The result is a weakening U.S. product and process technology base, and an eroding competitive technological edge. This edge is the only inducement (other than U.S. market share and capital risk abatement) for maintaining a U.S. presence in future foreign collaborations.

Both the Japanese and E.C. engine industries have access to government-backed low-cost capital and, in many cases, outright grants for cooperative development and productivity enhancement. The progress of the E.C. engine industry toward privatization and conglomerate ownership as EC92 approaches is preparing it to undertake a greater share in risk capitalization and to operate with the efficiencies of commercial corporate enterprises. Risk capitalization by the U.S. government is practically nonexistent. Government tax incentives and accelerated depreciation allowances exist in all three entities, but a comparative analysis of them is beyond the scope of this survey.

The Japanese, E.C., and U.S. governments all subsidize technology with state laboratories and direct funding. Japan has not emphasized this aspect in its engine industry but may be expected to increase emphasis as *technology innovation* becomes an increasingly important aspect of the nation's strengthening industry. The E.C. nations have a record of heavy, often interlocked, government/industry research activities and may be expected to continue in this mode. The U.S., with a history of heavy support of both military and civil research and development, is continuing to decrease its government support.

Domestic market protection for its engine industry is not a government issue in Japan; rather, its market access appears to be an indirectly negotiated factor in Japanese industry's international codevelopment/coproduction collaborations. Opinion differs in the U.S. regarding E.C. civil market protection measures to expect in post-EC92 Europe. But, as the E.C. engine industrial base continues to strengthen and politcal "buy domestic" pressures increase, the E.C. governing bodies probably will make it difficult for the U.S. to improve its E.C. market share. The U.S., Japan, and applicable E.C. nations are signatories to the *1980 Agreement on Trade in Civil Aircraft* of the *General Agreement on Tariffs and Trade* (G.A.T.T.), which eliminates import duties on civil aircraft and parts, and addresses other trade barriers. Although cumbersome and a victim of compromise, this Agreement provides a degree of "fair trade" among the signatories.

A basic conclusion to be drawn from examining the U.S. aircraft engine industry's trade position is that its apparent excellent health implied by media reports is overoptimistic and may promote a dangerously complacent attitude regarding the industry's future prospects. Both domestic and foreign market shares are eroding; unless the causal conditions change, the U.S. engine industry may find itself in a decade or so in a situation now existing among some of its more unfortunate sister industries.

A degree of market share erosion from the position of a virtual world monopoly is to be expected and should motivate increasing U.S. aircraft engine industry product quality, production efficiency, and marketing acumen. The trick is to perceive, at least a decade before, the point at which the cause of market share erosion will shift from primarily gains in foreign competence to primarily degradation of U.S. capability, and to plan and execute accordingly. Machine tools, automotive, and electronics missed the trick; will the engine industry?

The rise of Japanese machine tools, of its aircraft engines, and of the E.C. engine industry are due largely to the ability of the respective governments to shoulder the capital risk of product/process technology, product development, and productivity investments, and to constrain the industries to invest in long-term objectives. The U.S. machine tool collapse was due largely to the inability of the industry, without a paternalistic government, to resist investing for short-term profit motives rather than for long-term technology and productivity objectives. Both the previous and current Administrations have kept a "hands off" position with regard to the government 's involvement in the free market, and have minimized government investment to impact either strengths or weaknesses of U.S. industry sectors regardless of expansion potential or contraction dangers. There is little reason to expect a significant shift to occur in this behavior for the next several years. Can the U.S. aircraft engine industry, without depending on the existence of such a paternalistic government, devise the strategy and acquire the capital necessary to assure that a decade and more from now it will retain a controlling share of the world engine market?

Under the auspices of an organization with the promotion of the U.S. engine industry as a whole its fundamental objective (such as a trade association), the

U.S. aircraft engine industry should establish the policy and execute the strategy necessary to assure that U.S. aircraft engines are produced with superior quality at lower cost than can be achieved by any of its international competitors for the foreseeable future. A panel of representatives of the seven primary U.S. turbine engine corporations, with advisory support from appropriate government agencies, should be chartered with both fact-finding and policy/strategy responsibilities. Fact-finding issues need resolution to provide specifics upon which to justify policy and strategy and to gain public support for changes in both private sector capital investment objectives and public sector adjustments of pertinent legislation and regulatory interpretations. Policy and strategy in the private sector need to emphasize appropriately rationalizing productivity capital investment across industry while maintaining necessary domestic competition. Policy and strategy need to shift from acquiring development risk abatement abroad in return for production share, to acquiring development risk abatement domestically and limiting foreign coproduction to industrial development in intended market sectors. In the public domain, policies and strategies need to recognize the shift in competition from primarily intra-U.S. to U.S./E.C. now and a significant Japanese/East Asian threat after the turn of the century. Legislation and regulatory implementation originally established to assure and protect the individual competitiveness of industry in the U.S. now often obstructs the competitivenss of U.S. firms with their overseas adversaries, which jeopardizes the very industries the laws are designed to protect.

1.0 INTRODUCTION. The Integrated High Performance Turbine Engine Technology (IHPTET) initiative is a joint U.S. government/U.S. engine industry endeavor to assure that the United States maintains the technology lead over the rest of the world necessary to develop and manufacture aircraft engines meeting military requirements well into the next century. Exhaustive planning by industry and government for executing the IHPTET initiative reveals that about seven billion dollars must be invested in aircraft engine technology between 1988 and 2003 and that approximately half of these resources must be generated by the engine industry's Independent Research and Development (IR&D) and discretionary funded programs (Figure 1.0-1). Since IR&D and discretionary resources are derived from sales to the military and have associated with them resources generated from civil revenues, the continued health of the U.S. aircraft engine industry in the world civil market is important to achieving IHPTET objectives. Refer to WRDC-TR-89-2124 for additional information regarding the impact of the civil market on IHPTET objectives.[1]

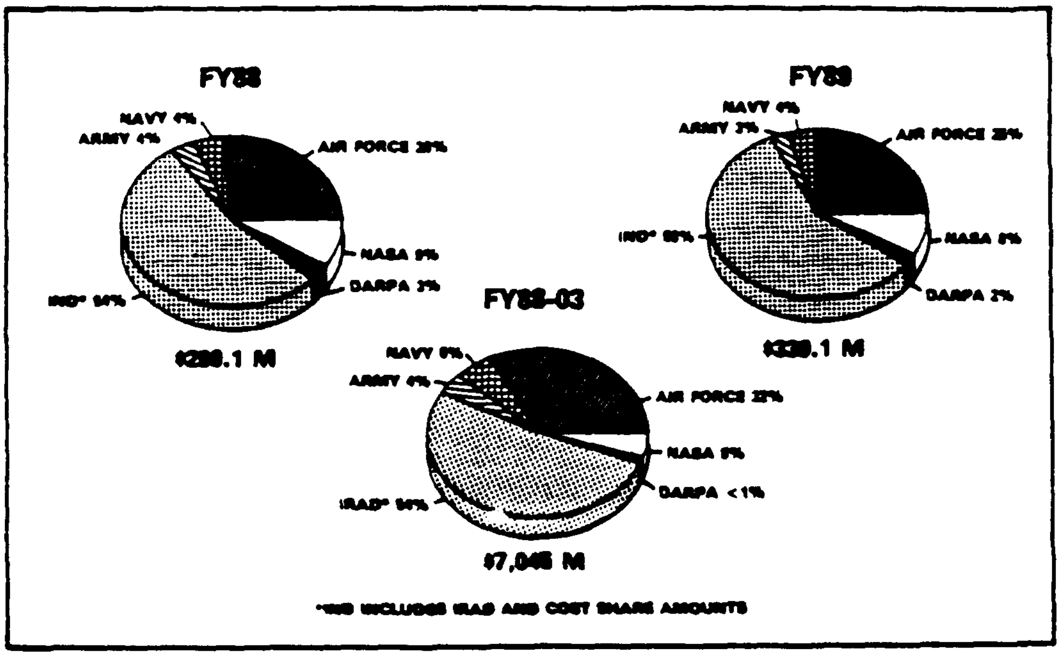

FIGURE 1.0-1 IHPTET Government/Industry Funding Distribution

Source: WRDC, Aero Propulsion and Power Laboratory, Turbine Engine Division

The civil market sector has become increasingly dominant over the military during the last decade. Department of Commerce, Bureau of the Census MA37D reports (surveys of about fifty companies representing a cross section of the U.S. aircraft turbine engine industry), reveal that while military orders and shipments grew modestly in the late eighties, they were outpaced by the growth in the civil sector. They further reveal that prospects for the immediate future do not favor reversing this trend: military backlogs fluctuated sluggishly while civil backlogs grew at a healthy pace; by 1988, the military backlogs were less than half those of the civil market sector (Figure 1.0-2). Comparing military and civil sales performance over the decade prior to 1988, civil new orders and shipments outpaced military orders every year, except 1982 and 1984. By 1988, military new orders had diminished to only 40 percent of civil, and military shipments were only about 70 percent of civil (Figure 1.0-2). Recent relaxation of world East/West tensions and the attendant pressure to reduce defense spending probably means that the civil market sector will maintain commanding leverage over military engines and parts sales until or unless a serious break occurs in East/West relations.

The dominance of the civil market over the military market makes the availability of research resources furnished by industry (hence the technology resources available to the IHPTET initiative) heavily dependent upon the competitiveness of the U.S. engine industry in the world civil marketplace. Therefore, an understanding of the behavior of the U.S. aircraft engine industry in the world market and its current position is of vital concern to the IHPTET planners. Understanding and performing the work in time to assure that the U.S. engine industry maximizes its position in the world market is one of the more important criteria to assure that IHPTET can meet its objectives for the next century.

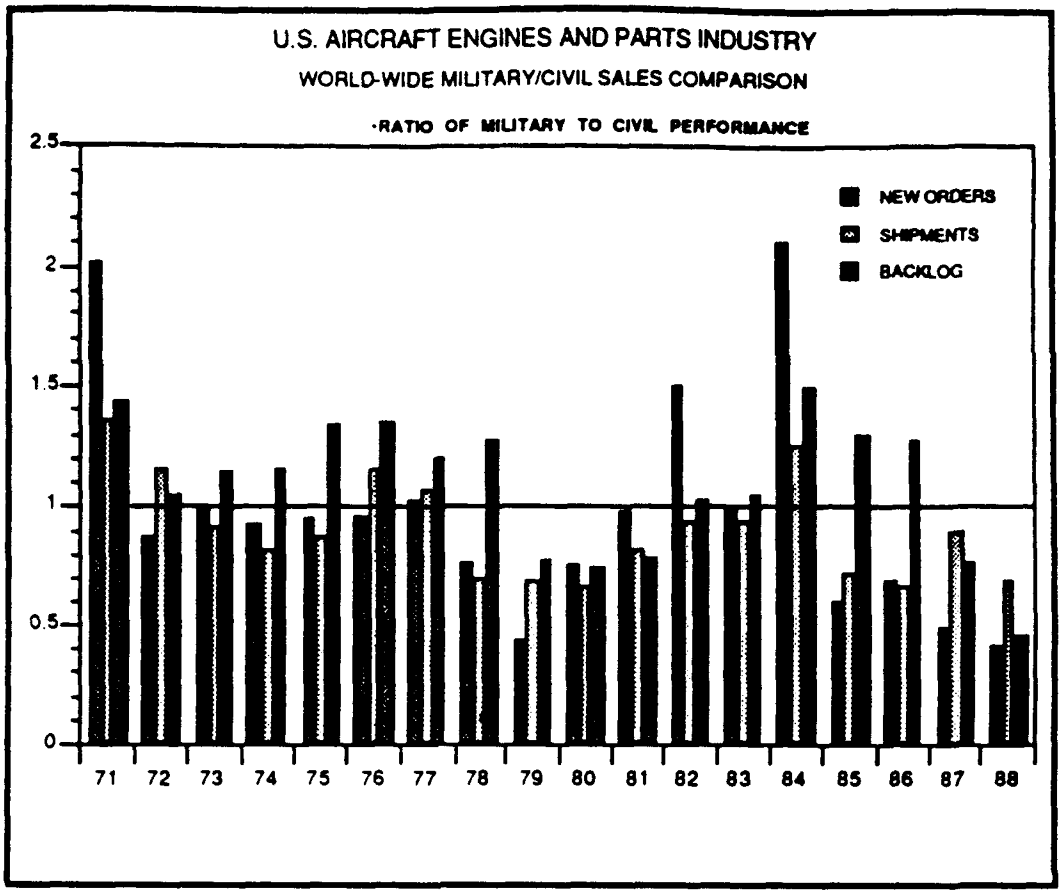

FIGURE 1.0-2 Role of the Civil Market in the U.S. Engine Industry

Source: Department of Commerce, Bureau of the Census, Current Industrial Repor' ; *'237D, MA37D

The Turbine Engine Division, Aero Propulsion and Power Laboratory, Wright Research and Development Center, employed the Universal Technology Corporation (U.T.C.) to develop a database system of information relating to the national and international trade position of the U.S. aircraft turbine engine industry and its major competitors and to formulate a picture of this position and its history over as extended a time period as practical. U.T.C. attempted to assemble information from which to draw aggregate technology and productivity comparisons of the U.S. and its major competitors, but found that information could not be made available in enough scope and depth to permit cogent international comparisons.

Aggregate information concerning U.S. engine industry productivity is available through various Department of Commerce reporting systems. U.T.C. incorporated this information, with export, import, and sales information, into the Commerce Propulsion Database System (C.P.D.), which is summarized in Appendix A.

To gain an understanding of the U.S. engine industry behavior in the international market, U.T.C. subscribed to the Forecast International/DMS Gas Turbine Forecast and extracted data forming the basis of the Propulsion Database System (P.D.S.), summarized in Appendix B, which traces western world engine production from 1970 to 1988. The engine production value information contained in the P.D.S., while not specifically sales information, yields an adequate comparative view of U.S. and foreign historical market performance.

U.T.C. extracted the information used in Sections 2 and 3 from the C.P.D. and P.D.S. systems, respectively. The databases contain information significantly beyond the data employed in Sections 2 and 3 to arrive at the observations discussed. Review of these databases will reveal other opportunities for understanding the production history of the western world turbine engine industry.

Sections 4 and 5 outline the research U.T.C. conducted to understand some of the causes and implications of the trade and production history. The research reveals that there is nothing sinister or unknown regarding the U.S. engine industry behavior, the rise in foreign competitiveness, and the actions needed to assure a continuously healthy U.S. market position.

Sections 6 and 7 offer conclusions and recommendations regarding the U.S. engine industry domestic and foreign trade position, outlining some of the basic actions U.T.C. believes are vital to the continued health of the industry.

2.0 U.S. AIRCRAFT ENGINE INDUSTRY SALES AND U.S. FOREIGN TRADE. The following material, based on various Department of Commerce reports, deals with the sales and export history of the U.S. aircraft turbine engine industry, the aggregate import history of the U.S. engines and parts customers, and the balance of trade history of the industry and the U.S. customers.

Engine industry sales have grown during the late seventies and eighties, more or less keeping pace with the growth in the domestic engine and parts market. But U.S. exports (as a percent of total sales), after rapid growth in the early and mid seventies to over 35 percent, have remained essentially static since then at about 30 percent. The U.S. engine industry balance of trade is a significant part of the aerospace industry's positive trade balance (comprising 25 percent of aerospace's 1988 balance). An 80 percent improvement (from 2.5 to 4.5 billion 1988 dollars) between 1986 and 1988 brought the aircraft engine industry to an all-time high in trade balance. The performance of the aircraft engine industry during the last two decades, when viewed with these sales, export fraction, and trade balance parameters, may foster a complacent attitude, but recent sluggishness in the domestic market and slackening in 1988 sales growth imply challenges to the engine industry that should impart a degree of uneasiness.

The competitiveness of the foreign engine industry is increasing. Rising U.S. imports have resulted in U.S. domestic market penetration by the foreign industry to over 20 percent in the mid and late eighties. In the late eighties, the engine parts and subassemblies trade segment rose to a dominating influence in both exports and imports, which implies that increasing coproduction with foreign industry is becoming a dominant market force. Declining trade balance, as a fraction of total sales, throughout the seventies until the late eighties (except for short-lived surges) may point to softness in U.S. foreign competitiveness. A recent (1987-88) surge in trade balance fraction was as much due to slackening total sales growth and domestic market sluggishness with contracting U.S. share, as it was to improving export sales.

The declining U.S. aircraft engine trade surplus during the seventies and eighties is not an encouraging trend. Between the late sixties and the late eighties, the U.S. engines and parts trade surplus eroded from a 90 percent surplus to a 30 percent surplus; if industry and government remain status quo with respect to their current policies, strategies, and tactics, the U.S. will become a net importer of jet engines and parts by the turn of the century.

These sobering aspects of the U.S. aircraft turbine engine industry's trade position are reviewed in detail in the remainder of Section 2.

2.1 U.S. Aircraft Engine Industry Sales and Balance of Trade. The U.S. aircraft engine industry, including the network of subtier contractors and suppliers, is a big business. The Department of Commerce Census of Manufacturers sets the 1988 value of shipments (Figure 2.1-1) for the engine industry (SIC 3724) at more than $21.6 billion. (SIC 3724 is the Standard Industrial Code for aircraft engines and parts.) These shipments represent almost 20 percent of the total aerospace industry business for 1988, which itself accounts for over 4 percent of the 1988 total manufacturing business of the U.S. After a sluggish period during the early and mid seventies, positive growth (in 1988 dollars) occurred in the engine industry during the past decade, except during the early eighties' recession The growth rate significantly diminished during 1988; whether or not this signals a retrenchment at the start of the new decade will be understood better when viewing the 1989 and 1990 figures.

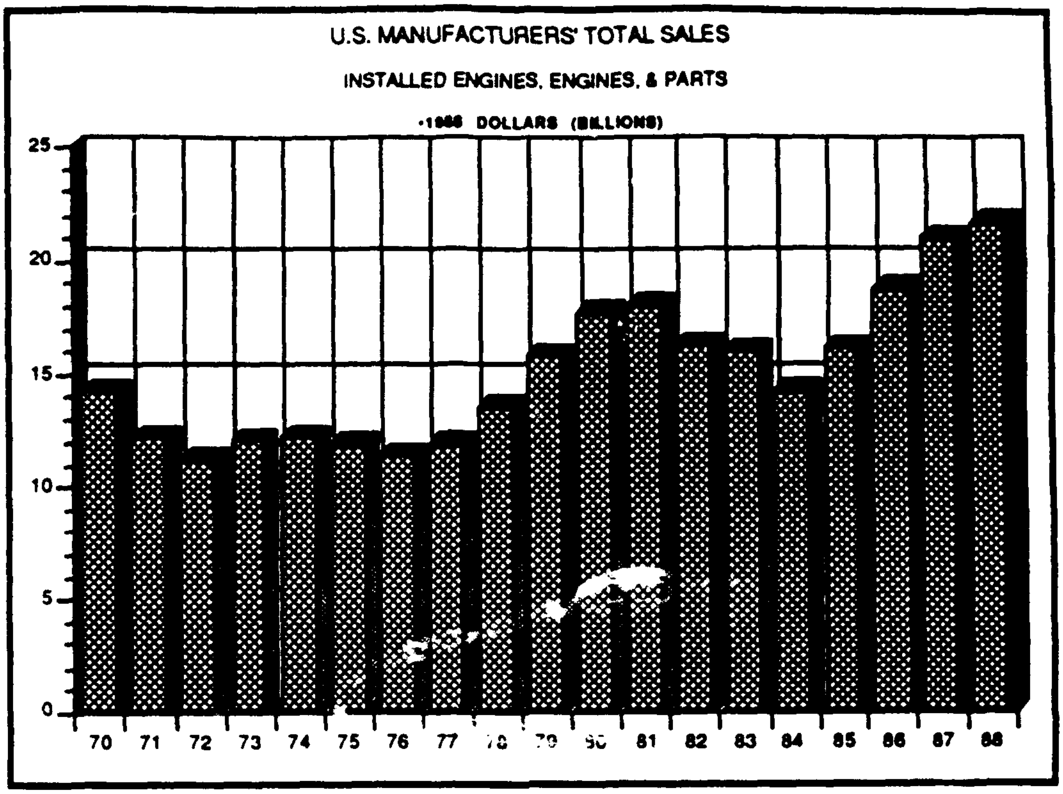

FIGURE 2.1-1 U.S. Aircraft Engine Industry Growth

Source: Department of Commerce, Bureau of the Census, Census of Manufacturers (Industries SIC 3724)

While the engine industry's sales remained flat (in 1988 dollars) during the early seventies, its export trade grew dramatically (Figure 2.1-2), almost doubling between 1970 and 1975. The mid-seventies fuel crisis probably was significant in slowing sales during 1975-77, but exports appear to have been more heavily affected than domestic sales, resulting in a loss in export business fraction in 1976-77 which the engine industry did not recover until 1988. Unfortunately, the domestic market (Figure 2.1-3) has slackened during the last two years, and the 1988 contraction is a factor in the rapid growth of the 1988 export trade fraction displayed in Figure 2.1-2.

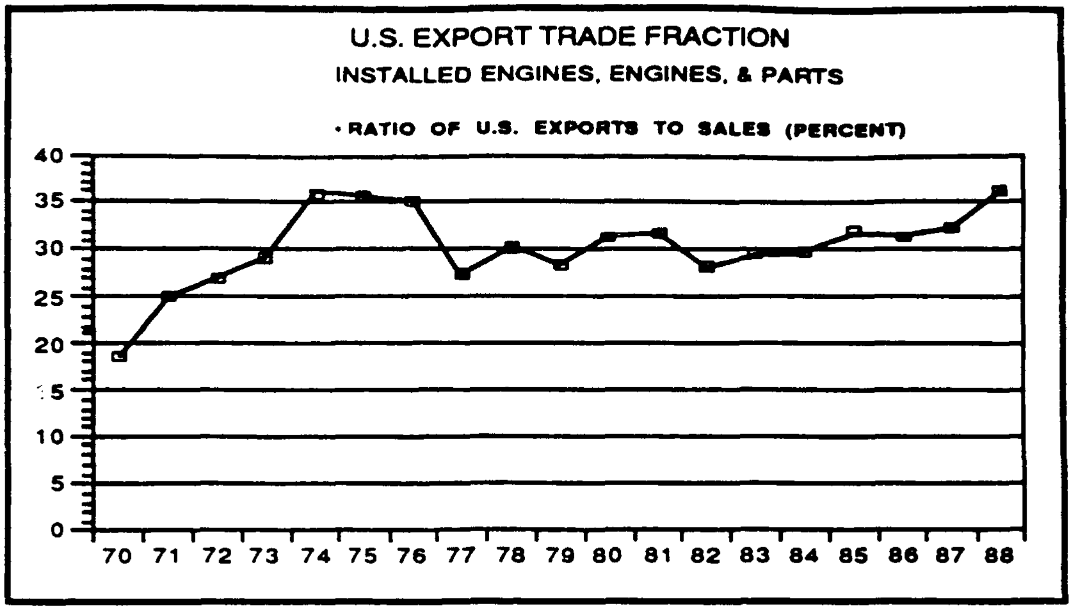

FIGURE 2.1-2 U.S. Aircraft Engine Industry Exports

Source: Department of Commerce, Bureau of the Census, Census of Manufacturers (Industries SIC 3724), and FT410, Ft446 (adjusted for installed engines by Universal Technology Corporation)

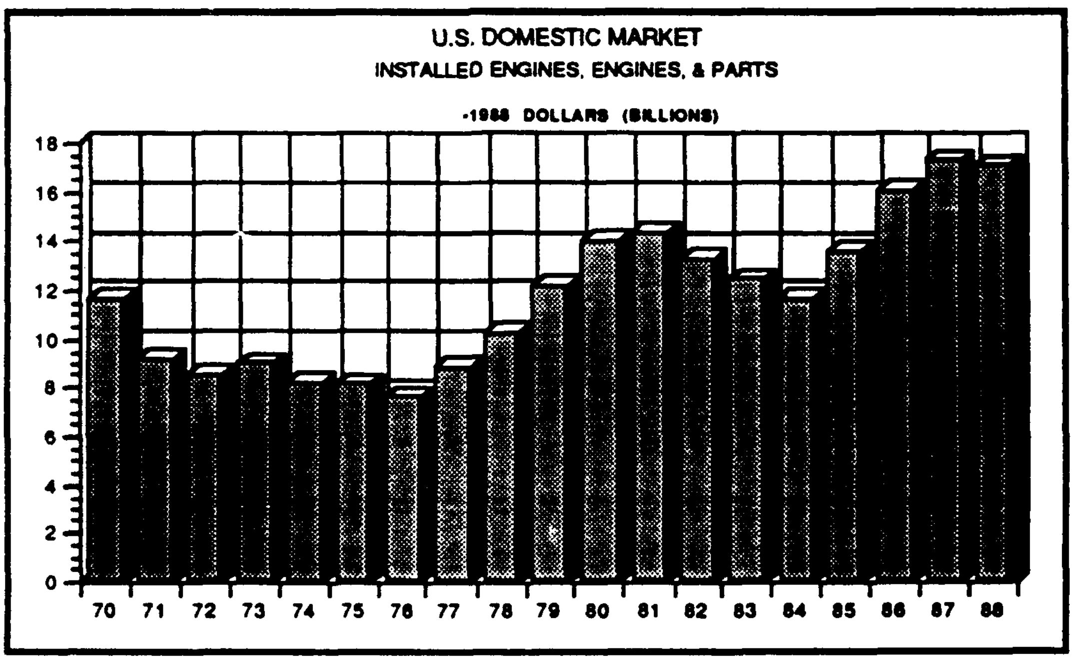

FIGURE 2.1-3 U.S. Aircraft Engine Domestic Market (U.S. Sales - Exports + Imports)

Source: Department of Commerce, Bureau of the Census, Census of Manufacturers (Industries SIC 3724), and FT410, FT446, FT246 (adjusted for installed engines by Universal Technology Corporation)

Aerospace is a major positive factor in the nation's efforts to return to a positive trade balance, currently one of the few remaining large industrial sectors maintaining a significant positive balance ($17.9 billion in 1988). Figure 2.1-4 displays the engine industry's performance in this important area, showing that it has contributed between $2.5 and $3.5 billion positive balance annually (1988 dollars) and increased its contribution during 1987 and 1988 to about $4.5 billion, approximately 25 percent of the total Aerospace 1988 positive balance of trade.

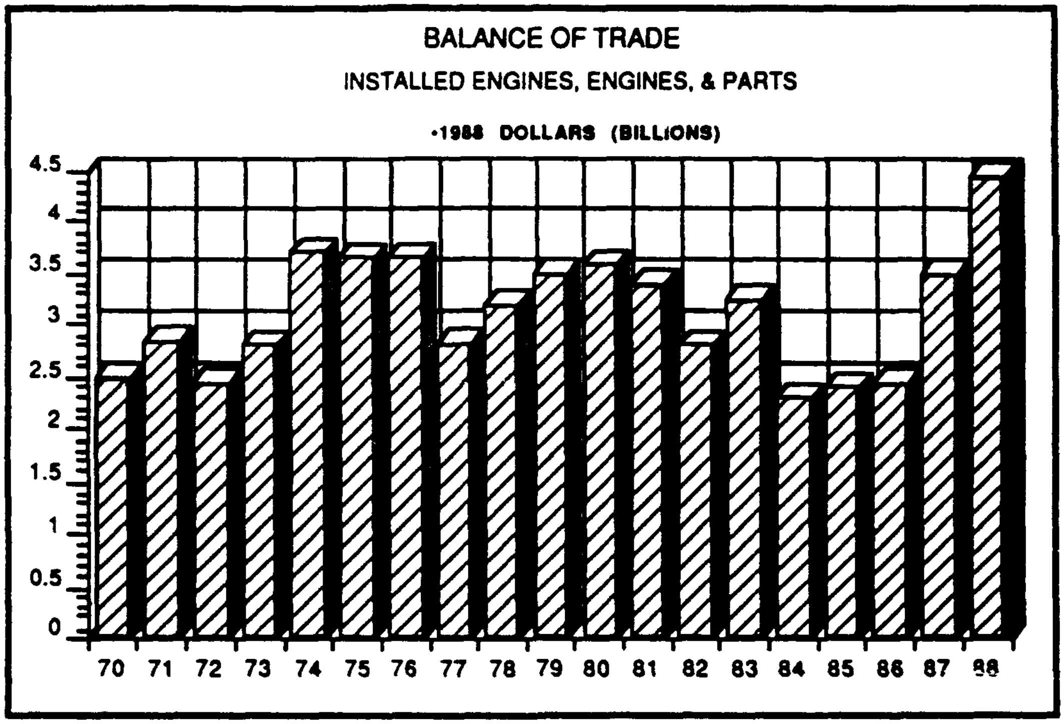

FIGURE 2.1-4 U.S. Aircraft Engine Industry Balance of Trade

Source: Department of Commerce, Bureau of the Census FT410, FT446, FT246 (adjusted for installed engines by Universal Technology Corporation)

The information displayed in Figures 2.1-1 through 2.1-4 generally indicates a healthy engine industry with a history of growth while contending with periodic economic sluggishness. Recent rapid increases in its sales growth, export trade fraction, and balance of trade indicate a continuing sound engine industry into the nineties, while recent sluggishness in the aircraft engines and parts domestic market (Figure 2.1-3) and the 1988 reduction in the engine industry's sales growth (Figure 2.1-1) imply challenges to its continued health. Several important issues need examination to provide the information to assure a competent forecast of the engine industry's performance status and prospects. These issues concern foreign trade activities of the U.S., the performance of foreign engine manufacturers in the U.S. domestic market, the growth of the international market, and the relative performance of the U.S. and foreign engine industries in the world market. Section 2.2 deals with foreign trade issues; Section 3, with international market issues.

2.2 U.S. Foreign Trade with Aircraft Engines. The previous section dealt principally with information generated by the Department of Commerce's Census of Manufacturers from throughout the U. S. manufacturing base, grouped into the various Standard Industrial Codes (SIC). The "value of shipments" information from SIC 3724 represents sales throughout the aircraft engine and parts industry, including sales to and through the various aircraft companies that construct, assemble and ship complete aircraft. This section, additionally, deals with export and import information gathered via FT246, FT410, and FT446 (see Appendix A). Sales of engines and parts that are exported and imported as entities are recorded, but engines installed in exported and imported aircraft are lumped with the value of the aircraft. Thus, domestically-assembled engines installed prior to export, imported engines installed on exported aircraft, exported parts and subassemblies installed within imported engines, and imported parts and subassemblies installed within engines for export are not visible to the Commerce export-import reporting documents. However, so long as both exports and imports of parts, subassemblies, and engines (both uninstalled, and installed on exported/imported aircraft) are tracked, the net value of exports and imports reflects as accurate a picture of the foreign trade status of the engine industry as is practical to obtain. U.T.C. estimated the aggregate value of installed engines on exported/imported aircraft as 20 percent of the yearly aggregate value of aircraft exports and imports, and added these estimates to the yearly aggregates of exported and imported engines and parts to obtain a more complete picture of the foreign trade status of the engine industry. Figures 2.2-1 and 2.2-2 display the results. Figure 2.2-1 does not display parts imports prior to 1980 because they were not tracked as an entity until 1980.

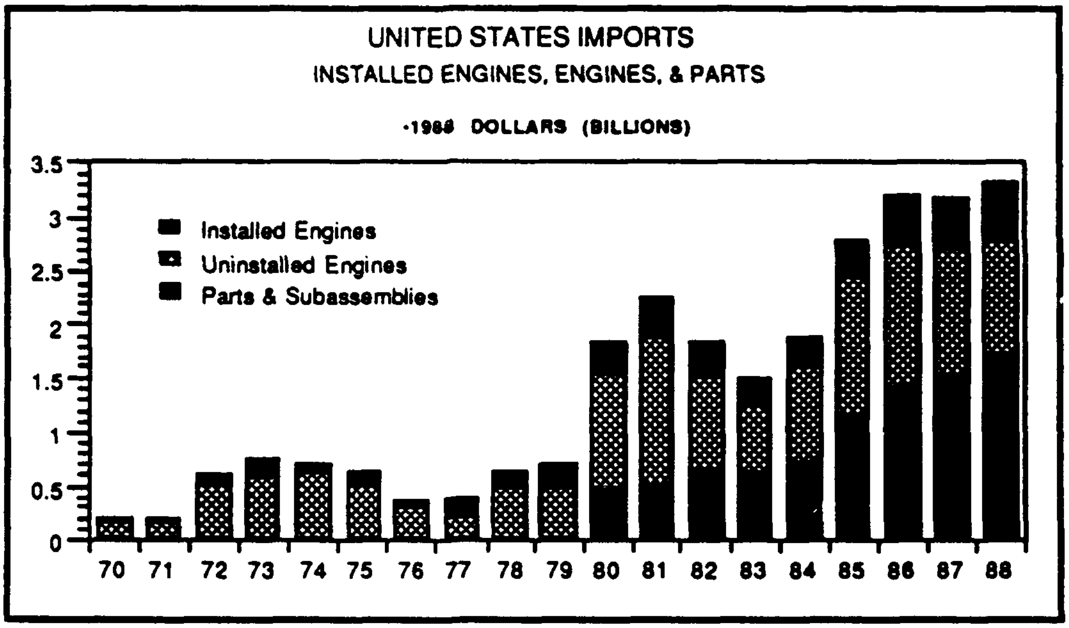

FIGURE 2.2-1 Import History of the U.S. Aircraft Engine Market

Source: Department of Commerce, Bureau of the Census FT246 (adjusted for installed engines by Universal Technology Corporation)

Note that the import trade grew, in less than two decades, from effectively zero, to more than a three billion dollar business. By the late eighties, over half of this business consisted of parts and subassembly imports. Some of the parts and subassemblies were assembled into U.S. subassemblies and engines for export, but a portion of these imports remained to penetrate (with imported installed and uninstalled engines) the U.S. domestic market--insignificant in 1970, but 20 percent of the domestic market in 1988 (Figure 2.2-3).

The export picture also is revealing. Taking into account the economic perturbations of the mid-seventies and early eighties, the export trade exhibits a healthy growth pattern from about $3 billion to almost $8 billion (1988 dollars) over the two-decade period (Figure 2.2-2). Particularly striking is the growth in parts trade--from less than a billion dollars in 1970, to almost $4 billion in 1988. By the late eighties, almost half of the U.S. engines/parts export trade consisted of parts and subassemblies.

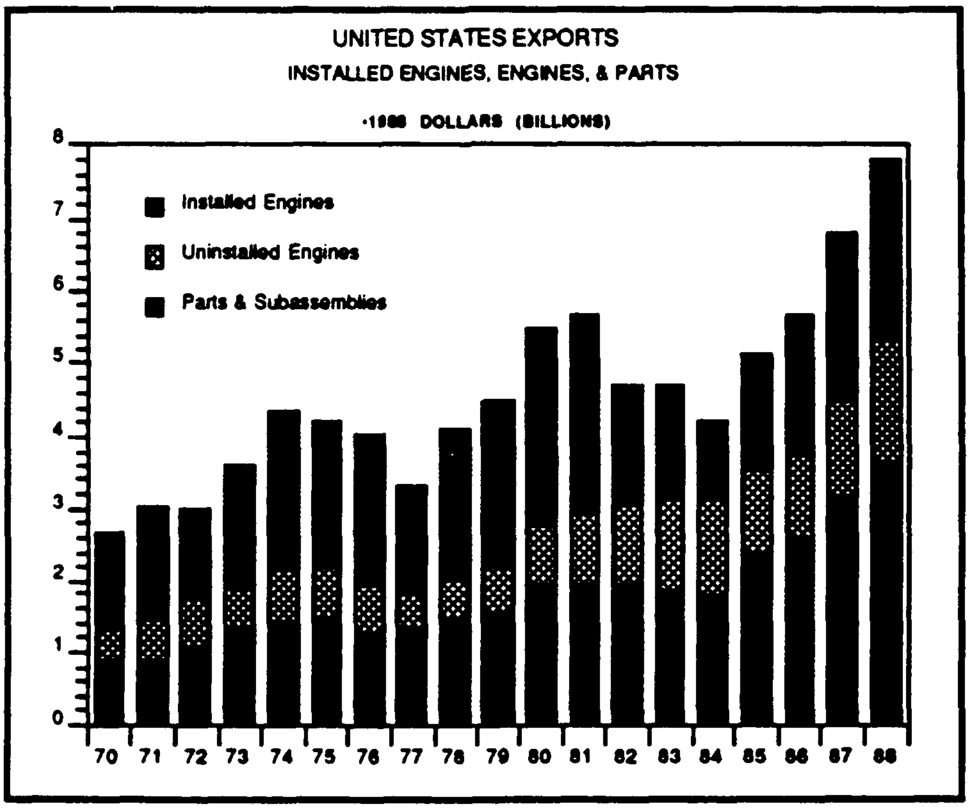

FIGURE 2.2-2 Export History of the U.S. Aircraft Engine Industry

Source: Department of Commerce, Bureau of the Census FT410, FT446 (adjusted for installed engines by Universal Technology Corporation)

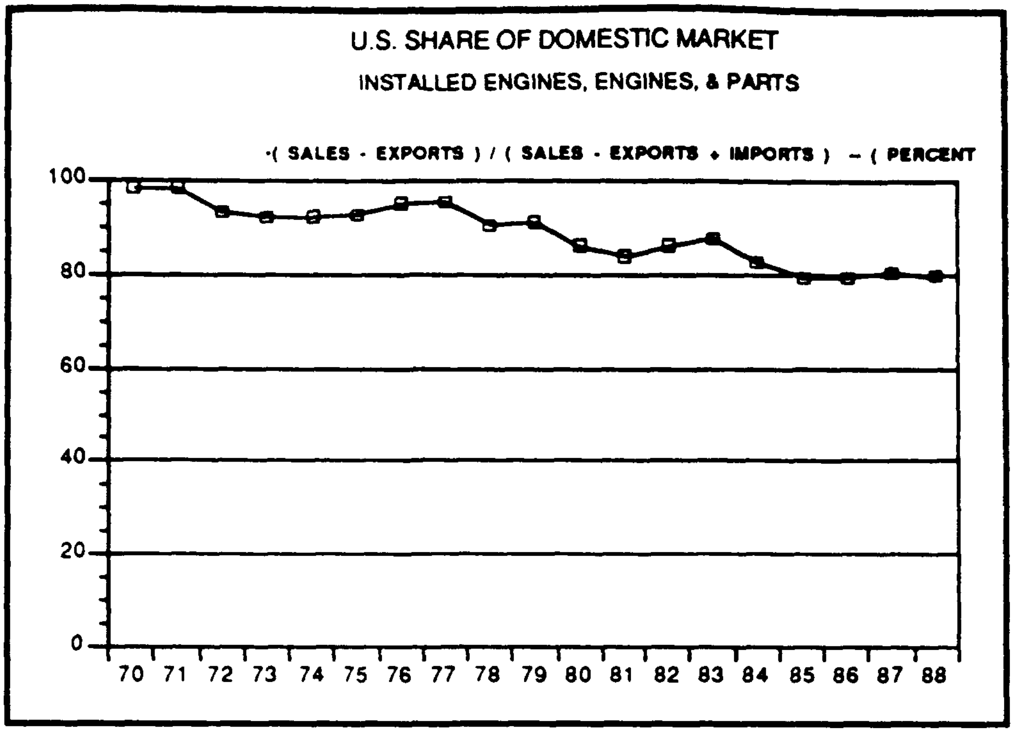

FIGURE 2.2-3 Foreign Penetration Into the U.S. Aircraft Engine Market

Source: Department of Commerce, Bureau of the Census, Census of Manufacturers (Industries SIC 3724), and FT410, FT446, FT246 (adjusted for installed engines by Universal Technology Corporation)

The engine industry exports engine parts and subassemblies for foreign overhaul and maintenance activities, and for assembling into engines produced by foreign companies under license to, or coproduction agreements with, U.S. counterparts. It also exports complete engines for foreign spares inventories and for installation into new foreign aircraft. The reverse is true (Figure 2.2-1) for imports. The thriving parts trade is due in large part to the growth in U.S./European codevelopment/coproduction collaborations occurring during the last decade. These collaborations are continuing to expand; the parts trade probably will continue to expand as a result; the degree to which parts imports grow compared to parts exports will significantly leverage the trade balance picture in the next decade. The engine coproduction picture is described in more detail in Section 3.

Notwithstanding the glowing reports of the press regarding the Aerospace Industry favorable balance, the U.S. engine industry exhibited an almost continuous loss in balance of trade fraction during 1976 to 1986 (Figure 2.2-4).

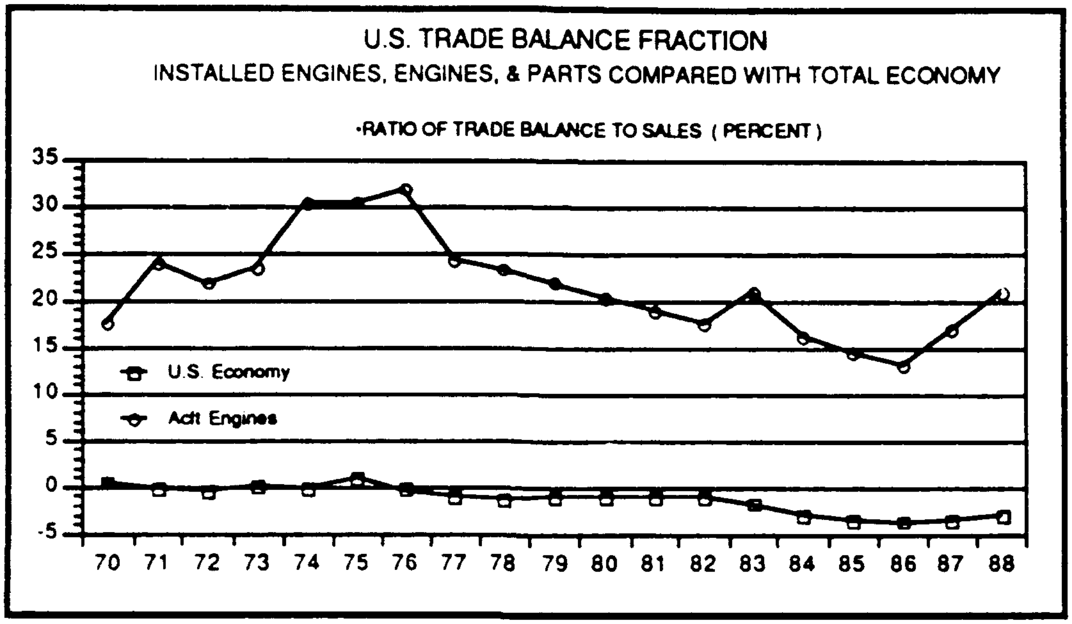

FIGURE 2.2-4. Declining Trade Balance Picture for U. S. Aircraft Engine Foreign Trade

Source: Department of Commerce, Bureau of the Census, Census of Manufacturers (Industries SIC 3724), and FT410, FT446, FT246 (adjusted for installed engines by Universal Technology Corporation)

Comparison of Figures 2.1-1, 2.1-3, 2.2-2, and 2.2-3 reveals that the 1987 rise in trade balance fraction occurred with a healthy expansion in engine industry total sales, because of a minor growth in domestic sales accompanied by a significant growth in exports. The rise in trade balance fraction continued in 1988 despite a significant slowdown in engine industry sales growth because a positive but smaller export growth rate occurred while both the domestic market and the engine industry's share were contracting. If the late improvement in trade balance fraction proves to be as temporary as the mid seventies and early eighties surges, there is cause for concern, especially when comparing the severity of the engine industry rate of decline with that of the U. S. economy as a whole (Figure 2.2-4).

The import history of the U. S. engine business, normalized to the total engine foreign trade (exports plus imports), provides a sobering view.

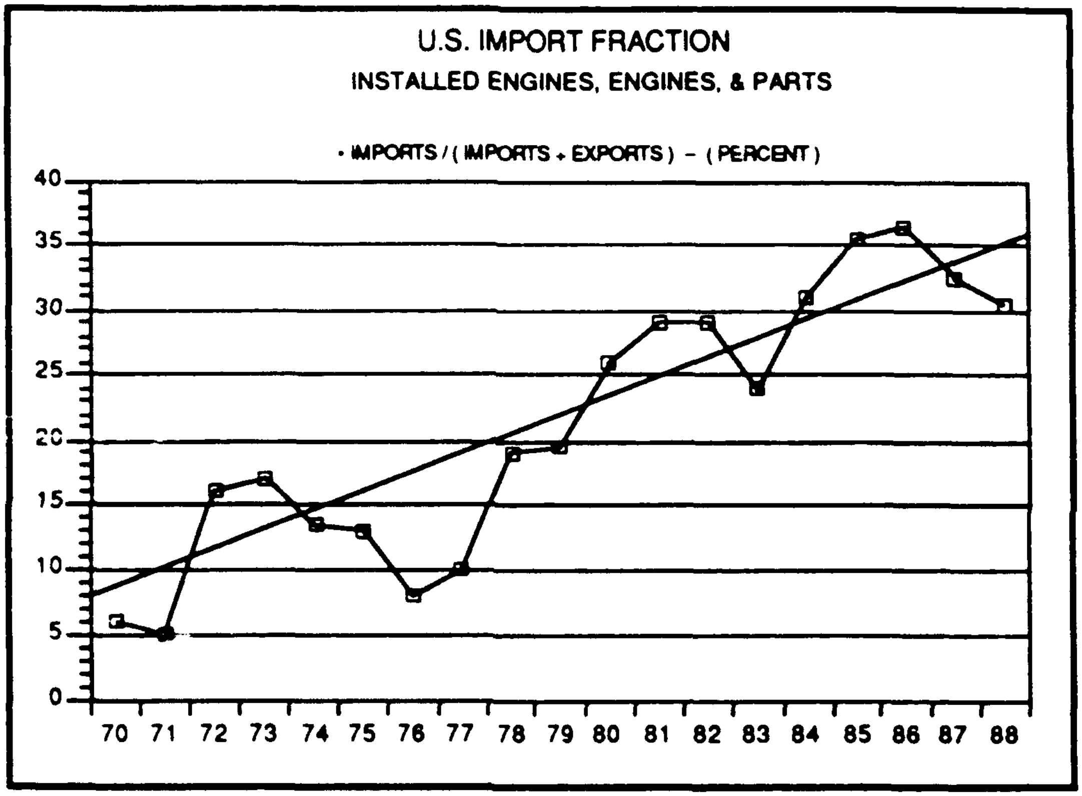

FIGURE 2.2-5 U.S. Aircraft Engine Trade Decline Toward Deficit Status
Source: Department of Commerce, Bureau of the Census, FT410, FT446, FT246 (adjusted for installed engines by Universal Technology Corporation)

Figure 2.2-5 displays this history as engine foreign trade cycled through the various periods of economic aggressiveness and sluggishness. Although the multiple impacts of corporate and government economic and political conditions, policies, and objectives upon engine foreign trade are not uniquely understood, it safely can be stated that continuing with no changes in them will result in the United States becoming a net importer of jet engines by the turn of the century, despite the glowing media reports of the current Aerospace Industry balance of trade picture. Thus, Aircraft Engines and Parts (SIC 3724) (comprising 20 percent of the Aerospace Industry, the lead export producer in the United States) will sink to trade deficit status by the end of the decade unless something changes the fundamental trend.

3.0 WESTERN WORLD ENGINE PRODUCTION AND THE U.S. MARKET SHARE.

MARKET SHARE. The western world aircraft turbine engine market, as reflected by estimates of the annual value of new engine production, has grown (between periods of temporary economic sluggishness) at a significant rate when measured in then-year dollars. But, when removing the inflation factor (using now-year dollars), the market has been effectively static except for downturns in periods of economic sluggishness. In fact, the gradual decline in the military engine market (measured in now-year dollars) would have resulted in an overall market contraction over the seventies and eighties had it not been for the growth in the civil engine market during the eighties.

The position of the U.S. aircraft turbine engine industry in the western world market is eroding. The U.S. share in military engine production declined during the seventies, and its civil share eroded during both decades. As a result, the U.S. engine industry lost significant production share in the seventies and barely managed to maintain its share in the eighties. Canada's expansion in the turboshaft segment and E.C.'s expansion in the turbojet/turbofan segment are largely responsible for the erosion in the U.S. share.

The character of the market has shifted significantly over the last decade. Formerly dominated by autonomous producers with corresponding engine development indigenous to each, the currently-prevailing condition verges on domination by coproduced engines manufactured under collaborative agreements involving two or more independent engine assemblers. This shift in market character is largely responsible for the E.C. gain during the eighties, but, although a significant factor in U.S. production in the late eighties, by 1988 the shift had not halted the erosion of the U.S. market share. U.S. coproduction in 1989 and 1990 will be critical in establishing the direction of the U.S. engine industry market--continuing the two-decade pattern, or a reversal to one of market share growth.

The Universal Technology Corporation (U.T.C.) generated these observations (which are detailed in the following material) by examining engine production history and assigning portions of the respective dollar value to appropriate engine assembly companies and licensed parts manufacturers. Forecast International/DMS (F.I.), of Newtown, Connecticut, tracks and records annual new engine production of the western world aircraft engine assembly organizations by engine type and model. F.I. also records an estimated per-engine dollar value for each model. U.T.C. personnel catagorized each model as an exclusive, licensed, or coproduced product of its assembly organization, and assigned portions of its value to the appropriate assembler, licensor, licensee, or coproducer. No attempt was made to assign portions of engine value to assembly company subtier contractors other than licensed and coproducing suppliers. Consequently, some portion of production value assigned to an engine assembler belongs to suppliers from other nations in cases where parts and sub-assemblies are imported from other than licensed or coproducer manufacturers. The resulting error in assigning new production value to nations and regions is considered minor and should not affect the trends observed in the following material.

U.T.C. generated an automated data base, incorporating this and other F.I. information on an annual basis from 1970 through 1988 and catagorizing the assemblers into regional areas (U.S., E.C., Japan, Other European, Other Asian, and Other). For certain engine models, U.T.C. had available only total units produced; in these cases, U.T.C. estimated an annual production breakout. The following material is sourced in this data base; U.T.C. uses it to generate a picture of the modern history of the western world aircraft turbine engine market and the position of the U.S. engine industry. A more detailed description of the F.I. information and the U.T.C. data base can be found in Appendix B. Table 3.0-1 lists the engine assembly companies and companies that manufacture parts under license and coproduction agreements, whose production consitutes the value of annual new engine production surveyed below.

TABLE 3.0-1 Companies Assembling Engines Exclusively or Under License and Coproduction Agreements, and Licensed or Coproducing Parts Manufacturers, Comprising the Total Value of Annual New Engine Production

Source: Forecast International/DMS

REGION	COMPANY	NATION	REGION	COMPANY	NATION
E.C	Fabrique Nationale	Belgium	OTH. EUR.	Valmet Corporation	Finland
"	KHD Luftfahrttechnik	F.R.G.	"	Norsk Jetmotor	Norway
"	Motoren-und-Turbinen-Union	F.R.G.	"	Volvo Flygmotor	Sweden
"	Alsthom	France	"	Sulzer Brothers	Switzld
"	Microturbo SA	France	OTHER	Hawker de Havilland	Australia
"	SNECMA	France	"	Hawker-Siddeley Orenda	Canada
"	Societe Turbomeca	France	"	Pratt & Whitney Canada	Canada
"	Hellenic Aerospace Industries	Greece	"	AOI Engine Factory	Egypt
"	Alfa Romeo	Italy	"	Hindustan Aero Ltd	India
"	Fiat	Italy	"	Bet-Shemesh Engines	Israel
"	Rinaldo Piaggio	Italy	"	Intreprinderea de Constructii	Romania
"	Casa	Spain	"	Intreprinderea Turbomecganica	Romania
"	Industria de Propulsion	Spain	"	Atlas A/C Corporation	S. Africa
"	Ames Industrial	U.K.	"	Turk Ucak Sanayii	Turkey
"	Noel Penny	U.K.	"	DMB Yugoslavia	Yugoslavia
"	Normalair-Garrett	U.K.	"	Orao-Vazduhoplovnic Zavod	Yugoslavia
"	Rolls-Royce	U.K.			
JAPAN	Ishikawajima-Harima		U.S.	Allison Gas Turbine Div., G. M.	
"	Kawasaki		"	Garrett Eng. Div., Allied Signal	
"	Komatsu/Mitsubishi St/Woodward		"	General Electric Engine Div.	
"	Mitsubishi		"	Microturbo North America	
OTH. ASIA	Shanghai Engine Factory	China	"	P&W Canada, W. Va. Div.	
"	Xian Aircraft Ind.	China	"	P&W Div., U.A.C.	
"	Singapore Aircraft, Inc.	Singapore	"	Teledyne C.A.E.	
"	Samsung Precision Ind	S Korea	"	Textron Lycoming	
"	Aero Industry Dev. Center	Taiwan	"	Williams International	

3.1 Western World New Engine Production. The commonly-accepted pattern of turbine engine market growth during the last two decades is reflected by the growth in annual value of engine production between 1970 and 1988 (Figure 3.1-1). Following a period of slow growth during the initial oil price crisis in the early and mid seventies, production surged before the economic recession of the early eighties. Economic recovery in the mid eighties saw a return of vigorous growth until production slumped in 1988.

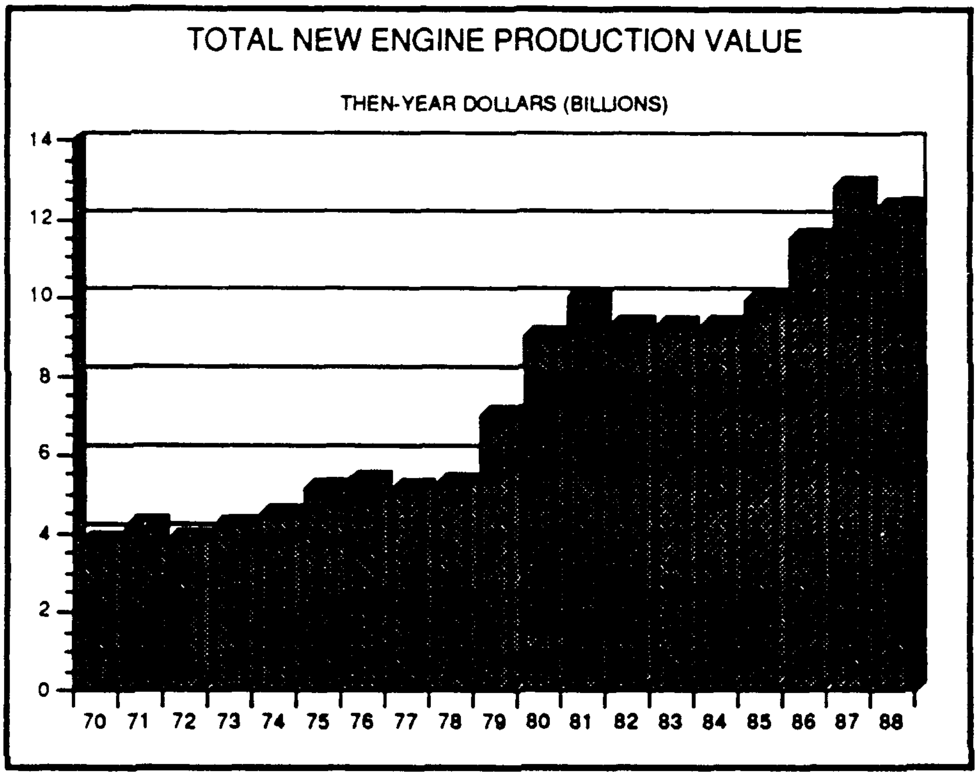

FIGURE 3.1-1 Growth in Western World Engine Production, Viewed with Inflated Dollars

Source: Forecast International/DMS and Universal Technology Corporation

When the inflation factor is removed from engine production value, the pattern of vigorous growth between periods of economic sluggishness changes significantly. Rather than growth, new engine production has contracted during economic recession periods and has recovered during intervening periods to a value that has not improved in two decades (Figure 3.1-2). The reduction in engine production value in 1988 may imply a continuation of this pattern of new engine market contraction and recovery into the next decade.

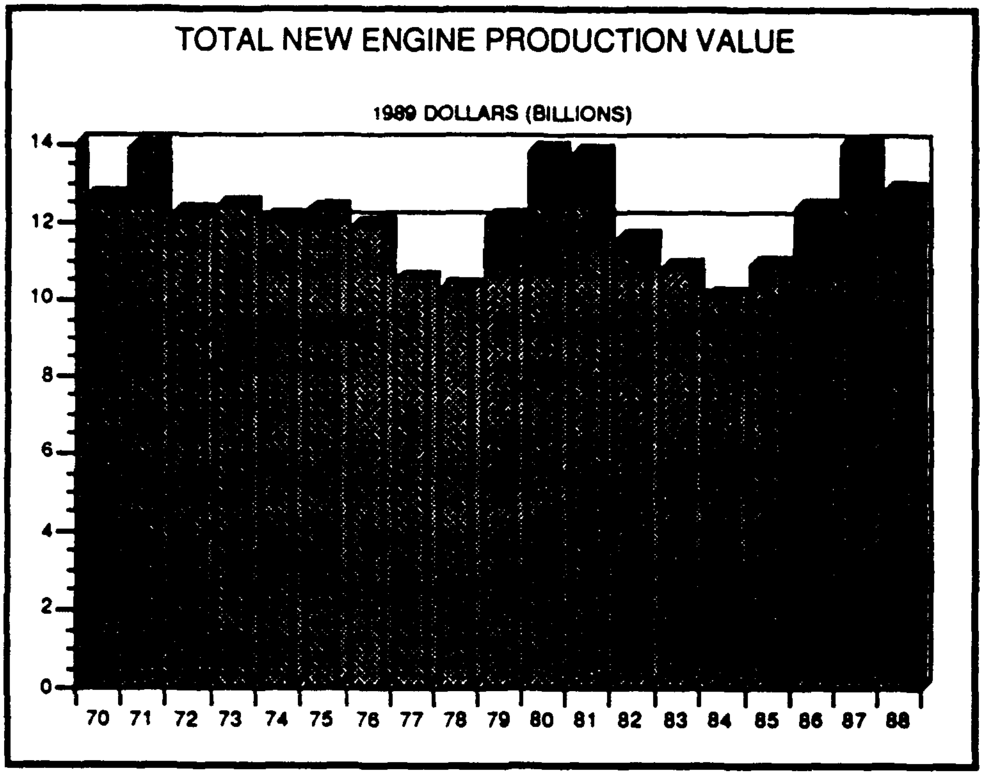

FIGURE 3.1-2 Periodic Contractions in Western World Engine Production, Viewed with Inflation-Free Dollars

Source: Forecast International/DMS and Universal Technology Corporation

This somewhat unexpected view of a western world new engine market that has remained static (between contractions) over the last two decades may be better understood by examining the military and civil segments. The military engine production segment (Figure 3.1-3) contracted throughout the early and mid seventies before essentially stabilizing in the late seventies and early eighties. Notice that growth in civil engine production in 1978-79-80 was largely responsible for the surge in overall production prior to the economic recession of the early eighties. A temporary surge in military engine production in the mid eighties, aided by continued growth in civil production, resulted in the mid eighties' surge in overall production value. Although military production suffered a significant downturn in 1988, the continuing growth in civil production ameliorated the contraction. The growth in civil engine production value occurring almost continuously over the last two decades was offset by the contracting military engine value, resulting in static overall production value between periods of economic recession.

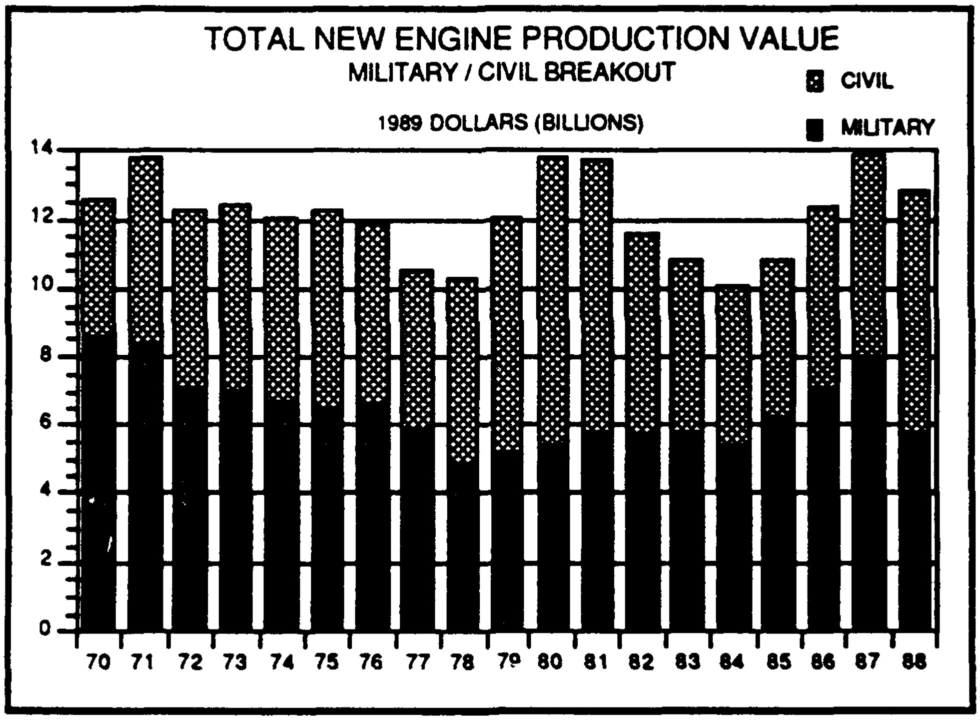

FIGURE 3.1-3 Growth in Influence of Civil Production

Source: Forecast International/DMS and Universal Technology Corporation

The 1988 contraction in military engine production value (Figure 3.1-3) may be signaling a return to a "norm" (observable throughout the seventies and early eighties) following a temporary surge in mid eighties' production. The current relaxation of East-West tensions may be reflected in a continued contraction in military engine production value. Continued growth in civil engine production is implied by forecasts of over 7 percent per year growth in airline traffic during the first half of the nineties. This growth in civil engine production will temporize the military contraction and may cause overall growth in annual engine production value during the nineties.

3.2 U.S. Industry Share of the Western World Military and Civil Market. While the western world new engine annual production value remained static during the last two decades, between periodic temporary downturns (Figure 3.1-2), by 1988, the U.S. had lost over 20 percent of its 1970 military share and over 30 percent of its 1970 civil share. E.C. growth in both the military and civil segments is primarily responsible for the erosion in U.S. market share.

The U.S. share of world new engine production value (Figure 3.2-1) declined between 1971 and 1982 from about 84 percent to 62 percent. Since 1982, the U.S. share has oscillated between 62 percent and 66 percent, but the last three years (1986-1988) show a resumption of share loss. The E.C. doubled its share during the 1971-1982 time period from 15 percent to 30 percent. Since then, it has been vying for share growth with the U.S. and appears to be gaining since 1986. The share produced by other than the U.S. and E.C. (largely Canada), after a healthy rise to about 10 percent in the seventies and early eighties, has stabilized near 7 percent during the mid and late eighties.

Figure 3.2-2 breaks out the shares of the U.S. and E.C. for the military segment. The U.S. lost heavily its military share in the seventies, falling from about 83 percent to 60 percent in 1979, with its share stabilizing at about 65

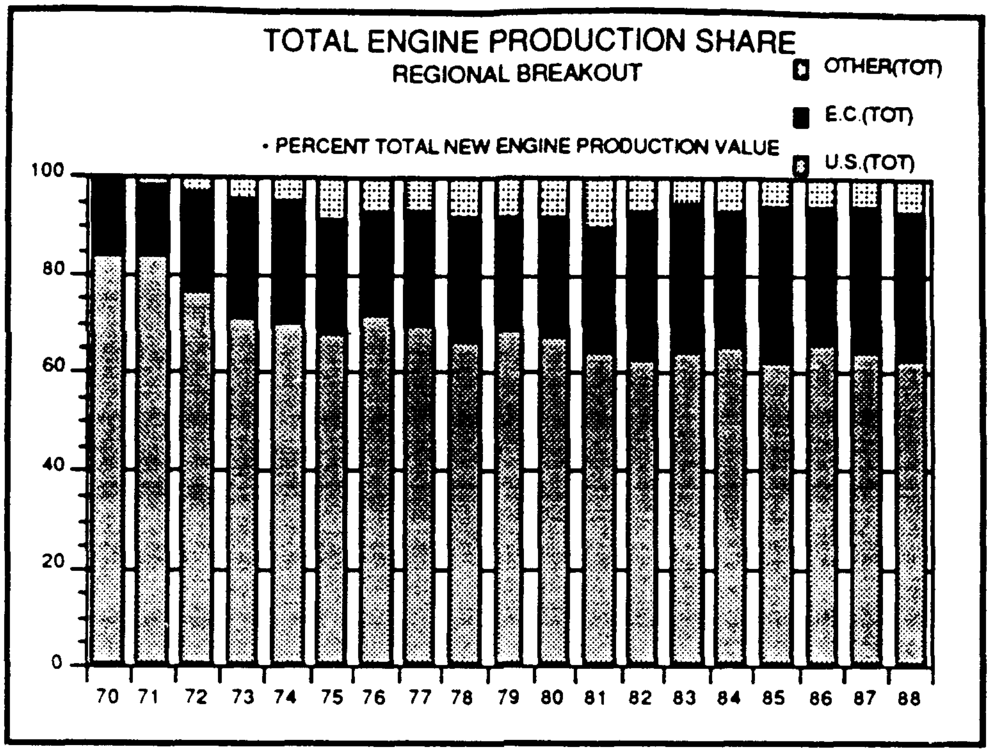

FIGURE 3.2-1 Erosion of U.S. Engine Production Share
Source: Forecast International/DMS and Universal Technology Corporation

percent through the eighties. The E.C. was the primary cause of the U.S. loss in military engine share, rising from 17 percent in 1970 to about 35 percent in 1979. But the U.S. pared the E.C. share to just over 30 percent by 1981, and thereafter the E.C. share stabilized between 31 percent and 33 percent. The increase in the U.S. military aircraft engine market during the 80's, largely absorbed by the domestic industry, probably was primarily responsible for stabilizing the U.S. military market share during the 80's.

The U.S. experienced more volatile share changes in the civil market (probably because the civil market is more susceptible to short-term economic factors than the military market), but its civil share loss was more severe, diminishing from 87 percent in 1970 to about 60 percent in 1982 (Figure 3.2-3). After a two-year recovery to 68 percent in 1984, the U.S. share oscillated between

60 percent and 62 percent, with a mild erosion occuring during 1987-88 to less than 60 percent. The E.C. civil engine market trend exhibits cyclic growth (during the early seventies and early eighties) from a 1970 share of 10 percent, retrenchment (late seventies and 1983-84), followed by mild growth in the late eighties to a two-decade high in 1988 of 30 percent.

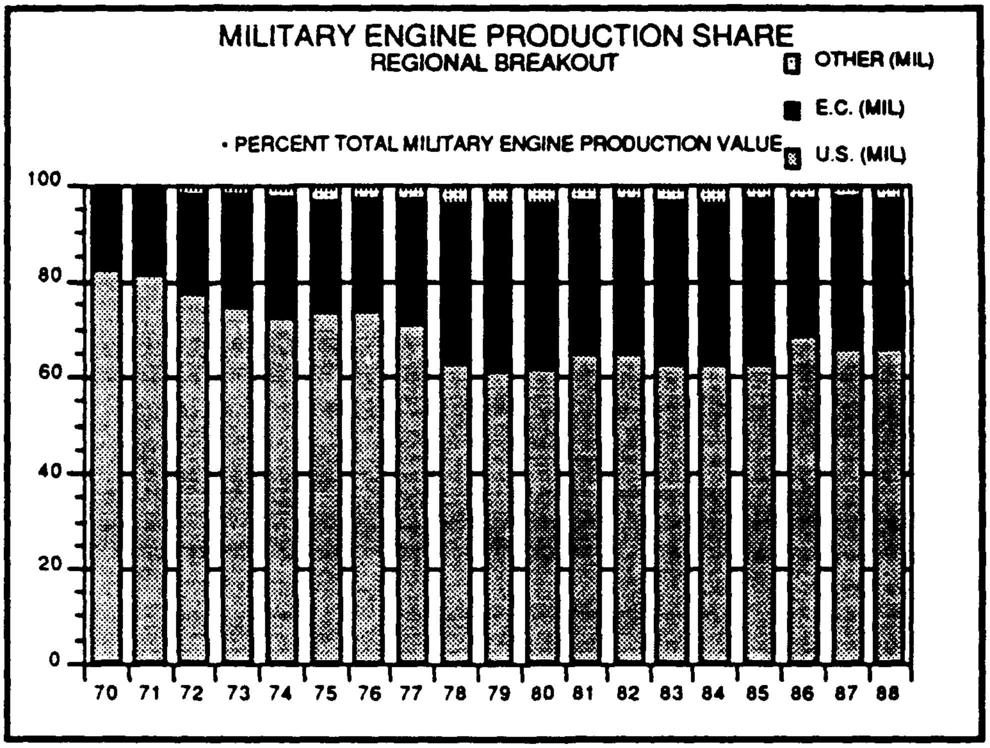

FIGURE 3.2-2 U.S. and E.C. Military Engine Production Trends
Source: Forecast International/DMS and Universal Technology Corporation

Thus, the E.C. has grown to a formidable competitor in the $10 billion to $14 billion (1989 dollars) new engine market during the seventies and eighties. The E.C.'s western world military market share doubled (17 percent to 35 percent) during the seventies, but stabilized during the eighties to about 32 percent. The U.S. military share stabilized at about 65 percent. The E.C.'s civil market share tripled (10 percent to 30 percent) during the seventies and early eighties, while the

U.S. share diminished from 87 percent to 60 percent. After a momentary recovery in 1984 the U.S. civil share eroded to slightly less than 60 percent in 1988, due to the E.C. rise (after its early eighties' erosion to about 22 percent) to its 1988 position of 30 percent.

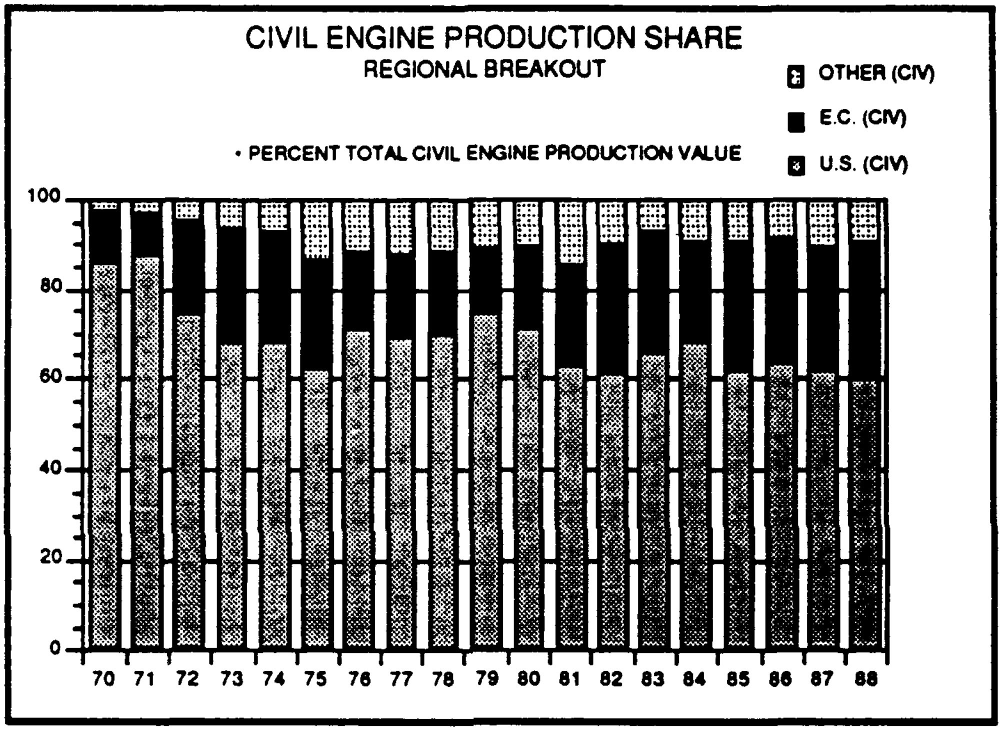

FIGURE 3.2-3 E.C.'s Ascent In Civil Engine Production Share

Source: Forecast International/DMS and Universal Technology Corporation

3.3 Market Share Trends in the Shaft and Turbofan/Turbojet Segments. During the seventies and eighties, the U.S. lost over 25 percent of its 1970 share of both the new shaft engine market segment for turboprop and helicopter aircraft and the turbofan and turbojet market segment for small and large high-performance and transport aircraft. Canada has become a major competitor in the shaft engine market, and the E.C., due to its growth in civil transport engine production, has captured almost a third of the value of turbofan/turbojet new engine production.

Shaft engine production for turboprop aircraft and helicopters varied between values of $1.5 billion and $2.5 billion (1989 dollars) during the seventies (Figure 3.3-1), stabilizing at about $1.5 billion in the late eighties. The shaft engine segment comprised about 15 percent of the total new engine market in the early seventies, improving to over 20 percent of the market in the late seventies due to a diminishing fan/jet production value (again in 1989 dollars). The fan/jet new engine market imp'oved during the mid and late eighties at a greater rate than the shaft market, so that by 1988 the shaft market, at about $1.4 billion, comprised only 11 percent of the annual new engine production value.

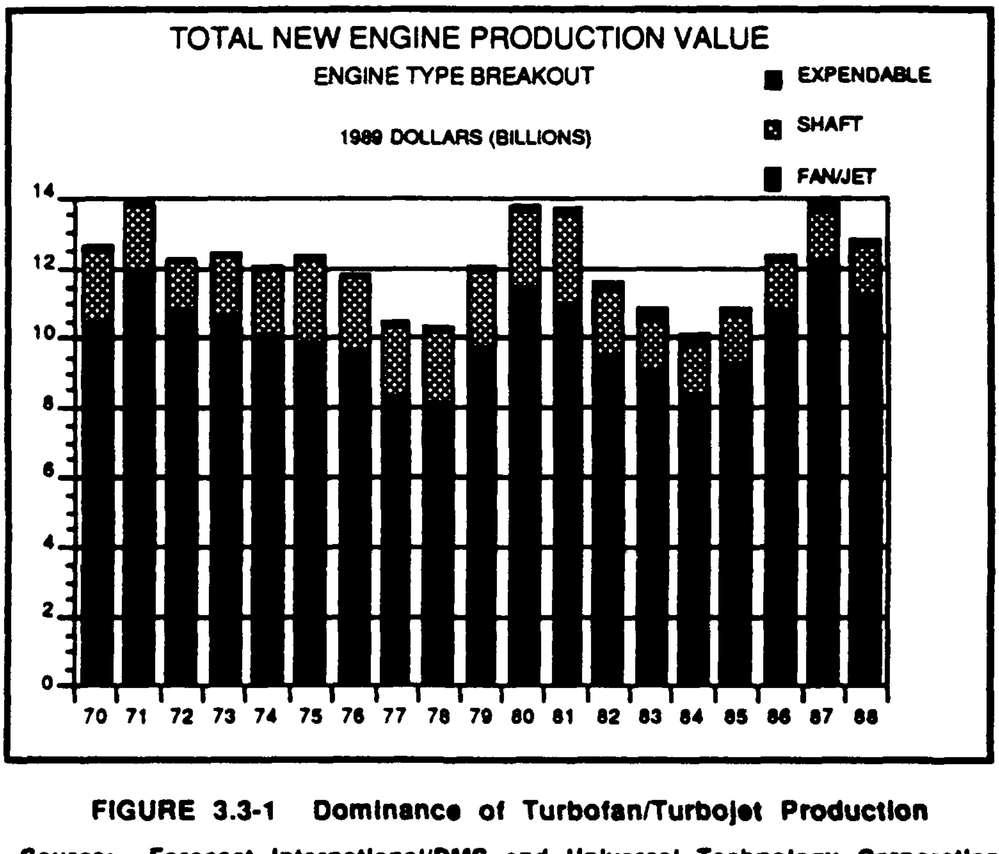

FIGURE 3.3-1 Dominance of Turbofan/Turbojet Production
Source: Forecast International/DMS and Universal Technology Corporation

The U.S. share in western world shaft engine production declined more or less steadily during the seventies (from 74 percent in 1970 to 47 percent in 1980), losing more than a third of its share during that decade (Figure 3.3-2). The early and mid eighties saw the U.S. regain a substantial portion of the shaft market; by 1986 it produced about 65 percent of the western world new engine value, but the U.S.' share resumed its decline until in 1988 it retained just over 55 percent of the western world's production. The E.C. suffered a significantly more severe loss in production share than the U.S.; by 1988 it had lost 75 percent of its 1972 share (from 30 percent in 1972 to 8 percent in 1988). The loss in mid 1990 of two U.S. shaft engine production programs to E.C. manufacturers and users (the GE T700 to

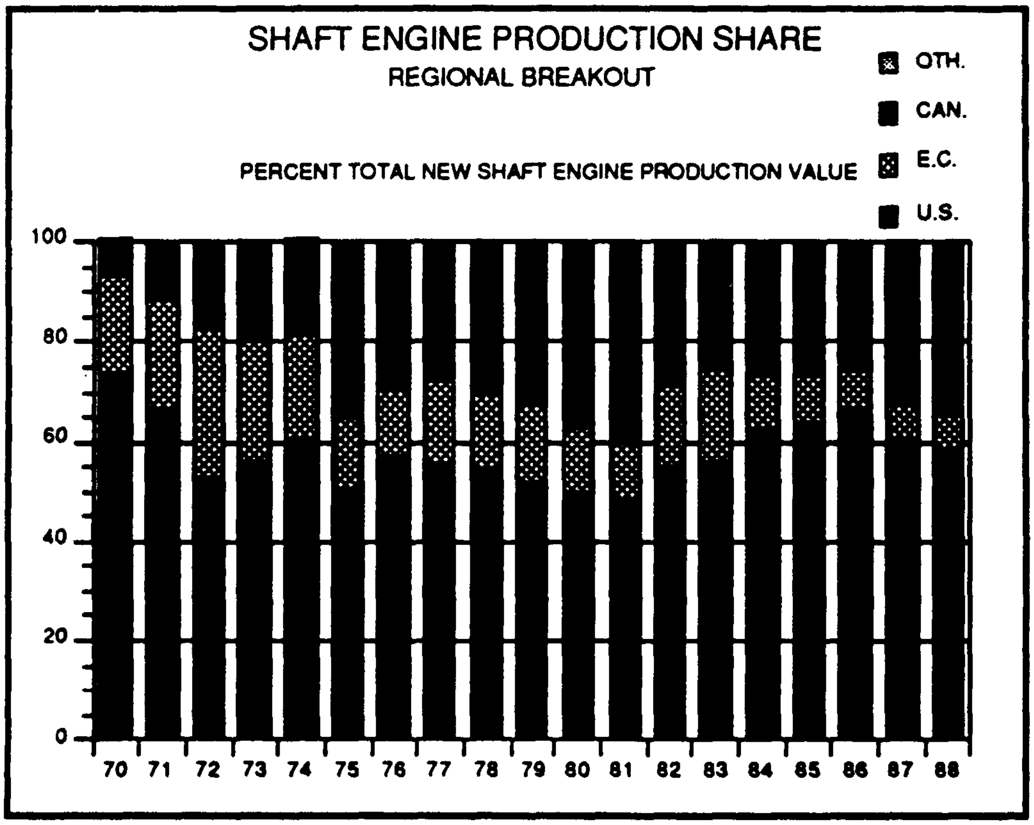

FIGURE 3.3-2 Canada--The U.S.' Primary Competition for Shaft Engine Production Share

Source: Forecast International/DMS and Universal Technology Corporation

the RTM322 for the U.K. Royal Navy EH101, and the LTS101-750 to the Turbomeca Arriel 1E for the BK117 upgrade) may be signaling a strengthening of the E.C. market share in the early nineties. The big gainer in shaft engine production share over the last two decades has been Canada, rising from 6.5 percent in 1970 to 32.5 percent in 1988.

The U.S. share in turbofan/turbojet engine production over the last two decades also has a sobering history. Overall value (in 1989 dollars) of fan/jet production diminished during the seventies from a high of about $12 billion in 1971 to $8 billion in 1978 (Figure 3.3-1). By 1980, production had recovered to over $11 billion before the economic slump returned the value to just over $8 billion in 1984. The mid eighties saw a recovery to almost the 1971 level, but an 8.5 percent contraction to $11 billion occurred in 1988.

Although fan/jet production value oscillated between $8 billion and $12 billion throughout the seventies and eighties, the U.S. experienced a continuing loss in production share during the seventies and early eighties, from over 85 percent in 1970 to about 63 percent in 1982 (Figure 3.3-3). The western world fan/jet production value rose rapidly during the mid eighties before the slump in 1988 (Figure 3.3-1), but the best the U.S. could accomplish in this production "boomlet" was to stabilize its share between 62 percent and 65 percent.

The E.C. has been the major factor in wresting fan/jet new engine production share from the U.S. The E.C.'s share more than doubled during the seventies and early eighties, from about 15 percent in 1970 to 33 percent in 1982 (Figure 3.3-3). Throughout the remainder of the eighties, the E.C.'s share has remained between 30 percent and 35 percent of the western world production value, but the 1986 through 1988 trend implies that the E.C. may be resuming its growth in fan/jet production share.

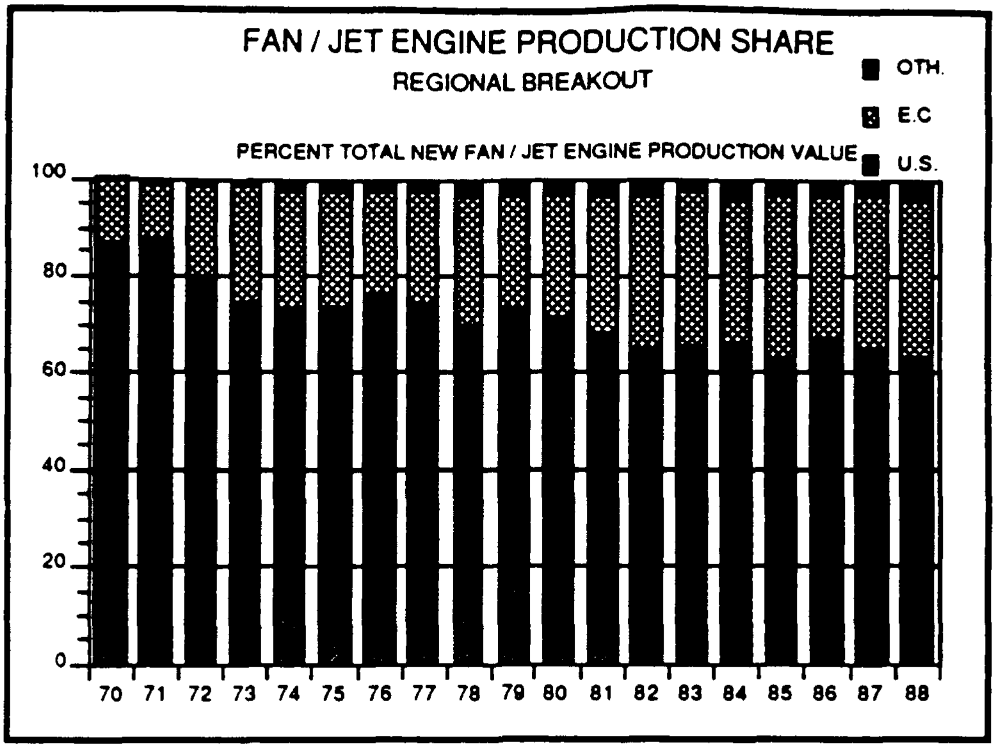

FIGURE 3.3-3 E.C.--The U.S.' Primary Competition for Fan and Jet Production Share

Source: Forecast International/DMS and Universal Technology Corporation

3.4 Growth of Coproduction to a Major Part of New Engine Production Value. Engine production evolving from international and domestic collaborations among the western world manufacturers in seven years has progressed from a negligible quantity to the point of dominating new engine production value. Prior to 1982, intra-E.C. collaborations dominated the then insignificant coproduction segment, but intensive activity to establish collaborations between U.S. and E.C. manufacturers initiated in the mid seventies started their market impact in 1982 and rapidly developed into a major force in the engine market. By 1988, the U.S. had become the primary beneficiary of coproduced engine production value, but the E.C. share was over 80 percent of the U.S.' coproduction share. The primary cause of the slump in 1988 engine production value was a sharp decline in independently-produced U.S. engines; the continuing rapid rise in coproduced engine value in 1988 prevented the overall slump from being significantly more severe. The active coproduction growth merely returned U.S. engine production to the level of its early eighties' surge, but this growth has been the primary cause of the E.C.'s growing penetration into the western world market following the economic slump of the early eighties.

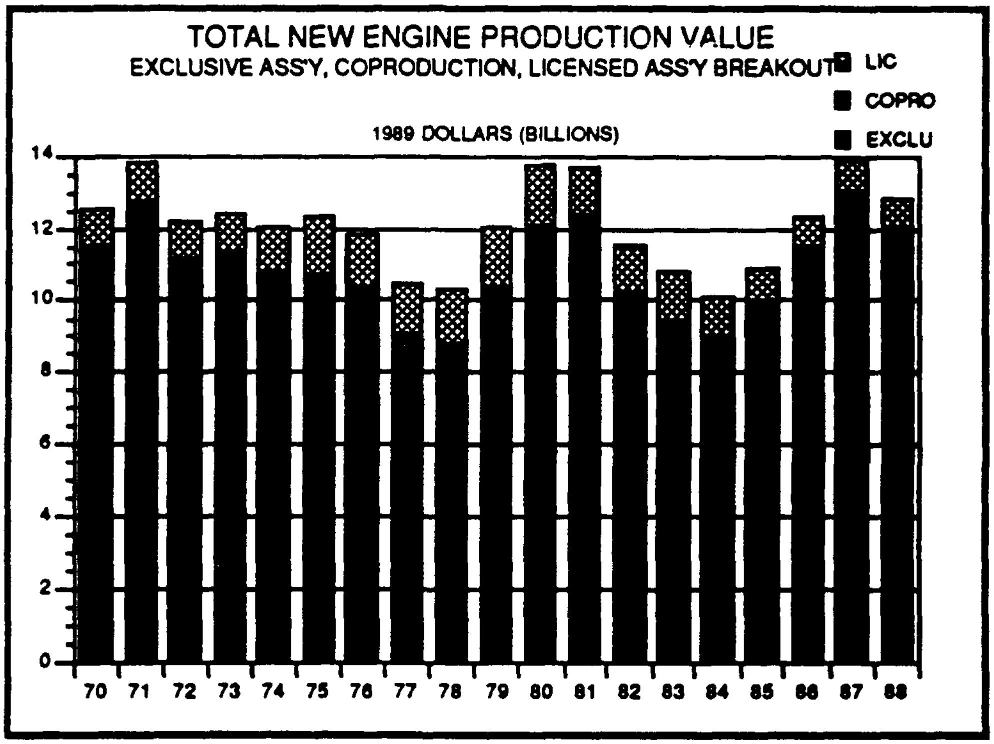

FIGURE 3.4-1 Diminishing Influence of Exclusive Assembly

Source: Forecast International/DMS and Universal Technology Corporation

The decline in the value of western world annual new engine production by exclusive assemblers during the eighties is startling. From a level of almost $11.5 billion (1989 dollars) in 1981, production was halved in just seven years to about $5.5 billion in 1988 (Figure 3.4-1). The annual value (to both licensee and licensor) of engines assembled under license shrank to insignificance, from about 1.5 billion dollars in 1980 to just over three-quarter billion dollars by 1988.

Engines produced under coproduction agreements grew steadily from 1981 (maintaining a growth rate even during the recession of the early eighties) to a position that verged upon market dominance in 1988. By 1988, annual coproduction engine value (in 1989 dollars) had grown from an insignificant three-quarter billion dollars in 1981, to almost $6.5 billion, about half of the total 1988 engine production value. Note in Figure 3.4-1 that while total value contracted in 1988, coproduced engine production continued its rapid growth. This rapid growth of the coproduction segment toward dominance is clearly displayed in Figure 3.4-2; in 1981 it accounted for only 6 percent of the production value, but in only seven years grew to 50 percent.

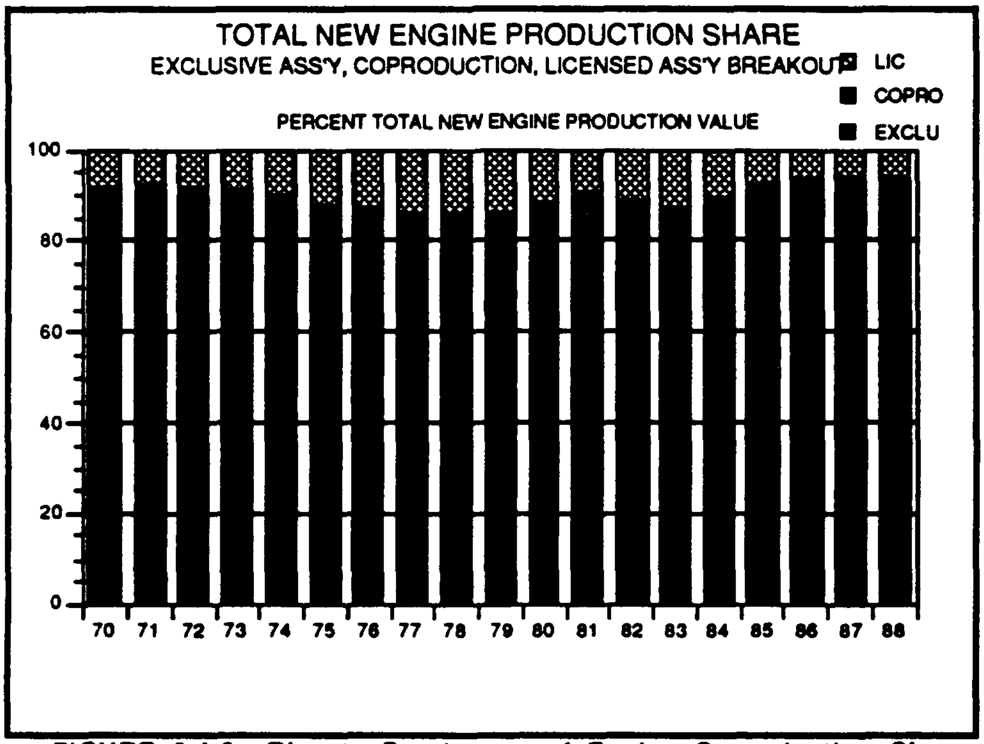

FIGURE 3.4-2 Rise to Dominance of Engine Coproduction Share

Source: Forecast International/DMS and Universal Technology Corporation

The U.S. exclusively-assembled engine business has eroded (except for two surges in the late seventies and the mid eighties) throughout the last two decades (Figure 3.4-3). On the other hand, E.C. exclusively-assembled engine business grew in the early seventies and stabilized following the contraction during the mid seventies' oil crisis (Figure 3.4-4). Interestingly, the E.C.exclusive assembly business failed to recover following the recession of the early eighties while U.S. business enjoyed a short recovery in the mid eighties, before its

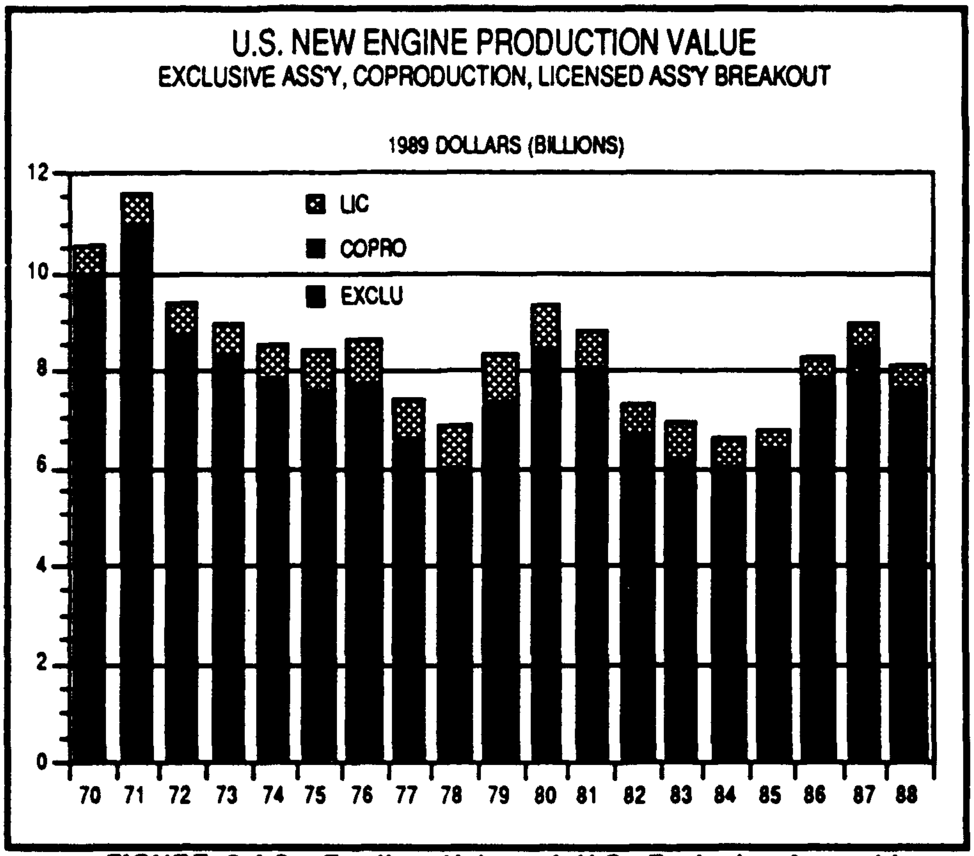

FIGURE 3.4-3 Eroding Value of U.S. Exclusive-Assembly

Source: Forecast International/DMS and Universal Technology Corporation

precipitous slump in 1988. Another point to note by comparing Figures 3.4-3 and 3.4-4 is the growth in annual overall engine production value enjoyed by the E.C.

during the eighties due to the vigorous growth in the coproduction segment, while the U. S. was barely able to recover its pre-recession position.

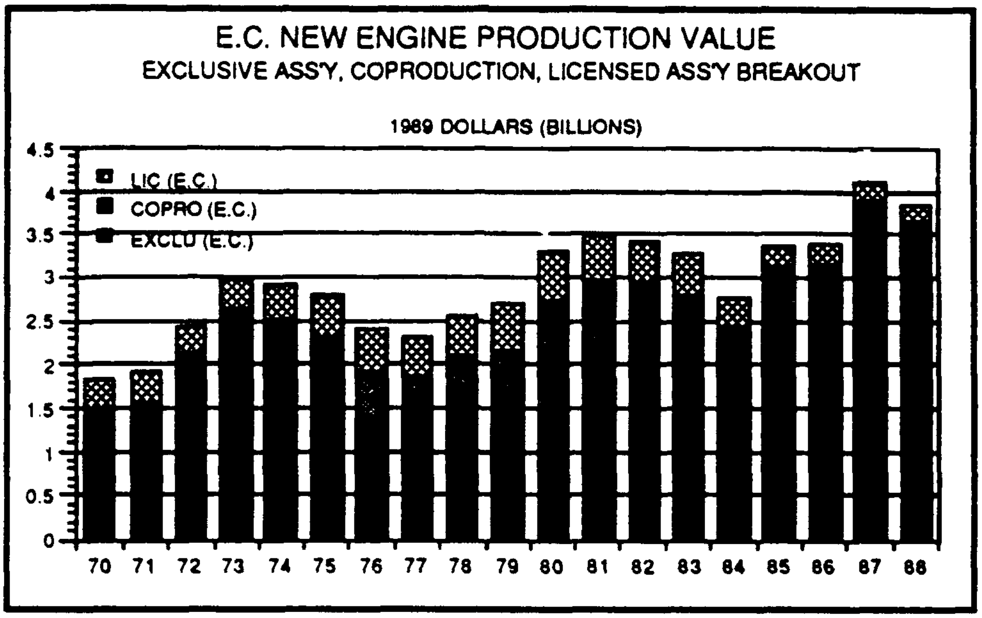

FIGURE 3.4-4 Rise of Coproduction as a Dominating Influence in E.C. Engine Production

Source: Forecast International/DMS and Universal Technology Corporation

The most significant point to observe in the character of western world aircraft engine production is the appearance of international coproduction arrangements among the engine manufacturers as a major driving force. The degree to which the U.S. can successfully exercise leverage over these arrangements probably will determine whether its engine market position will continue to erode or will improve in the nineties. Although Japan has not yet significantly contributed to the engine market, its success with other industries may imply lessons to be learned from these successes that would be useful to the U.S. engine industry. The following sections survey Japanese activities with their machine tool and aircraft engine industries and the E.C. aircraft engine industry, and compare them with parallel activities in the U.S. They reveal some strategy the U.S. could employ to promote most effectively a return to an improving share of western world aircraft engine production.

4.0 THE RISE (AND FALL) OF JAPANESE (AND U.S.) MACHINE TOOL INDUSTRIES.

Sections 2 and 3 display sobering trends for the U.S. aircraft turbine engine industry in both domestic and foreign trade. The European Community engine industry poses a real near-term competitive threat as the East European Market opens and the Pacific Rim/East Asian markets continue their rapid expansion. Japan's competitive threat (see Section 5.2) is further down-stream and may become real to the extent it can leverage a leadership role with an emerging Asian engine industry. Although the Japanese currently do not pose a threat to the U.S. turbine engine industry's world-wide market, Japan has successfully challenged and overpowered the U.S. market position in several other industries. Japan's success during the last two decades in wresting control of the machine tool market from the U.S. is a prime example.

The trend during the last two decades in U.S. turbine engine industry foreign trade has been negative (see Section 2), but not nearly as catastrophic as the collapse of the U.S. machine tool industry foreign trade. Between the late sixties and the late eighties, the U.S. machine tool industry foreign trade declined (Figure 4.0-1) from a 50 percent surplus to a 50 percent deficit. During the same period, U.S. turbine engine industry foreign trade declined from a 90 percent surplus to a 30 percent surplus..

The performance of the Japanese and U.S. machine tool industries in the world market and in the U.S. market sector during the seventies and eighties is depicted in Table 4.0-1. During this period Japan captured almost 25 percent of the world market while the U.S. saw its share diminish from over 25 percent to less than 10 percent. The U.S. domestic market doubled in size from the mid seventies to the mid eighties, but the U.S. share in its own market fell from about 90 percent to less than half.

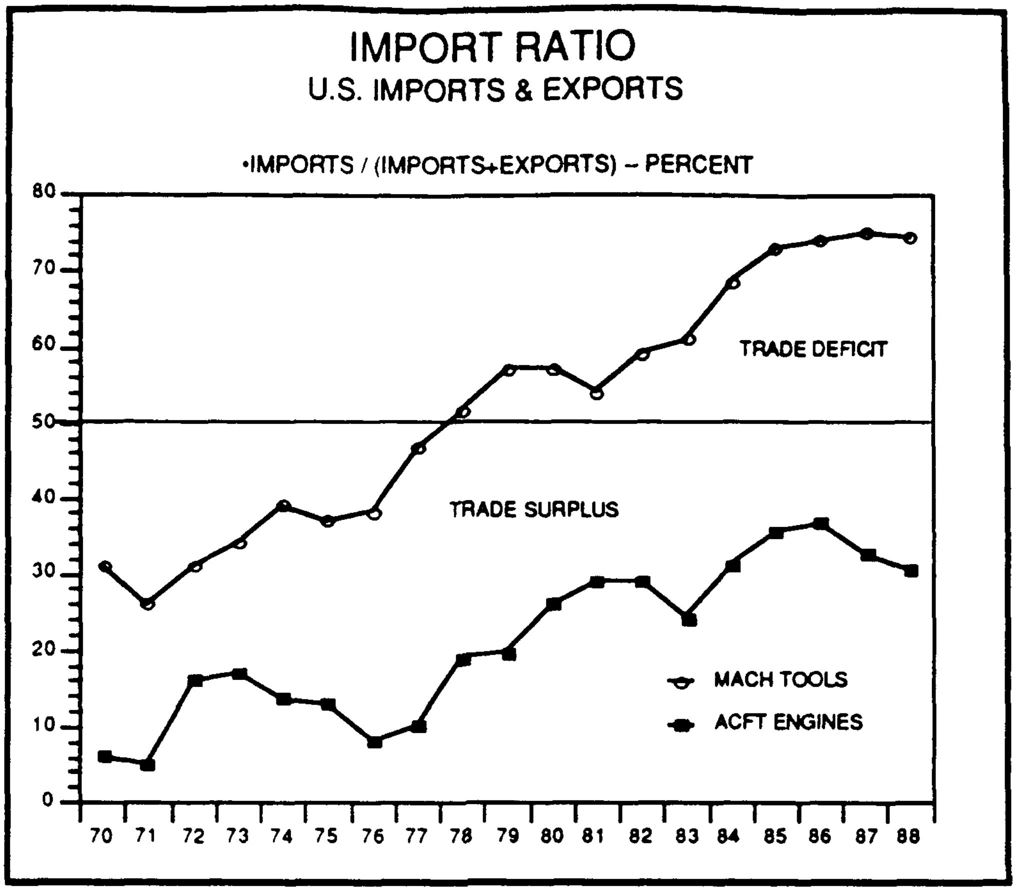

FIGURE 4.0-1 Trend Similarity -- Machine Tool and Aircraft Engine Foreign Trade

Source: Department of Commerce, Bureau of the Census; FT150, FT246, FT410, FT446, FT450

An understanding of conditions and behavior responsible for the shift from U.S. to Japanese machine tools may assist in identifying actions necessary in the U.S. to assure that the E.C.-caused trend in U.S. turbine engine western world market share will reverse in the next two decades. The following material compares Japanese and U.S. machine tool industrial strategy and U.S. government policy and support issues, highlighting significant similarities and differences. Although not nearly as catastrophic as the machine tool industry decline, there may exist similarities that, if identified, can be corrected to help prevent a further decline in the U.S. turbine engine market share. The comparison does not infer that the decline of U.S. preeminence in propulsion is analogous to that of the machine tool industry. The significantly increased depth and breadth of work needed to confirm or refute such an analogy is beyond the scope of this report.

TABLE 4.0-1 Collapse of the U.S. Machine Tool Industry

Source: Ravi Sarathy, "The Interplay of Industrial Policy and International Strategy: Japan's Machine Tool Industry," *California Management Review*, Spring, 1989, p. 135. The M.I.T. Commission on Industrial Productivity, *Made in America--Regaining the Productive Edge*, MIT Press, 1989, p. 235

	1960's	1977	1982	1986
WORLD MARKET				
Size ($B, then-year)	n.a.	15.1	22.1	28.5
U. S. Share (%)	>25	16	16	9
Japanese Share (%)	7.5 (1968)	10	10	24
U.S. MARKET				
Size ($B, then-year)	n.a.	2.4	4.3	4.3
U.S. Share (%)	96	84	71	48

4.1 Japan's National Policy, Strategy for Industry. The following exerpt from Sarathy[2] describes a basic national policy for the Japanese industry in general. "Japanese industrial policies have long been guided by the Ministry for International Trade and Industry (MITI). As Johnson[3] has shown, MITI is committed to a process of *Developmental Capitalism* where the state works hand-in-glove with private enterprise to further economic development." After the post-war years of applying

Developmental Capitalism to regain its strength in the basic industries, MITI shifted emphasis "..... to the development of high-technology industries, based on a premise that the market mechanism alone would not ensure an adequate supply of and demand for technology and would not offer sufficient returns to those that developed new technologies."[4] "..... MITI policies for the future of any particular industry are spelled out in 'vision' statements ..... the greater importance of these vision statements stems from the fact that they have been worked out in cooperation with concerned firms in the industry, and thus represent the consensus of major firms in that industry. Such visions also signal to the banks that lending to that new technology is officially encouraged, thus ensuring capital availability in the growth phase."[5] Since its shift in the fifties to high-technology industry development, MITI has employed *Developmental Capitalism* to nurture "..... an industry-wide knowledge base that will support vigorous interfirm competition in product development and manufacture. ..... Interfirm cooperation in the development of industrial technology, combined with interfirm competition in product design, sales, and marketing, has proved extremely potent in spurring the growth of Japanese export industries. It should be noted that MITI's policies have not been consistently supportive of intense inter-firm competition. The attempts of MITI to force mergers among Japanese automakers suggests some considerable trepidation concerning the benefits of competition."[6]

The shift toward high technology industry development was caveated by a second facet of its basic policy--*Technology Exploitation*. Japan employs *Technology Exploitation* to assist in improving the position of other than the specifically-targeted industries through technology "linkages" between industries and to position the product far enough ahead of potential international competitors to assure market leadership for significant periods. Hadley notes that "Japanese target industries have been selected not only for their own importance, but for their ramifying effect on other (Japanese) industries."[7] Mowery and Rosenberg note that some earlier targets for MITI *Developmental Capitalism* did not maintain their product market advantage; i.e., Japan's steel advantage was rapidly undercut by such Asian competitors as South Korea and Taiwan.[8]

Japan implements its *Developmental Capitalism* and *Technology Exploitation* policies with its *infant industry*, or *catch-up* strategy. The "..... policy framework applied by MITI and the Ministry of Finance .... has combined elements of support of the market (including protection of the domestic market in the early years) for the products of these industries with support for the technological development of industry."[9] Martin Smith describes the strategy, " ..... gain a foothold in the market where the product most closely resembles a commodity (it competes on price) then upgrade the product where quality is a primary requirement and price is secondary-- is probably one of the most clever and audacious marketing strategies in the last fifty years. More than anything else, marketing strategy has been the great strength behind Japan's large export market."[10]

Thus, Japan has applied *Developmental Capitalism* and *Technology Exploitation,* via MITI Vision Statements, to specific high-technology industries with linkages to other industries to facilitate the spread of technology gains. In most cases, MITI and the Ministry of Finance, with the consensus agreement of the targeted industry, apply the *Infant Industry* strategy to position the industry as a successful international competitor. This strategy employs subsidized support for both product and process technology improvements, domestic market protection until the industry return on investment is realized, and an initial price-competitive product followed by technology upgrades after the market position has been secured. Compare this with U.S. basic national policy for industry summarized in Section 4.4.

4.2 Japan's Business Strategies for its Machine Tool Industry. Japan's decision in the early fifties to target its machine tool industry and the subsequent concerted actions by Japanese Government and industry represent a classic example of applied Japanese national policy and strategy. MITI, as early as 1956 identified metal-cutting machine tools as a key industry, and implemented policies to rationalize the industry through mergers, divesture of product lines, and achieving economies of scale. Implementing its *technology exploitation* policy to position its product well ahead of its Asian competitors, MITI generated a major strategic shift in the early sixties from metal-cutting to numerically-controlled (NC) machine tool development, with a target of 50 percent of total output for NC tools. This objective was reached in 1982.[11]

The *infant industry* strategy was implemented by targeting an initial product niche--standardized NC machine tools--where U.S. competition was less entrenched, developing a low-cost and large-volume/scale economics producer position, and exploiting their *Extraordinary Measures Law* to protect their domestic market from foreign incursion.[12]

The Japanese domestic market for advanced NC tools was stimulated with additional depreciation allowances granted for their purchase. The Japan Robot Leasing Authority exemplifies the approach, subsidizing short-term leasing of Japanese-manufactured robots, thus stimulating their wide diffusion in Japanese manufacturing.[13] These MITI/Finance/Industry coordinated efforts assured the existence of a protected hi-tech demand within the large domestic market to mature the NC machine tool industry to its objective of hi-tech products manufactured by a high-productivity industry at lower costs than could be achieved by their foreign competition.

The U.S. economy's booming demand for machine tools in the seventies and eighties, together with the rising U.S. backlogs and poor delivery schedules, meshed with the Japanese-developed low-cost and large-volume/scale product position. Taking advantage of this advantageous producer-market position, the Japanese supplied their product on quick-delivery terms, aggressively-priced due to their cost advantage and a favorable yen/dollar exchange rate, and sold to a dissatisfied and neglected U.S. customer segment. The Japanese sold to the small U.S. job shops that needed less expensive machine tools of a standardized and simple nature, with short delivery time, so that short-lived profit opportunities could be exploited. They followed up this advantage with on-site stockpiles and an international distribution network in the U.S. to exploit service. Finally, they followed up their U.S. market breakthroughs by gradually establishing a U.S. manufacturing presence to consolidate gains and to prepare for the evolution of machine tool demands toward flexible machinery systems.[14]

The Japanese business strategy for machine tools remains oriented to the future market. Challenged by newly industrialized countries in the low-cost machine tool market, Japan is moving toward turn-key systems and more customized machines, precision machining, and the flexible machining system (FMS). "The Japanese industry is ahead of the world in installing and using FMS's, and the machine tool builders have taken the lead by putting the technology to work in their own factories. As machine tool makers turn their own shops into flexibly automated factories, Japanese vendors will be able to turn out modular, specialized machines, building them to order on short lead times. They are accelerating the shift from competition based on product engineering to process capabilities. They are already beginning to offer integrated process solutions that use hardware products via systems similar to what they are selling.[15]

4.3 Japan's Government Support for Machine Tools. Government support is evident in the overhaul of the machine tool industrial infrastructure, finance, and market access. Support by the government to the machine tool industry was, and continues to be "highly directive," with well-organized *vision statements* and supporting strategy applied by tightly organized financial, trade, and industrial segments.

Prior to the sixties, Japan's machine tool industrial infrastructure consisted of hundreds of small family firms. MITI "encouraged" them to join stronger, larger companies. "These larger enterprises then grew internally until the top 14 of about 70 machine-tool builders now account for nearly two-thirds of Japan's business."[16] MITI encouraged domestic collaborative research "cartels" funded by the government. These funds and the resulting joint research were coordinated and shared by members of the Machine Tool Industry Association.[17] State laboratories with government-sponsored research were a significant part of the industrial technology-generating infrastructure. The laboratory research objectives were geared to strategic objectives directly supporting the MITI *vision statements*; therefore, the work was stabilized toward long-range market-driven objectives rather than being subjected to the "fits and starts" associated with short-term profit needs and political motives.

Financial support occurred to encourage machine tool technology development, productivity enhancement, and market potential. "Haudaille Industries emphasized the importance of research funds supplied by MITI to the machine tool industry, claiming that such funds were derived from MITI's control of legal wagering on bicycle races (the Bicycle Racing Fund) and were thought by Haudaille to exceed $1 billion over a decade."[18] These funds were made available in the form of "loans," to be repaid only if the return on investment was less than seven years, (thus promoting long-term research objectives rather than near-term profit-motivated work). Additionally, tax credits were provided for R&D spending, and additional depreciation allowances (13 percent) were granted for purchase of NC tools by

Japanese industry. The resulting stimulation of the Japanese industry to invest in capital equipment (NC tools) was timed to occur as the new products became available from Japan's machine tool manufacturers. Also available were Government-guaranteed (therefore low-cost) capitalization loans for both the machine tool manufacturers and their Japanese customers.[19]

The Japanese government provided substantial market support in both the domestic and export sectors. In addition to financial measures to promote domestic factory modernization across the entire industry, Japan passed the *Extraordinary Measures Law for the Promotion of Specified Machinery Industries* in 1956. Subsequent renewals concentrated on directing the strategic shift to NC machines. The effect of this law was to double the tariff on machine tools over that of the U.S., and it wasn't until 1979 that tariff parity was achieved with this commodity. As a direct result, foreign penetration of the Japanese machine tool market has been held to 7-8 percent of consumption.[20] A third aspect of domestic market demand stimulation involves the State Laboratories, which provided NC and CNC training to customers throughout Japan free of charge.

MITI assisted in establishing export cartels to set floor prices on NC tools, to monitor dumping attempts by individual Japanese companies, and to allow for sharing of export market research and intelligence expenses.[21] These trading companies provided generous introductory offers and financing for American customers, such as allowing ninety-day trials at no cost. The government provided "under-the-table" export subsidies such as sugar import licenses to the trading companies, until the practice was dropped after European objections. MITI then tapped bicycle and motorcycle racing pools, finally admitting that over $100 million per year was going to the machine tool industry from these sources (eventually, close to $1 billion per year was documented).[22]

4.4 U.S. National Policy, Strategy for Industry. U.S. national policy regarding its industry is positive but the polar opposite of that of Japan, which borders upon socialistic directorship (it's basic industry policy--*Developmental Capitaliism*--often is referred to as "Communal Capitalism" in the literature). U.S. policy, often described in such terms as "market-driven capitalism," or "private enterprise," or "individualistic" or "competitive capitalism," is basically "hands-off," within limits. An exception to this hands-off policy is the antitrust legislation and penalties that continue to maintain a reluctant atmosphere within the industry to engage in domestic inter-company discussions or actions that might appear to "antagonize" this legislation. Other exceptions involve tax structure, foreign trade, and research/development legislation, the intent of which is to enhance the position of the U.S. vis-a-vis foreign industry. They are discussed in more detail in Section 4.6. The impact of this "hands-off" policy on the U.S. machine tool industry lies in the fact that no quantitative national vision for maintaining the long-term strength of this industry ever evolved as a rallying point for vitally-needed plans and programs. This is not to say that the U.S. government/industry complex is not capable of such action. But, in the U.S., to galvanize the government/industry complex into actions needed to successfully achieve the objectives, vision statements must react to situations generally considered by the public to be in conflict with national interests. The active word here is "react."

Kennedy's vision to place man on the moon in a decade capitalized upon a highly-publicized Soviet event in the late fifties and galvanized the government/ industry complex into a concerted drive that would not have been successful but for the vision statement and the continuing popular support which permitted top-level Administration leadership to focus desire and effort throughout the U.S. during the 1960's.

4.5 U.S. Business Strategies for Its Machine Tool Industry. Without the national vision and resulting impetus toward concerted effort, business strategy was formed and executed by the individual companies comprising the industry. According to Melman, "The machine tool firms simply followed accepted methods of maximizing their profits. Like many other U.S firms, they were overly concerned with quarterly financial figures. There are large fluctuations in the U.S. machine tool market, and the managers sought to protect their firms against these. These companies diversified into other businesses, such as manufacturing machinery for making textiles and building roads, and they entered into a variety of foreign arrangements. These included not only investing in factories but also licensing patents and providing blueprints."[23]

Whereas the Japanese were exploiting their machine tool technology gain by subsidizing and spreading the re-tooling effort to the entire domestic industrial base, user-demand for machine tools in the U.S. was weak. "While other nations went through a postwar reconstruction, American industry allowed its installed base of machinery to age. Under pressure for short-term results, industrial managers opted for proven technology rather than take risks with new technology. Major manufacturers like General Motors kept costs down by forcing tough price competition among their suppliers, a practice that discouraged innovation and investment by companies that made parts and equipment. There was little effort by the major manufacturing industries (such as autos, steel, consumer products, and textiles) to upgrade the state of the art."[24]

The contrast between Japan's *Technology Exploitation* to gain competitive edge (shift to standardized low-cost NC tools) and the U.S.'s exploitation to gain capability for precision manufacturing of complex parts also is striking. In the U.S., a mismatch developed between the machine tool technology that was developed and that which was needed by most potential users. "MIT's Servomechanisms

Laboratory, under Air Force sponsorship, developed hardware and software suitable for precision aerospace manufacturing of very complex parts. These developments then became institutionalized through the efforts of the Aircraft Industry Association. The resulting hardware and software were much too costly for most industries and for smaller users. A program at the Illinois Institute of Technology Research Institute to propagate MIT's APT (Automatic Programmed Tools) software throughout industry failed to attract the interest of machine tool builders. Scaled-down versions of the software suitable for such simple machines as lathes and drills, rather than complex contour milling machines, did not become available, and the Air Force did not see its role as extending beyond the support of advanced aerospace manufacturing."[25] Thus, the U.S. government-sponsored research to extend the machine tool industry technology was limited to that necessary to meet Air Force immediate needs for precision machining of complex parts. There was no national vision to recognize the long-term impact upon the military readiness posture of a collapsed machine tool industry, and no national strategy in place to recognize and exploit the technology necessary to assure a continuing healthy industry. Contrast these facts with the Japanese foresight and actions regarding the same industry.

While Japan proceeded to implement (and subsequently to reap the harvest of) its *infant industry* strategy, U.S. industry and government for the most part ignored the threat. By the early eighties, 85 per cent of machine tool production had become concentrated in just twelve firms, and the number of active companies had shrunk steadily until only about 500 remained. "The trend toward conglomerate ownership (of U.S. machine tool companies) during the sixties and seventies potentially could have helped the industry by providing capital for research and development and advanced machining.....(and by rationalizing) product lines, marketing, and advertising, achieving greater economies of scale. Unfortunately, consolidation had just the opposite effect. Conglomerates such as Textron, pushed by Wall street for higher quarterly earnings, were attracted by the high profits of machine tool makers in boom times. But the conglomerates had little commitment to the business. Rather than reinvesting, they used the profits to fund other ventures and for corporate overhead. Being 'numbers-oriented,' they tended to drop specialized machines because it was hard to show a profit on each order. Instead, they concentrated on building high-volume products on steadily-deteriorating equipment, eventually making the machine tool producers vulnerable to commodity competition."[26]

"The (U.S. machine tool) industry's response to business cycles may have been even more damaging. Orders were backlogged during boom times and the backlog worked down as orders slowed so as to keep production and employment levels more stable over the course of a cycle. Customers often had to wait from 18 to 24 months for machine tools ordered during busy periods."[27]

The Japanese consolidated their penetration into the world market by moving into computer numerically controlled (CNC) and flexible machinery centers as their competency grew. U.S. top management, rather than risking costly 5- to 10-year productivity investments to improve their competitive position, became less concerned about the long-term productivity in their U.S. factories as they increased their foreign investments and their diversification into other businesses. They sought tariff protection and defense orders to sustain their machine tool businesses.[28]

As early as the late seventies, U.S. firms, recognizing their loss of competitiveness, in some cases "..... made arrangements for manufacturers in western Europe and Japan to produce machines for them. These machines will carry the nameplates of the U.S. firms, which will do the marketing in this country. In a large exhibit by one of the leading U.S. machine tool firms at the 1980 International Machine Tool Show, half the machines the company offered were built abroad. That company is well on its way to terminating its role as a producer and focusing on marketing. This may result in a fine showing on the profit-and-loss statement but at the expense of less manufacturing--and fewer jobs--in the United States."[29]

4.6 U.S. Government Support for Machine Tools. In general, as Section 4.5 infers, the U.S. government policy of "hands-off" free trade, with effectively no incentives to promote global competition in machine tools, permitted the industry's short-term "profit-center-driven" incentives to govern business strategy. Consequently, no incentives surfaced which could promote decisions based upon long-range market share criteria.

Without the incentives present for centralizing and specializing to focus on foreign market penetration, the U.S. machine tool industry was left to centralize as dictated by short-term profit motives. The industry infrastructure consolidated, but without the "heavy" government direction and encouragement which the Japanese government had given the Japanese infrastructure. Consequently, the industry consolidated into conglomerates, but operated as loose aggregations of separate units. By the early eighties, twelve firms produced 85 per cent of the U.S. machine tools, but two-thirds of the 500 remaining machine tool firms had less than twenty employees each. Manufacturing rationalization was negligible; product specialization and combined marketing operations effectively did not exist.[30] While Japanese research cartels flourished in the machine tool industry, U.S. anti-trust laws impeded domestic collaborative research. Japanese state-sponsored research in State Laboratories was geared to strategic objectives while U.S. federally-sponsored manufacturing technology programs were geared to narrow immediate DoD requirements for large, precision, special purpose machines for complex parts.[31] The Japanese industrial infrastructure included state-promoted and sponsored interfirm competition for design and manufacture of NC machine tools.[32]

There was virtually no NC/CNC technology transition in the U.S. (with either government or private sources) to low-cost commercial market needs.[33]

U.S. government financial support to the machine tool industry includes tax credits for research and development investment by industry, as does the Japanese. Although beyond the scope of this survey, a detailed comparison of U.S. and Japanese tax credit structure might reveal useful information. Except for the federally-sponsored Manufacturing Technology Program [which was oriented toward DoD needs (see Section 4.5), effectively ignoring long-term industry needs to maintain market share], there has been no parallel in the U.S. to the Japanese research "loan" program that levered industry toward long-term objectives. Ironically, the U.S. does have an assistance program related to the machine tool problem, but its objective is to retrain the labor force as the U.S. loses markets to foreign industry --not to prevent the market loss in the first place. The Labor Department Trade Adjustment Assistance Program pays workers who have lost jobs in losing industries to obtain training in new industries. "In truth, however, only a fraction of the program's monies is spent on training--most of the annual $1.6 billion program goes out in cash subsidies, over and above unemployment compensation, to workers who have lost their jobs because of imports. .... In contrast, the miniscule amount of money spent on training has provided results so long as the funds were disbursed on a decentralized basis."[34] Contrast this annual $1.6 billion U.S. federal subsidy to cope with defeat, with the Japanese federal subsidy of over $1 billion in a decade to the machine tool industry to generate the technology needed to win the market war.

Compared to Japan, U.S. government support for productivity enhancement in the machine tool industry has been and remains as weak as its support for product technology enhancement. Minimum government capitalization support has occurred under the auspices of the Industrial Modernization Incentives Program (IMIP), but an analysis of this incentive, compared to the Japanese guaranteed loan structure for capitalization, probably would reveal an ineffective incentive for the U.S. machine tool industry to modernize its production facilities. This factor, along with frequent changes in U.S. tax policy, discouraged long-term capital investment,[35] thus making the machine tool industry vulnerable to cyclical capital spending and erratic factory modernization throughout the U.S. industry and weak user-demand for new machine tools until "boom" periods.

U.S. government stimulation of market demands for U.S. machine tools, miniscule compared to the Japanese Extraordinary Measures Law to protect their domestic market (see Section 4.3), has been limited to "jawboning" attempts to limit Japanese imports. Positive attempts, such as low-cost guaranteed loans to U.S. industry for capital investment in U.S. produced machine tools, did not occur. The result: as of 1986, penetration by imports to the U.S. machine tool market amounted to 52 per cent of the total U.S. consumption in machine tools (Table 4.0-1).

Stimulation by the U.S. government of foreign market demands has in large part been negative, caused by excessive regulation and paperwork that discourages exporting.[36] By 1979, "jawboning" on the part of both U.S. and European countries managed to achieve an effective parity with Japanese tariffs, but by that time the Japanese had captured their internal market and the U.S. industry was in no position to offer a competitive product.

4.7 Machine Tool Industry Similarities and Disparities. The following material summarizes the survey of the U.S. and Japanese machine tool industries and outlines (Table 4.7-1) some of the prominent similarities and disparities. Industrial strategic policy in the U.S. has as its basic premise the mutual independence of industry and government. While in practice the courses of corporate and government policies are more often than not mutually supporting, the U.S. prides itself in this independence and refuses to allow excessive government control of industry. Public reaction to recent loan guarantees to Lockheed and Chrysler exemplifies the reticence to move toward interdependence and closer government control of industry. On the other hand, public opinion regarding excessive strength in the hands of a single corporation also is evident in antitrust legislation and in the willingness to sacrifice corporate efficiency and productivity to prevent excessive corporate strength (for example, the recent break-up of AT&T). This basic premise of government/corporate independence is not likely to, and should not, change. The U.S. has learned that in the long run the advantages of independence, balanced with restrictions on the strength and control of individual companies, outweigh the disadvantages. This is not the case with many of the other industrialized nations of the world. Nationalized corporations are frequent, and if significantly more power in the hands of government (compared to the U.S.) is not the policy, it is almost universally evident. The Japanese government has tight control over the financial, trade, and industrial segments of its economy.

This basic disparity between the U.S. and Japanese governments is evident in the behavior of the two nations' machine tool industries. Japanese national policy regarding its machine tool industry is explicit in the form of MITI *vision statements* with industry consensus, implemented and enforced by a government with tight control of finance and trade actions. MITI employed its policy of *Developmental Capitalism*, nurturing and supporting development of an internally competitive machine tool industry while promoting interfirm cooperation to develop the necessary product and process technology. It targeted its machine tool industry for *Technology Exploitation* to take advantage of the technology linkages between machine tools and other industries and to ensure long-term market share objectives.

The U.S.' free enterprise system, with its industry/government independence and without a publicly-supported national "vision," limited itself to the financial pressures of stockholders unaware of or unwilling to recognize the strategic value of long-term market share objectives.

The strategies employed by the two machine tool industries were equally disparate. The Japanese employed their *infant industry* strategy: targeting and funding long-term objectives for its product and process technology improvements; entering the market with a price-competitive product to establish itself, followed by share extension with technology upgrades; while protecting and stimulating its domestic market until the industry recovered its investment. The U.S., on the other hand, maximized its short-term profits. The industry set a low priority on productivity capitalization and product technology and stimulated sub-tier price competition which further suppressed innovation. It concentrated on high-volume products to cut costs and, when faced with a deteriorating market share, diversified into other businesses.

The industrial infrastructures possessed similarities, but their exploitation was very different. Both Japanese and U.S. machine tools moved toward conglomerate ownership, but while the Japanese rationalized (specialized) production across industry and took advantage of economies of scale, the U.S., with a low commitment to the machine tool divisions of the parent companies, diverted the machine tool boom-time profits to other uses rather than investing in product and process technology. Collaborative research occurred throughout the Japanese industry, with both private and government research coordinated toward common objectives. Fear of antitrust violations prevented U.S. collaborations in technology and productivity advancements.

Government support to Japan's machine tools was characteristic of their actions with industries targeted for *Technology Exploitation.* Low-cost loans and grants were distributed for both product and process technology advancements. The Japanese established "research cartels" to conduct the technology advances, and the results were shared across the machine tool industry. Domestic markets were protected by trade barriers until the industry became profitable, and the government established "export cartels" which unified export procedures, prevented excessive undercutting, and provided sales inducements to foreign buyers. The Japanese also provided various forms of tax relief to the machine tool industry.

U.S. government support was limited to the industry segment providing immediate defense needs in machine tools. With its "free market" policy, domestic markets were open, and no effective foreign sales inducements were forthcoming. However, tax relief for the industry was available.

In short, the U.S. machine tool industry and its parent organizations, with their relative independence from the government, did not exercise the responsibility that accompanies this independence. Short-sighted motivations replaced the long-term needs that should have become clear with strategic planning. The U.S. government did not revise the laws and regulations that could have assisted industry to gear up for the future machine tool market. Neither government nor industry provided the promotion necessary to alert the general public to the problem, thereby preventing machine tools from becoming a nationally-recognized issue in time to take effective action.

TABLE 4.7-1 Japanese and U.S. Machine Tool Industries Similarities and Disparities

	JAPAN	U.S.
National Policy	o Developmental Capitalism - Vision statements - Inter-firm cooperation for technology - Inter-firm competition for design, development - Export cartels o Technology Exploitation - Linkages - Long-term market leadership · Emphasize N.C./C.N.C. · Follow up with F.M.C.	o Free Enterprise - Independent industry - Short-term objectives o No National Policy
Strategies	o Infant Industry - Long-term objectives for product/process technology - Enter with price competition, extend with technology - Market protection/stimulation	o Maximize Short-Term Profits - Low priority for productivity capitalization - Subtler price competition - Concentrate on high volume - Diversify into other businesses
Infra-structure	o Conglomerate Ownership - Rationalized production - Economies of scale o Collaborative Research - Coordinated private/public programs	o Conglomerate Ownership - Low parent company commitment - Diverted profits o No Collaborative Research - Legacy of intra-U.S. competition - Discouraged by antitrust legislation
Government Support	o Low-Cost Loans/Grants - Long-term ROI incentives o Research Cartels--Shared Results o Domestic Market Protection; Export Sales Inducements o Tax Relief	o Private Capital - High Cost o Government Research Limited to Defense Needs o "Free Market"; Few Foreign Sales Inducements o Tax Relief

5.0 COMPARATIVE SURVEY OF JAPANESE, E.C., AND U.S. TURBINE ENGINE INDUSTRIES. Surveys, analyses, reviews, and assessments document well the Japanese industrial complex and to a lesser extent its aircraft engine industry. The European Community, in 1992, will take a significant step in its progress toward becoming an industrial entity when its members plan to become a single civil market with parallel plans to create a unified market in defense trade.[37] Since it is just now emerging as an industrial entity, the E.C. has not been exposed to the level of exhaustive study given the Japanese industry; however, enough information exists to permit a cursory comparison of the E.C. engine industry with that of Japan and the U.S.

5.1 Japan's National Policy Applied to its Turbine Engine Industry. Japan's application of *Developmental Capitalism* (see Section 4.1) to its aircraft and aircraft turbine engine industries has been visible since the immediate post-World War II period. MITI *vision statements* setting policy and objectives for the aircraft industry have been in effect since the late fifties. The 1954 *U.S./Japan Mutual Defense Assistance Agreement* provided for Japanese production of U.S. military aircraft for use by the Japanese Self-Defense Forces. Beginning with production of the F-86 fighter in the mid fifties, Japanese production of U.S. military aircraft has continued to the present.[38] The MITI *vision statement* for the 1980's regarding the commercial aircraft industry is typical of its *Developmental Capitalism* policy for hi-tech industries. "The aircraft industry is a typical knowledge-intensive industry, characterized by high added value and far-reaching technological spin-off. It will play an important role in the national plan to remold Japan's industrial structure into an innovative knowledge-intensive type ..... at present the aircraft industry is smaller in scale in Japan than in advanced Western countries and relies excessively on demands for defense industry. It should direct more attention to the manufacture of planes for civil transportation which has a big future. ..... It seems realistic that the private sector should bear the ultimate risks involved in an aircraft development project, but for the time being the government will subsidize projects on the condition that a percentage of the profits be contributed to the government, contingent on success. ..... It is hoped that Japan will build up a system for basic research and development of aircraft engineering so that it may be fully ready for the expected technological innovation in the 1990's for the manufacture of the next generation aircraft. Development of aircraft engineering must be conducted on the initiative and assistance of the government as it involves highly sophisticated and complex technology." [From the Ministry of International Trade and Industry, Industrial Structure Council, *The Vision of MITI Policies in the 1980's* (Tokyo: Industrial Bank of Japan, 1980), pp.291-292.][39]

Initial development of Japan's commercial aircraft engine industry followed its *Technology Exploitation* policy. The policy was applied to small turboprop engine development and strategy employed, but provided neither the product quality nor the price leadership necessary for successful foreign market penetration. Consequently, Japan's indigenous engine production has been an insignificant part of its total production during the last two decades (Figure 5.1-1). Licensed assembly (primarily military engines) is the mainstay of its engine production activities, but coproduction is emerging as a major force in the Japanese engine industry. Japan's new engine production value remains an insignificant part of the western world total (about $0.12 billion in 1988, compared to almost $13.0 billion). But its continued growth (largely because of its coproduction strategy) in 1988, despite the decline in world-wide production value (Figures 5.1-1 and 3.1-2), signals continuing effort to become a competitor in the world aircraft engine market.

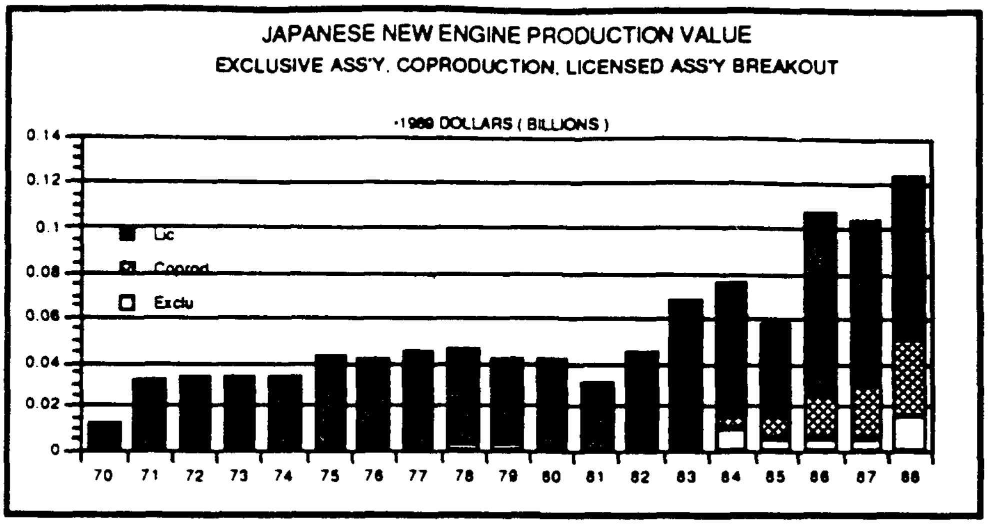

FIGURE 5.1-1 Emergence of Coproduction as an Important Element of Japan's Aircraft Engine Industry

Source: Forecast International/DMS and Universal Technology Corporation

Japan's initial failures with aspects of its *Technology Exploitation* policy and *infant industry* strategy applied to its aircraft engine industry (elaborated upon in Section 5.2) set back the nation at least a decade behind the target established by its 1980 *vision statement.* Japan appears to be shifting its strategy under their *Developmental Capitalism* umbrella to establish a globally-competitive aircraft and engine industry early in the next century.

5.2 Japan's Business Strategies for Its Turbine Engine Industry.

Japan's *infant industry* strategy applied to its aircraft industry was visible in the late fifties when it started indigenous development of a medium technology, low-cost commuter aircraft suitable for Japan's domestic airline needs. "The YS-11, a twin-turboprop 60-seat commuter plane, was a technical success but a commercial failure for which the government picked up the tab. ..... If the plane had made a profit, all the money would have been repaid; instead the government lost an estimated $83 - $167 million. ..... The major problem, says Atsushi Kasai, Senior Managing Director of Japan Aircraft Development Corporation which is handling the 757 project, was the size of the domestic market. 'In automobiles and electronics, we break even in Japan, and then we can export,' he says. 'For (small turboprop) airplanes, the Japanese market was so small that we had to sell (the YS-11) overseas before the break-even point.' He adds that overseas prices were 'too low'--approximately half of their production cost--because of competition from the Dutch Fokker F27 ..... " Production of the YS-11 was stopped in 1974.[40]

Despite some success during the sixties and seventies in the general aviation and business aircraft market (Mitsubishi Heavy Industries' MU-2 and Diamond 300), MITI policymakers in the late seventies appeared to shift emphasis. They became interested primarily in entry by Japanese firms in the design and production of large commercial transports, rather than general aviation or commuter transport aircraft, despite the fact that the market outlook in commuter aircraft was more robust than that for large commercial transports. The shift seems to follow the Japanese policy of *Technology Exploitation* since "..... technological supremacy is less central to the sales of (business and commuter) aircraft, implying lower unit profitability and less significant technological spillovers than is true of large commercial aircraft. General aviation and commuter aircraft design also demands a lower level of technological expertise, meaning (among other things) that a Japanese technological lead in this industry segment is likely to be shorter in duration."[41]

Evidence of this shift toward exploitation of the "higher-technology" large commercial transport development was apparent in the early seventies. In 1973, MITI formed the Japan Commercial Transport Development Corporation (J.C.T.D.C.), comprised of Mitsubishi, Kawasaki, and Fugi Heavy Industries, to develop and produce the XX, a 150-passenger transport. As the magnitude of the *infant-industry* strategy failure with the YS-11 became apparent, coproduction negotiations with Boeing "..... culminated in a Memorandum of Understanding in 1978 in which the J.C.T.D.C. was committed, as a 'risk-sharing subcontractor' to produce 15 percent (measured as a share of costs) of the airframe and other structures of the Boeing 767,"[42] a 200-passenger wide-bodied twin engine airliner. By 1987, the Japanese produced 15 percent of the value of the 767--in practical terms, most of the fuselage. Over 130 Japanese employees were dispatched to Seattle during the 767 development, even though the agreement was for coproduction--not codevelopment. Boeing's benefit (Pacific Rim market penetration) is exemplified by Nippon Airways' order for twenty-five 767-300's (over $2 billion), even though the Airbus 320's seemed to be preferred, according to the *Japan Economic Journal*.[43]

Japan's 767 coproduction collaboration has proven significantly more successful financially than its earlier YS-11 indigenous program. By the end of 1986, "..... the government (had) already received about 40% of its $60 million share of the production costs ....."[44] Encouraged with this success, and actively solicited by several other major U.S. and European aircraft builders for collaborations, in 1986 the Japanese companies reached a formalized agreement with Boeing for collaboration on the then planned 7J7, which included not only co-production, but codevelopment, sales, and service, with their acceptance of 25 percent of the development costs and manufacture of 25 percent of the 7J7.[45] The 767-7J7 experience typifies the Japanese activities with international collaborations in its civil aircraft industry in the mid and late eighties. A trend toward increasing codevelopment activity is visible in Japan's large transport sector, as is a steadily growing financial and technological competency.

A similar trend is visible in the aircraft engine sector of Japan's aircraft industry. Originally conceived as a means to achieve indigenous large transport engine development and production capability, in 1971 MITI supported establishment of Japan Aero Engines (J.A.E.), a consortium of Ishikawajima-Harima (I.H.I.), Mitsubishi (M.H.I.), and Kawasaki Heavy Industries (K.H.I.), to explore development of a 20,000-pound thrust high-bypass engine for the 150-seat YX. The consortium soon realized the need for costly engine test facilities, which led to a co-equal joint venture with Rolls-Royce to develop the RJ500 using the U.K. test facilities. "Mushrooming development costs and increasingly fierce competition in this segment of the engine market (expected to provide the engines for a 150-seat aircraft) contributed to the subsequent decision by Pratt and Whitney, along with M.T.U. of Germany and Fiat of Italy, to join with the existing RJ500 consortium in the development of a slightly larger engine (now known as the V2500). J.A.E. has a 20 percent share in the consortium (International Aero Engines), and is responsible for 23 percent of the work, primarily compressor and fan design and manufacture."[46] The recent agreement between I.H.I. and Pratt and Whitney for codevelopment and coproduction of an advanced PW4000 engine is evidence of Japan's continuing push toward increased engine development capability.

Aside from MITI's push for large transport engine development and production capability, since the fifties, Japan has steadily improved its engine manufacturing competence. Following earlier agreements under which it assembled foreign engines primarily for military applications, Japan is now manufacturing and assembling large percentages of modern military turbine engines. IHI is manufacturing the Pratt and Whitney F100 engine for their F-15 aircraft and continues to assemble, under license, Allison T56-IHI-14, G.E. J79-IHI-17, T64, T58, and the RR-Turbomeca "Adour." I.H.I. also has been developing a

3700-pound thrust turbofan engine for Japan's indigenous XT4 trainer (the F3-IHI-30, production starting in 1987) and in 1989 bench-tested a 1000-horsepower turboshaft engine for light helicopters. Notwithstanding Japanese industry's continuing development, production, and coproduction activity with military and small turbine engines, the MITI/industry complex has emphasized the civil aircraft market during the seventies and eighties. Heavily subsidizing *technology imitation* activities with foreign firms (after its *infant-industry* strategy failure), it applied its "growing financial and technical muscle,"[47] initially to coproduction activities, then to heavier involvement in codevelopment during the eighties.

A trend toward *technology innovation* as opposed to *technology imitation* has become noticeable during the late eighties in Japan's dealings with foreign aircraft and engine firms. Using the penetration of the Japanese civil large transport market as leverage for obtaining coproduction, and later, codevelopment programs with foreign aircraft and engine firms, Japanese firms, heavily subsidized by MITI, largely imitated western manufacturing and product technology to gain competency and a market share. A characteristic *Trade or Die* mentality of Japan is visible in its aircraft and engine activities following its failure to penetrate the world civil market with an indigenous capability (the YS-11 problem). In the seventies and early eighties, this mentality ("Japan had to export its exportables and import not only natural resources and foodstuffs, but also western technology so as to catch up with the West."[48]) was observable in its *technology imitation* activities with western aircraft and engine firms.

The *Trade or Die* mentality seems to have undergone change recently toward technology innovation, rather than imitation, as necessary to maintain Japan's world-wide trading leverage. Kotabe expresses a rationale for this revision in the Japanese national attitude toward trade: "..... to maintain an adequate and continuous supply of resources from abroad, Japan has to behave as a 'good citizen' of the world. Economical or political criticism of the technological imitation and export orientation of the Japanese government-business consolidation has made Japan extremely vulnerable to protectionistic attitudes in the world market, whether due to a resource nationalism, to an overpresence of Japanese products, to an imbalance of trade, or to foreign countries' envy of Japanese success. In other words, for Japan, there is no ..... (alternative) ..... but to ..... offer the world something for which every country will have to depend upon."[49] "This 'something,' as perceived by MITI, is a level of technology (primarily for commercial applications) which even the United States has not reached yet. And, the MITI has incorporated a policy of technological innovation as one of the major objectives for the 1980's and beyond in the context of the *Trade or Die* mentality."[50]

Compare this application of Jaoanese *Trade or Die* mentality to technology innovation, expressed by Hotabe in 1984, with current activities in the Japanese aircraft and engine industry. Throughout the eighties the Japanese have increased their influence in international aircraft industry collaborations. They progressed from 15 percent of the airframe in the Boeing 767 collaboration to a planned 25 percent in the 7J7 collaboration. In April 1990, Boeing signed a Memorandum of Understanding (MOU) regarding 767-X development and production with M.H.I., K.H.I., and Fuji Heavy Industries (F.H.I.), assigning the Japanese consortium 15-20 percent share of the total airframe, plus vendor business in hydraulic, electrical, electronic equipment, lavatories, wing ribs, and carbon-carbon composite material for tail surfaces and other parts. The MOU calls for Japanese investment in program costs beyond those associated with producing airframe parts, amounting to 8-10 percent of an expected total program cost of $3-4 billion, which is tne greatest participation that Boeing has allowed another entity in a commercial transport effort. I.H.I. during this same time period was discussing with General Electric participation in the GE90 engine development.[51]

The J.A.E. share of 23 percent of the International Aero Engines Corporation (I.A.E.) V2500 engine program, next to Pratt & Whitney and Rolls-Royce with 30 percent each, makes it the third-largest shareholder in the five member consortium (M.T.U. holds 11 percent, Fiat holds 6 percent). The trend toward *technology innovation* is apparent in the I.A.E. consortium with Japan accepting the development risk and responsibility for the fan, case, and booster compressor. Also apparent is the trend away from attempts to improve market share, toward improving production share, using the vehicle of international collaborations.

More recent moves by Japan show greater emphasis upon *technology innovation* as the means of increasing its influence in the world commercial aircraft market. The Materials Research Center, an intra-Japan joint venture of private companies and local governments, and a parallel Material Research Institute, are being formed to take an international leadership role in the development of advanced aerospace materials. In 1989, MITI organized and presented to international industry its position regarding a high-speed civil transport propulsion research program. By late February 1990, three major Japanese engine manufacturers (Mitsubishi, Kawasaki, and Ishikawajima-Harima Heavy Industries) and the four major western firms (General Electric, Pratt and Whitney, Rolls-Royce, and SNECMA) were involved in preparatory meetings to develop propulsion technology for a commercial supersonic and hypersonic transport plane (SST/HST). John Harbison, a vice president of Booz-Allen, New York, considers that the Japanese view hypersonics as a way to leapfrog efforts of other countries: "..... they are taking a long-term view of the industry and taking a position that will guarantee them a position in the future ..... so that they will not be in the catch-up mode, they will be ahead of everyone else."[52] According to Michael Green of

Defense News, "The SST/HST project is the first international consortium organized by MITI since the Japanese government changed the *Aircraft Enterprise Law* in 1986 to encourage international joint development in civil aerospace."[53]

These recent moves by Japan and its aircraft industry attest to its current strategy of moving toward equity participation in international aircraft and engine codevelopment/coproduction collaborations. Japan's success with this strategy is in large part due to adding technology innovation capability to its leverages with development risk abatement and internal market share, as a means of improving its world-wide production share of future civil aircraft.

The step beyond equity participation is leadership in the civil aircraft market, and it is not difficult to envision the circumstances under which this could occur. Japan failed to gain an indigenous competitive position in the world aircraft market by protecting its internal market for the industry to use as a means to gain the return on its productivity and technology investments. The Japanese internal market was too small. Airline traffic in the Pacific Rim (and East Asia) is growing at a record pace and is expected to lead the world in growth rate in the coming years (forecast by the International Air Transport Association to be 10-14 percent annually, through 1995).[54] Developing East Asian nations will increase use of their internal markets as leverage for aircraft and engine licensed production or coproduction agreements, resulting in a Pacific Rim trading area that will rapidly improve the region's capacity to develop and manufacture parts and assemble engines. To the extent that Japan can gain and/or extend its economic influence within such an East Asian "trading bloc," the Japanese engine industry may attempt to lead the bloc to an engine development and production capacity indigeneous to East Asia. This last step in a scenario of successive strategies, if successful, would achieve early in the next century Japan's MITI-stated vision for exploiting the civil aircraft and engine industry through exercise of its policy of *Developmental Capitalism* for economic development.

5.3 Japanese Government Support for the Turbine Engine Industry.

The Japanese aircraft and engine industry infrastructure reflects a characteristic employment of its *Technology Exploitation* policy. The government, through low cost loan and tax policies, forced domestic consortia to develop and spread technology. In 1958, the *Second Aircraft Promotion Law* formed the Nippon Aircraft Manufacturing Company (Mitsibishi, Kawasaki, Fuji Heavy Industries, plus Showa Aircraft, Japan Aircraft, and Shin Meiwa Industries) to design and develop the YS-11 (Section 5.2), with 54 percent of the funds provided by the government.[55] By the early seventies, the Japanese *infant industry* strategy with the aircraft industry had failed (Section 5.2); the shift in strategy from indigenous development to codevelopment was observable in the formation of the Japan Commercial Transport Development Corporation for a new high bypass ratio 150-seat transport. This program, originally consisting of a consortium of the above three Heavy Industries, plus Ishikawajima-Harima Heavy Industries, soon became a codevelopment/coproduction program with Boeing for the 767. The government, rather than fostering inter-firm cooperation in research and development and competitive product design and manufacture, has led its airframe and engine consortia to cover all phases of design, development, production, and sales. This shift from its usual policy probably is due to extreme development costs and similar cooperative behavior between companies with military aircraft contracts. The resulting government policy (for the aircraft/engine industry) of subsidizing reliance on international joint ventures and "life-cycle" inter-firm cooperation "thus appears to be something of a compromise between the *infant industry* strategy and a more long-term policy aimed at the strengthening of indigenous technological resources."[56]

TABLE 5.3-1 Japanese Aircraft Engine Manufacturers

Source: Forecast International/DMS and Universal Technology Corporation

Company	Agreement	Role[1]	Model	Series	Type[2]	Size[3]
Ishikawajima -Harima Heavy Industries	Coproduction	P	V2500	A1/A5	TF	25.0-28.0
	Indigenous	DPA	F3	30	TF	2.2-3.7
	Licensee	A	T58	10	TS	1.4
	Licensee	A	J79	n.a.	TJ	15.6-18.7
	Licensee	PA	T56	14/427	TP	3.5-5.9
	Licensee	PA	T700	401	TS	1.7
	Licensee	PA	F100	100	TF	23.8
	Licensee	A	CT58	110/140	TS	1.2-1.4
	Licensee	A	ADOUR	801A	TF	7.3
	Licensee	PA	T64	10/10E/10J	TP	2.9-3.0
Kawasaki Heavy Industries	Coproduction	P	PW4000	n.a.	TF	52.0-60.0
	Coproduction	P	V2500	A1/A5	TF	25.0-28.0
	Indigenous	DPA	KJ-12	n.a.	EX	0.3-0.4
	Licensee	PA	AL5512	n.a.	TS	4.1
	Licensee	PA	T53	13/703	TS	1.4-1.8
Komatsu, Mitsubishi St, Woodward	Coproduction	P	225	B10/B20/C10	TP	0.4
Mitsubishi Heavy Industries	Coproduction	P	V2500	A1/A5	TF	25.0-28.0
	Corpoduction	P	JT8D	209/217/219	TF	19.0-21.7
	Indigenous	DPA	TJM3	n.a.	EX	0.5
	Indigenous	DPA	TJM2	n.a.	EX	0.3
	Licensee	A	CT63	5A	TS	0.3
	Licensee	A	JT8D	9	TF	14.5

[1]**Role:**
- P Parts Manufacturing
- A Assembly
- D Development
- M Program Management

[2]**Type:**
- TF Turbofan
- TJ Turbojet
- TP Turboprop
- TS Turboshaft
- EX Expendable

[3]**Size:**
- TF, TJ, EX Thrust - thousands of lbs.
- TJ, TP Power - thousands of HP

n.a. Information not available.

Six Japanese corporations have experience with manufacturing engine parts and assembling engines. All are divisions of large conglomerates and have various collaborative arrangments with themselves and with foreign engine companies. Table 5.3-1 lists their activities with the various engines and the types of agreements under which they operate.

A government-fostered industrial infrastructure appears to be forming currently to exploit the long-term objective of indigenous strength in the international civil aircraft and engine market. The High Speed Commercial Transport (HSCT) program is lodged with a vertically-organized domestic collaboration to emphasize innovation and prepare to lead an international codevelopment and coproduction program. This collaboration, the Society of Japanese Aerospace Companies, consists of domestic airlines, airframe manufacturers, and engine manufacturers, led by MITI.

Financial support for the Japanese aircraft and engine industry is similar to that for other sectors under the *Developmental Capitalism, Technology Exploitation* umbrella. Tax provisions and guaranteed loans encourage both product and process development. Public financial support in the form of low-interest or forgiven loans (Hojokin) provided aircraft and engine consortia with 50 percent of design and development costs. As a result of Hojokin, "..... by the early 1980's, government aid to jet engines almost equaled that given to computers and exceeded that for telecommunications, energy, and new base technologies."[57] In the period of 1980-82, over 50 percent of the J.A.E. V2500 costs were borne by MITI.[58]

Government financial support for "nonoriented" or "nonmission-oriented" aeronautics R&D within Japan is "..... very modest."[59] "Neither the National Aeronautics Laboratory nor the Japanese Defense Agency are significant sources of research funding, and the number and sophistication of engine and airframe test facilities within Japan are low."[60] This focus on acquiring existing product and process technologies from abroad, rather than on generic research, aligns with the Japanese *technology imitation* strategy, but may shift to heavier participation in un-aligned research as they perceive success with their *technology innovation* strategy and recognize that to maintain a lead requires this type of investment.

Government policy regarding domestic and international market access has both similarities and differences, compared with Japan's other industrial sectors. Its *infant industry* protectionist strategy regarding the domestic commuter aircraft market failed because the market is too small to independently support effective returns on product development and productivity investments. Subsequent to the YS-11 attempt at indigenous development and production, the Japanese government has used its domestic market as trading material for international co-development and coproduction collaborations.

The Japanese aircraft and engine industries have not used the MITI-led export cartels, or *sogo shoshas*, to the extent employed by the basic materials industries and many high technology sectors such as the machine tool industry. "Japanese manufacturing firms (such as the aircraft and engine manufacturers) ..... decreased their dependence upon the trading companies for their exports and direct investments abroad as they gained foreign manufacturing management abilities, financial strength, and marketing skills."[61]

Japan is a signatory to the *Agreement on Trade in Civil Aircraft* of the *General Agreement on Tariffs and Trade* (G.A.T.T.) which went into effect in the U.S. on January 1, 1980. This aircraft agreement eliminates import duties on civil aircraft and related parts in signatory countries and addresses other nontariff trade barriers. Although cumbersome to apply and a compromise among differing and competing interests, it provides a regulatory context for "fair trade" in the civil aircraft area.[62]

5.4 European Community Industrial Policy. The post-war E.C. aircraft engine industry, like that of the U.S., was founded upon the indigenous capability of a very few firms, largely Rolls-Royce and later SNECMA. Indigenous production of military products, and later, the Rolls-Royce RB211, comprised the major portion of E.C. engine production value during the seventies (Figure 3.4-4). But the eighties saw coproduction activities take the lead in E.C. engine output and by 1987 accounted for over 70 percent of E.C. production value.

The bulk of aircraft engine development, parts manufacture, and assembly occurs in seven of the twelve members of the E.C., with seventeen firms providing the major part of new engine production value. These firms, listed in Table 5.4-1, have sole, licensed, or coproduction equity in the engines and parts they produce, with a large international subtier supplier system supporting them.

The *1986 Single European Act* establishes the European Community program to create a borderless open market within its twelve members on January 1, 1993 (EC92). The participating countries "..... have embarked on a mammoth adventure in deregulation that aims to sweep away obstacles, some of them centuries old, to the free movement of goods, services, capital, and people within the European Community. Barriers that have sheltered inefficient home markets will be dismantled in favor of a unified market of 323 million consumers--half again larger than the U.S. market. This single market will produce $4.5 trillion in goods and services, putting it just behind the U.S. and far ahead of Japan in economic might."[63] A basic objective of the E.C. is to strengthen its world-wide competitiveness through increased inter-firm business link-ups among the E.C. nations and through increased industrial strength by exploiting the "free" internal market created by the *1986 Single European Act*. "Already, mergers designed to create corporations large enough to compete across Europe and around the world are sweeping up manufacturers of military hardware and commercial goods. Late last year (1989), Britain's General Electric Company and the Federal Republic of Germany's Siemens AG gained control of the United Kingdom's Plessey Company. West Germany's Daimler-Benz took over Messerschmitt-Boelkow-Blohm (M.B.B.). In early January, Thomson-CSF absorbed defense units of Dutch electronics giant Philips Gloeilampenfabrieken."[64]

TABLE 5.4-1 European Community Aircraft Engine Manufacturers

Source: Forecast International/DMS and Universal Technology Corporation

Company	Agreement	Role[1]	Model	Series	Type[2]	Size[3]
BELGIUM:						
Fabrique Nationale	Coproduction	P	CFM56	5C	TF	31.2
	Coproduction	P	PW4000	n.a.	TF	52.0-60.0
	Licensee	PA	F100	100/200	TF	23.8
	Licensee	P	TYNE	RTY.20	TP	4.8-5.7
	Licensee	PA	ATAR	9C/9K	TJ	11.2-15.9
	Licensee	A	LARZAC	n.a.	TF	2.9-3.2
FEDERAL REPUBLIC OF GERMANY:						
KHD Luftfahrttechnik	Coproduction	P	LARZAC	n.a.	TF	2.9-3.2
	Coproduction	P	CFM56	5C	TF	31.2
	Indigenous	DPA	T317	n.a.	EX	0.2
	Indigenous	DPA	T117	n.a.	EX	0.2
	Licensee	PA	ORPHEUS	n.a.	TJ	4.5-4.9
	Licensee	P	LARZAC	n.a.	TF	2.9-3.2
	Licensee	PA	T53	11	TS	1.1
	Licensee	P	T64	7	TS	3.9
	Licensee	P	LARZAC	4C6	TF	2.9-3.2
Motoren und Turbinen Union (MTU)	Coproduction	P	CF6	80C	TF	52.5-60.2
	Coproduction	P	V2500	A1/A5	TF	25.0-28.0
	Coproduction	P	JT8D	209/217/219	TF	19.0-21.7
	Coproduction	P	LARZAC	n.a.	TF	2.9-3.2
	Coproduction	P	PW300	n.a.	TF	4.5-6.0
	Coproduction	P	PW2000	2037/2040	TF	37.0-41.7
	Coproduction	P	CF6	80C	TF	52.5-60.2
	Coproduction	PA	EJ200	n.a.	TF	20.0
	Coproduction	PA	RB.199	MK 1xx	TF	15.3-18.0
	Coproduction	PA	ETJ1081	n.a.	EX	1.0-1.3
	Coproduction	MPA	MTR390	T	TS	1.2-1.3
	Licensee	P	CF6	50C	TF	46.5-54.0
	Licensee	P	LARZAC	n.a.	TF	2.9-3.2
	Licensee	P	CF6	80A1	TF	48.0
	Licensee	PA	250	C20	TS	0.4
	Licensee	PA	T64	7	TS	3.9
	Licensee	A	J79	n.a.	TJ	15.6-18.7
	Licensee	P	LARZAC	4C6	TF	2.9-3.2
	Licensee	P	TYNE	RTY.20	TP	4.8-5.7

TABLE 5.4-1 (Continued)

Company	Agreement	Role[1]	Model	Series	Type[2]	Size[3]
FRANCE:						
Alsthom	Coproduction	P	CFM56	5C	TF	31.2
Microturbo SA	Indigenous	DPA	TRS18	075/076/201	EX	0.2-0.3
	Indigenous	DPA	TRi60	1/2/3	EX	0.8-0.9
	Licensor	DP	TR160	2	EX	0.8
	Licensor	DP	TR160	1	EX	0.8
	Licensor	DP	TRS18	075	EX	0.3
	Licensor	DP	TRS18	075/076/201	EX	0.2-0.3
SNECMA	Corproduction	P	ADOUR	1xx/8xx	TF	4.5-8.5
	Coproduction	PA	CF6	80C	TF	52.5-60.2
	Coproduction	PA	GE36	C25	PF	14.0-25.0
	Coproduction	PA	CFM56	5C	TF	31.2
	Coproduction	PA	F108	100/102/400	TF	22.0-24.0
	Coproduction	PA	LARZAC	n.a.	TF	2.9-3.2
	Coproduction	PA	CFM56	2/3/5A/5B	TF	18.5-24.0
	Indigenous	DPA	M88	1/2/3	TF	16.0-20.0
	Indigenous	DPA	ATAR	9C/9K	TJ	11.2-15.9
	Indigenous	DPA	M53	2/5/P2	TF	18.0-22.0
	Licensor	DP	ATAR	9C/9K	TJ	11.2-15.9
	Licensor	DP	ATAR	9C/9K	TJ	11.2-15.9
	Licensor	DP	ATAR	9C/9K	TJ	11.2-15.9
	Licensor	P	ADOUR	811	TF	8.4
	Licensor	P	ADOUR	851	TF	5.2
	Licensor	P	ADOUR	801A	TF	7.3
	Licensor	PA	TYNE	RTY.20	TP	4.8-5.7
	Licensor	DP	LARZAC	4C6	TF	2.9-3.2
	Licensor	DP	LARZAC	n.a.	TF	2.9-3.2
	Licensee	PA	CF6	50C	TF	46.5-54.0
	Licensee	DP	M53	P2	TF	21.4
	Licensee	PA	CF6	80A1	TF	48.0
Societe Turbomeca	Coproduction	PA	GEM	2/41/42/60	TS	0.8-1.3
	Coproduction	PA	RTM322	01/02/05	TS	2.1-3.0
	Coproduction	PA	MTR390	T	TS	1.2-1.3
	Coproduction	PA	ADOUR	1xx/8xx	TF	4.5-8.5
	Coproduction	MPA	LARZAC	n.a.	TF	2.9-3.2
	Indigenous	DPA	TP319	n.a.	TP	0.5
	Indigenous	DPA	ARRIEL	1	TS	0.6-0.8
	Indigenous	DPA	MAKILA	IA/IAI	TS	1.7-1.8
	Indigenous	DPA	ARBIZON	III/IV	EX	0.8-0.9
	Indigenous	DPA	TM333	IA/IM/B	TS	0.9-1.0
	Indigenous	DPA	ARTOUSTE	n.a.	TS	0.6
	Indigenous	DPA	TURMO	IIIC/IVC	TS	0.8-1.6
	Indigenous	DPA	BASTAN	n.a.	TP	0.8-1.1
	Indigenous	DPA	TM319	2	TS	0.5
	Indigenous	DPA	ASTAZOU	II/III/XIV/XVII	TS	0.5-0.9

TABLE 5.4-1 (Continued)

Company	Agreement	Role[1]	Model	Series	Type[2]	Size[3]
Societe Turbomeca (continued)	Indigenous	DPA	ASTAZOU	II/XII/XIV/XVI	TP	0.6-1.0
	Licensee	DP	ADOUR	801A	TF	7.3
	Licensee	DP	ADOUR	811	TF	8.4
	Licensee	DP	RTM322	H60	TS	2.1-3.0
	Licensor	DP	ASTAZOU	XIV	TS	0.9
	Licensor	DP	ARTOUSTE	III	TS	0.6
	Licensor	DP	ASTAZOU	III	TS	0.6
	Licensor	DP	ASTAZOU	III/XIV	TS	0.6-0.9
	Licensee	DP	ADOUR	851	TF	5.2
	Licensee	DP	WZ	8	TS	0.7
	Licensor	DP	ARTOUSTE	III	TS	0.6
	Licensee	DP	RR1004	n.a.	TS	0.9
	Licensor	DP	LARZAC	n.a.	TF	2.9-3.2
	Licensor	DP	LARZAC	4C6	TF	2.9-3.2
GREECE:						
Hellenic Aerospace Industries	Licensee	PA	M53	P2	TF	21.4
ITALY:						
Alpha Romeo	Coproduction	P	RB.199	MK 1xx	TF	15.3-18.0
	Coproduction	P	TAY	610/620/650	TF	12.4-18.0
	Indigenous	DPA	AR.TJ140	n.a.	EX	0.3-0.9
	Licensee	A	J85	n.a.	TJ	2.8-5.0
	Licensee	P	TAY	620/650	TF	13.9-15.1
	Licensee	A	CT58	140	TS	1.4
	Licensee	PA	CT7	6	TS	2.1
	Licensee	PA	PT6T	3/6	TS	0.9-1.8
	Licensee	PA	T700	T6	TS	2.1
	Licensee	A	T58	10	TS	1.4
	Licensee	P	T64	P4D	TP	4.1
Fiat	Coproduction	P	PW2000	2037/2040	TF	37.0-41.7
	Coproduction	P	PW4000	n.a.	TF	52.0-60.0
	Coproduction	PA	RB.199	MK 1xx	TF	15.3-18.0
	Coproduction	PA	ETJ1081	n.a.	EX	1.0-1.3
	Coproduction	P	CF6	80C	TF	52.5-60.2
	Coproduction	P	EJ200	n.a.	TF	20.0
	Coproduction	P	V2500	A1/A5	TF	25.0-28.0
	Coproduction	P	CF6	80C	TF	52.5-60.2
	Coproduction	P	PT6B	35/36	TS	0.7-1.0
	Licensee	P	CT7	6	TS	2.1
	Licensee	PA	T64	P4D	TP	4.1
	Licensee	P	T700	T6	TS	2.1
	Licensee	A	J79	n.a.	TJ	15.6-18.7
	Licensee	PA	SPEY	MK 807	TF	11.0
	Licensee	PA	ORPHEUS	n.a.	TJ	4.5-4.9

TABLE 5.4-1 (Continued)

Company	Agreement	Role[1]	Model	Series	Type[2]	Size[3]
Rinaldo Piaggio	Coproduction	PA	RTM322	01/03/05	TS	2.1-3.0
	Licensee	PA	RR1004	n.a.	TS	0.9
	Licensee	P	VIPER	11/540/632	TJ	2.5-4.5
	Licensee	PA	T55	11/712	TS	3.8-4.4
	Licensee	PA	T53	11/13	TS	1.1-1.4
SPAIN:						
Casa	Licensee	A	F404	400	TF	16.0
Industria de Propulsion	Coproduction	P	EJ200	n.a.	TF	20.0
UNITED KINGDOM:						
Ames Industrial	Licensee	PA	TRI60	1	EX	0.8
	Licensee	PA	TRS18	075	EX	0.3
Noel Penny	Indigenous	DPA	NPT	171	EX	0.2
Normalair-Garrett	Indigenous	DPA	WAEL	600N	EX	0.1
Rolls-Royce	Coproduction	MPA	GEM	2/41/42/60	TS	0.8-1.3
	Coproduction	P	MTR390	T	TS	1.2-1.3
	Coproduction	P	TF41	912-B52	TF	23.0
	Coproduction	MPA	EJ200	n.a.	TF	20.0
	Coproduction	MPA	RB.199	MK 1xx	TF	15.3-18.0
	Coproduction	MPA	ADOUR	1xx/8xx	TF	4.5-8.5
	Coproduction	MPA	RTM322	01/03/05	TS	2.1-3.0
	Coproduction	MP	RB211	524/535	TF	37.0-63.0
	Coproduction	MPA	RB.580	n.a.	TF	6.5-7.1
	Coproduction	PA	CF6	80C	TF	52.5-60.2
	Coproduction	MPA	TAY	610/620/650	TF	12.4-18.0
	Coproduction	PA	V2500	A1/A5	TF	25.0-28.0
	Coproduction	MPA	F402	406/408	TF	22.0-23.8
	Indigenous	DPA	RB211	22/524/535	TF	37.0-63.0
	Indigenous	DPA	TYNE	RTY.1/11/12	TP	4.4-5.7
	Indigenous	DPA	GAZELLE	n.a.	TS	1.4-1.6
	Indigenous	DPA	PEGASUS	MK 61/15x	TF	21.5-23.8
	Indigenous	DPA	NIMBUS	n.a.	TS	0.7
	Indigenous	DPA	SPEY	MK 1xx/5xx	TF	9.9-20.5
	Indigenous	DPA	DART	n.a.	TP	1.5-3.2
	Indigenous	DPA	VIPER	11/531/6xx	TJ	2.5-5.0
	Indigenous	DPA	ORPHEUS	n.a.	TJ	4.5-4.9
	Licensee	PA	TPE331	5	TP	0.7-0.8
	Licensor	DP	SPEY	MK 807	TF	11.0
	Licensor	DP	TAY	620/650	TF	13.9-15.1
	Licensor	DP	SPEY	512	TF	12.0
	Licensor	DP	VIPER	632	TJ	4.0-4.5

TABLE 5.4-1 (Continued)

Company	Agreement	Role[1]	Model	Series	Type[2]	Size[3]
Rolls-Royce (continued)	Licensor	DP	VIPER	11	TJ	2.5
	Licensor	DP	TF41	A1/A2/A400	TF	14.5-15.0
	Licensor	DP	TYNE	RTY.20	TP	4.8-5.7
	Licensor	DP	VIPER	11/540/632	TJ	2.5-4.5
	Licensor	DP	VIPER	632/.633	TJ	4.0-5.0
	Licensor	DP	DART	RDA.7	TP	1.5-3.2
	Licensor	DP	RR1004	n.a.	TS	0.9
	Licensee	DP	ADOUR	811	TF	8.4
	Licensee	DP	ADOUR	801A	TF	7.3
	Licensee	DP	ADOUR	851	TF	5.2
	Licensor	DP	RTM322	H60	TS	2.1-3.0
	Licensee	PA	ASTAZOU	III	TS	0.6
	Licensor	DP	VIPER	11/632/633	TJ	2.5-5.0
	Licensor	DP	ORPHEUS	n.a.	TJ	4.5-4.9
	Licensor	DP	ORPHEUS	n.a.	TJ	4.5-4.9
	Licensor	DP	ORPHEUS	n.a.	TJ	4.5-4.9
	Licensor	DP	SPEY	MK 807	TF	11.0
	Licensor	PA	GNOME	H.1200/H.1400	TS	1.3-1.6

[1]**Role:**
P Parts Manufacturing
A Assembly
D Development
M Program Management

[2]**Type:**
TF Turbofan
TJ Turbojet
TP Turboprop
TS Turboshaft
EX Expendable

[3]**Size:**
TF, TJ, EX Thrust - thousands of lbs.
TJ, TP Power - thousands of HP

n.a. Information not available.

Also evident, particularly within the E.C. aerospace industry, is a strategy to strengthen its position in the U.S. market through increased presence (local offices, advertising, and service facilities), acquisition of U.S. subsidiaries, and through collaborations of all types. Major European companies also have expanded business in the U.S. by buying plants and setting up subsidiaries. "Thomson-CSF acquired Burtek, a company that builds commercial and military simulators in Tulsa, Oklahoma, in 1979 and Wilcox Electronics, Kansas City, Missouri, in 1987.

In late 1988, M.B.B. opened a U.S. subsidiary, Conventional Munition Systems, Inc., Arlington, Virginia, to produce weapons for the Department of Defense."[65]

Developments in eastern Europe during late 1989 and 1990, resulting in a lessening of East-West tensions, threaten to contract significantly the defense market in the early nineties. "As demand for weaponry dips in each country, multinational defense corporations are expected to strive for large shares of their own markets and make a vigorous bid for additional work in the United States and Third World nations."[66]

By mid-1990, it was becoming apparent that France was headed toward "privatization" of its national aerospace industry as a means of increasing its competitiveness in the world's commercial markets. According to *Defense News*,[101] Aerospatiale, France's leading aerospace industry, is moving its operating units into the private sector, with many being spun off into a variety of joint ventures with other domestic and foreign manufacturers. Aerospatiale will act as a holding company "..... that owns major shares of the various joint ventures to establish long-term goals and corporate strategies."[102] Aerospatiale, now a national company owned and operated by the government as an agency, is moving toward operating as a commercial entity subject to commercial laws, with the government its sole shareholder. *Defense News* expects the next step to occur in December 1990, with the incorporation of Eurocopter SA, an independent corporation comprised of the helicopter businesses of Aerospatiale and Messerschmitt-Boelkow-Blohm (M.B.B.) of Germany. The French government may integrate Dassault Aviation into Aerospatiale's corporate structure to further increase efficiency of operations. A major aspect of Aerospatiale's drive to increase its world competitiveness is its centralized coordination of research and development among its many subsidiaries "..... to cut duplication and maximize return on investment."[103]

The actions of the French government and its aerospace industries are typical of those throughout most of the E.C. nations--to position E.C. aerospace to challenge the U.S. for leadership in the world market during the coming decades.

5.5 European Community Business Strategies for Its Turbine Engine Industry. The intra-E.C. business link-up and U.S. market penetration strategies also are apparent in the E.C. turbine engine industry. Rolls-Royce and SNECMA have discussed an agreement to pool some expensive resources such as production facilities for advanced alloys. B.M.W. has teamed with Rolls-Royce to form a joint venture company (B.M.W. Rolls-Royce) that will position B.M.W. to reenter the aircraft gas turbine business.[67] Rolls-Royce and SNECMA have signed an agreement that lays the groundwork for the companies to cooperate on powerplants for the next generation of supersonic commercial and business transports. This two-year agreement allows joint participation in the Japanese SST propulsion effort and the proposed U.S./Soviet supersonic business jet.[68] SNECMA also is seeking to acquire a 10-15 percent holding in the Belgian company Fabrique Nationale (F.N.), already having placed work on the CFM56 and M88 engines at F.N.[69] SNECMA is seeking to set up a multinational European industrial subsidiary to produce powder metallurgy components for use in high-temperature applications in military and civil engines, so as to become independent of U.S. sources. The subsidiary should be operational by the mid nineties to meet European manufacturers' requirements for materials to be used in advanced engines.[70]

Germany's aerospace industries are integrating under the umbrella of Deutsche Aerospace, the aircraft, space systems, defense systems, and propulsion systems arm of Daimler Benz AG. With a workforce of 55,000 and annual revenues of $7.4 billion, Deutsche Aerospace intends to become a "..... major player in global aerospace."[104] Toward this objective, Motoren-und-Turbinen-Union (M.T.U.) seeks an increased equity share in cooperative development and production programs. According to an interview with Juergen E. Schrempp, Chairman of Deutsche Aerospace, *Aviation Week and Space Technology* reported that the failure of the G.E./M.T.U. arrangement for development of the GE90 occurred because of a low (6 percent) development share in favor of the P&W/M.T.U. codevelopment of advanced versions of the PW4000 which involves cross-equity shares between M.T.U. and United Technologies and greater access to world markets.[105]

As pointed out in Section 2, penetration of the U.S. engine market by the E.C. recently has been significant. The many international codevelopment/co-production collaborations with U.S. engine companies currently in force attest to the major E.C. engine manufacturers' employment of their penetration strategy; the improving U.S. market penetration attests to the success of the strategy. Section 3 describes the success of this strategy in the western world market as well. The E.C. activities to organize and centralize risk capital, to rationalize long-term technology investments for maximum efficiency, and to compete among themselves for maximum productivity in subsystem manufacturing point to a continually improving market share in the coming years.

5.6 Government Support for the E.C. Turbine Engine Industry. The industrial infrastructure of the E.C. is in the midst of change to prepare for the impending EC92 open market. During the seventies and early eighties, E.C. nations such as the U.K., France, and F.R.G. actively engaged in expanding their engine development and production capacity through heavy subsidies for coproduction and, during the eighties, increasing support for codevelopment with their U.S. counterparts. The ability to quickly combine product and process technology available from their U.S. collaborations with their expanding research activities in turbine engines was mainly due to the respective governments' providing "most of the working capital for development and production ..... in the form of low-cost loans whose repayment is contingent on a revenue stream. Thus, the tremendous risk and cost of working capital is borne primarily by European governments rather than by private industry. Airbus is said to have received close to $10 billion in government aid for its first three models and another $4 billion to $5 billion for launching work on its new A330/340 program."[71] The tendency toward privatization of E.C. industry will decrease the level of direct government support, but E.C. industry currently is preparing to undertake a greater share in risk capitalization through the formation of conglomerates, holding companies, and joint ventures between and among the various E.C. nations.

The solidifying prospects for an E.C. open market in the early nineties was a major factor in the accelerating process of intra-E.C. industrial collaborations occuring since the mid-eighties. As noted in Sections 5.4 and 5.5, the E.C. industry in general, and its aircraft engine industry in particular, is combining talent and resources to exploit "specialized expertise" and economies of scale to acquire an intra-E.C. indigenous capability to develop, produce, and market aircraft turbine engines. As the turn of the century nears, the U.S. may expect to see the E.C. engine industry decrease its cooperative production arrangements with the U.S. engine industry as it divides its attention between the U.S. market, and its drive to become a formidable competitor in the rapidly expanding East Asian and East European civil transport markets.

Significant levels of controversial opinion exist currently regarding the degree of E.C. domestic market protection to expect during the next decade for both civil and military sectors. Sources in the U.S. seem to be in general agreement that the defense sector of the European market will continue to receive a higher degree of protection than its civil sector. "American industry concerns about the changing European defense market were aggravated by the Independent European Program Group 1986 report, *Toward a Stronger Europe.* The report called for the creation of a common market for armaments in Europe, including a joint research and development agency. The European defense ministers who make up the group were quick to add that they had no plans to raise barriers to shut out U.S. companies. Nevertheless, U.S. officials fear greater cooperation among European neighbors means less work for American business."[72]

"Most companies are not worried about obvious protectionism but about hurdles such as new business regulations or technical standards," says Robert O'Rourke, Staff Vice President, International, Hughes Aircraft Company, El Segundo, California. "The European Community is contemplating national content rules on some products that would give a company based in Europe a three percent price advantage over a company based outside Europe."[73]

"The market in Europe is going to be increasingly fenced for the Europeans," says Gene Harwell, Director for International Operations at Texas Instruments' Defense Sytems and Electronics Group, Dallas, Texas. "It will not be an obvious fence, but an invisible curtain ..... the Europeans will be careful not to try to raise protectionist issues."[74] A recent announcement (April 23, 1990) by Jacques Delors, President of the E.C. Commission, seems to substantiate at least the part of Mr. Harwell's opinion dealing with "obvious" fences. The idea of a common, E.C.-wide tariff on all defense-related parts and components short of finished goods (such as tanks and airplanes), which surfaced within the E.C. Commission in 1988, is being dropped.[75]

"According to Pratt and Whitney and G.E. officials (in an early 1989 survey), many European politicians view military (aircraft) engines as a market that has been and should continue to be closed to U.S. manufacturers. The 1992 changes are unlikely to alter their views, and, with limited exceptions, U.S. engine manufacturers will continue to be closed out of European military propulsion programs."[76]

Europe's civil aircraft and engine industry began expanding in the early seventies, resulting in a current "aggressive, global marketing effort that is frequently interdependent with U.S. manufacturing."[77] This "global" market is frequently biased by political "buy domestic" pressures on the various nations' nationalized airlines and aircraft companies, and "indirectly" biased by national product/process technology, development, and production grants and low-cost or forgiven loans which often provide an unassailable price advantage to the domestic manufacturer. These biases exist in the E.C. nations and will most likely become more prevalent with EC92 and the strengthening of the E.C. engine industrial base. The rapidly expanding and strengthening engine industry currently is closely allied with U.S. industry which, among other things, is permitting U.S. access to the European civil market. Opportunities for the U.S. to increase its penetration of the E.C. market probably will decrease as intra-E.C. mergers and collaborations (encouraged by EC92) strengthen the E.C competitive position vis-a-vis the U.S. The remaining option for improving the U.S. market position in the E.C. then would be the ability to compete successfully based on price and quality.

The E.C. nations' support to their engine industries' foreign trade, in addition to the indirect support from the various tax, grant, and loan subsidies mentioned above, is similar to that of the U.S. "American producers claim these subsidies are illegal violations of the *General Agreement on Tariffs and Trade* (G.A.T.T.), because there is no expectation of repayment, which allows the Europeans an unfair pricing advantage and allows them to make outrageous financial deals."[78] The U.S., in an attempt to ameliorate the European subsidies, supports various export-import bank financing, Domestic Internal Sales Corporations, certain tax incentives, and research and development funding. These are described in more detail in Section 5.9.

5.7 U.S. National Policy for Its Turbine Engine Industry. In contrast to both Japan and the E.C., the U.S. does not now possess a national policy regarding its aircraft or turbine engine industry. There is no national movement to guide the formulation and execution of government, financial, and industrial strategies to assure a long-term positive trade balance and stable share in the world market for its turbine engine industry. Prior to 1978, a national policy framework existed which significantly benefitted the U.S. aircraft engine industry. The policy framework was not a "purposive, coherent package of measures" aimed at the aircraft industry specifically, as the U.S. political environment "is inhospitable to the explicit formulation of industry-specific strategies."[79] But this policy framework benefitted the commercial aircraft industry (prior to 1978) because it simultaneously influenced the demand for, and supply of, technology innovation, which was the keystone of the U.S. engine industry's post-war success.[80]

Demand (or pull) for technology innovation was stimulated by the Civil Aeronautics Board (C.A.B.) until 1978, when deregulation removed this impetus. The C.A.B. "created markets and stimulated airline demand for advanced technology by controlling entry, pricing, and route structure, thus preventing price competition and encouraging service-based competition. Each airline sought to get an edge on performance through rapid adoption of advanced-technology aircraft and engines. Manufacturers could pass on the costs of this technology to end customers via C.A.B.-approved fare increases."[81]

Supply of (or push for) technology innovation was furnished by the post-war U.S. government through its federal R&D programs. "The aircraft industry received large infusions of public funds (in addition to the C.A.B.-supported fare structure) for the support of R&D directed toward military applications, and benefitted as well from military procurements. In many cases, especially in the development of jet engines, these military technologies had significant spillovers into civilian applications. In addition, (federal financial support occured) for a large program of fundamental research with important civilian applications, through the National Advisory Committee on Aeronautics (NACA) and its successor, the National Aeronautics and Space Administration (NASA)."[82]

"In recent years (since 1978), lower rates of growth in funding for NASA aeronautics research, deregulation of domestic air transportation, and some reduction in the extent of military-civil spillover have meant that many of the key elements of this policy framework no longer exert a major impact on the U.S. commercial aircraft industry."[83]

A replacement, or repair, of this previous U.S. national policy framework has not occured, and there appears to be neither industry- nor government-led activity toward this end. As a result, rather than a concerted national effort to achieve a goal energized by a "vision statement" or equivalent (as is occuring in both the Japanese and E.C. engine industries), the U.S. engine industry is driven by short-term profit incentives through independent business deals with foreign and domestic competitors and customers.

5.8 U.S. Turbine Engine Industry Business Strategies. In the early post-war years, the engine industry enjoyed a virtual monopoly in civil jet engine development and sales. The U.S. government gave incentives to promote technology innovation through both the pull of a domestic airline market regulated to compete on quality and service rather than price, and the push of a heavily-subsidized military development program and civil research program. With these market and product quality advantages, the U.S. engine industry led the western world, owning, in 1970, 84 percent of western world new engine production value (Figure 3.2-1). By 1970, the U.S. engine industry consisted of individual company-indigenous engine development and production capabilities, with a generous level of both development and production work assigned to subtier firms with specialized skills. To assure continued dominance in western world markets, U.S. companies encouraged foreign licensed production of parts and subassemblies. As the manufacturing skills of the western foreign nations improved, and combinations of airline traffic growth and national economic health permitted, U.S. industry increased licensing activities in the customer nations to include higher-technology parts, and later to include engine assembly activities, to assure continued foreign market growth. This activity occurred with technology (both product and process) bleed to the licensees, so that by the late sixties, codevelopment was appearing as an additional cost of maintaining foreign markets and as an opportunity to spread the capital risk of rapidly increasing engine development costs.

The U.S. engine producers are recognizing the necessity for productivity enhancements, as competitive pressures from both within the U.S. and from the E.C. nations have become intense during the eighties. Without the low-cost, long-term loan inducements enjoyed by E.C. nations for the capital improvements necessary to revamp and modernize factory operations, the U.S. engine companies compete for productivity capitalization with short-term profitability objectives and conservative debt-equity ratios within their own corporate entities.

Strategy for the acquisition of development risk capital has shifted significantly since the late seventies. "Commercial aviation has been marked by very strong working relationships between manufacturers and airlines, particularly those major carriers whose early orders allow the development of a new aircraft to be launched. Transports are sized and designed to meet the multiple and usually conflicting demands of these 'launch customers.' In return, the manufacturer used to receive launch payments that provided from 20-30 percent of their working capital."[84]

"Deregulation, Airbus competition, and the growing importance of foreign markets have made such payments the exception. Instead of providing capital, the airlines now look to the manufacturers to finance the sale, or they choose to lease aircraft. By 1986 one-third of the fleets of the major U.S. domestic airlines were leased, and fully half of the airplanes delivered between 1982 and 1984 were leased. Though the flexibility of leasing is attractive to the airlines, it passes risk back to the manufacturers and forces them to replace the working capital no longer provided by progress payments."[85] This loss by the aircraft manufacturers of an important source of working capital to spread the development risk (hence the "trickle-down" impact on the availability of engine development risk capital) is an important stimulus for the U.S. engine industry to "globalize," to acquire development risk capital. These stimuli (spreading of development risk and foreign market penetration) have resulted in strategy observable across the entire U.S. engine prime producers that is increasing codevelopment/coproduction collaborations with E.C. and Japan and that is increasing the number of coproduction collaborations with emerging nations located in areas of expected growth in airline traffic such as the Pacific Rim (South Korea and Singapore, for instance) and eastern Europe.

A second strategy, replacing the "performance" competition strategy employed by the engine industry prior to deregulation, is "price competition." Prior to deregulation, the U.S. "policy framework" sustained a technology innovation impetus (see Section 5.7) in the U.S. engine industry, upon which the performance competition strategy was based. "Large airline engineering staffs ..... worked closely with the manufacturers and played a lead role in making fleet-purchase decisions, establishing design geometries, and choosing airplane systems. Airline engineers spent thousands of hours evaluating designs from suppliers, suggesting alternatives of their own, and making strong arguments for the choices they felt best fit their own airline's needs. The power of the engineering departments, in conjunction with the regulated business environment, exerted strong customer pull for technology-based performance improvements in new airplanes and engines. During the (eighties), however, many airlines, especially in the United States, have drastically reduced the size and role of their engineering staffs. Purchase agreements are increasingly made by marketing and financial staff. This trend is being accentuated by the rapid rise of leasing companies."[86]

This shift in strategy from performance- to price-competition may be "..... salutary insofar as manufacturers are being forced to rethink their design and development processes, to design for manufacturability, and to reorganize their operations more efficiently. But there are serious drawbacks as well. The demand pull for technology has diminished." There is declining technology sophistication among users and buyers. Instead, "..... manufacturers are expected to offer creative financing, which may take the form of buybacks, offsets, leases, expanded warranties, insurance, training, or very low interest rates. Export financing policies and terms offered by export credit agencies are also an essential marketing tool. In some cases, sales are coordinated with political deals, often involving senior government officials who can negotiate trade agreements and route awards, landing rights, or regional economic assistance."[87]

The results of the shifts in strategy (from development and production indigenous to individual companies, to codevelopment and coproduction with foreign competitors, and from "performance" competition to "price" competition), the increased difficulty in acquiring long-term productivity risk capital, and the increasing strength of the E.C. engine industry are displayed in Figure 3.4-3. The U.S. experienced a 60 percent loss (in 1989 dollars) in annual value of exclusively-assembled new engine production between 1970 and 1988. In 1988 the U.S. share in codeveloped/coproduced engines comprised 45 percent of its total value of annual new engine production.

5.9 U.S. Engine Industry Infrastructure. The seven U.S. aircraft engine companies comprising the U.S. engine industry prime contractor base are listed with their development and production activities during the seventies and eighties on Table 5.9-1. Also listed are three additional firms that recently have become active on a small scale with turboshaft or expendable engines. Notice that all seven prime contractors have experience with indigenous development/production, codevelopment/coproduction, and licensed production.

TABLE 5.9-1 United States Aircraft Engine Manufacturers

Source: Forecast International/DMS and Universal Technology Corp.

Company	Agreement	Role[1]	Model	Series	Type[2]	Size[3]
Allison Gas Turbine	Coproduction	PA	578	n.a.	PF	14.0-20.0
	Coproduction	PA	RB.580	n.a.	TF	6.5-7.1
	Coproduction	MPA	225	B10/B20/C10	TP	0.4
	Coproduction	MPA	TF41	912-B52	TF	23
	Coproduction	PA	T800	n.a.	TS	1.2-1.3
	Indigenous	DPA	T63	5/720/730	TS	0.2-0.4
	Indigenous	DPA	T703	700	TS	0.6-0.7
	Indigenous	DPA	T406	400	TS	6.0-7.0
	Indigenous	DPA	250	10/18/20/28	TS	0.2-0.7
	Indigenous	DPA	GMA	2100	TP	4.0-8.0
	Indigenous	DPA	501	D13/D11/D39	TP	3.5-6.0
	Indigenous	DPA	250	B17B/C/D	TP	0.3-0.7
	Indigenous	DPA	T56	14/16/101/42	TP	3.5-6.0
	Licensee	MPA	TF41	A1/A2/A400	TF	14.5-15.0
	Licensor	DP	CT63	5A	TS	0.3
	Licensor	DP	T56	14/427	TP	3.5-6.0
	Licensor	DP	250	C20	TS	0.4
Garrett Engine Division	Coproduction	MPA	T800	n.a.	TS	1.2-1.3
	Coproduction	MPA	TFE731	5	TF	4.3-4.5
	Coproduction	MPA	TFE1042	70P	TF	8.4
	Coproduction	MPA	ETJ1081	n.a.	EX	1.0-1.3
	Coproduction	PA	CFE738	n.a.	TF	5.6-7.0
	Indigenous	DPA	ATF3	6	TF	4.0-5.4
	Indigenous	DPA	TFE109	1/3	TF	1.6
	Indigenous	DPA	TFE731	2/3	TF	3.2-3.7
	Indigenous	DPA	F109	100	TF	1.3
	Indigenous	DPA	T76	10/12/416/420	TP	0.7-1.0
	Indigenous	DPA	TPE335	20	TP	1.8-2.0
	Indigenous	DPA	TPE331	1-3/6/8-12/14	TP	0.6-1.7
	Licensor	DP	TPE331	12B	TP	1.0-1.1
	Licensor	DP	TPE331	5	TP	0.7-0.8
General Electric	Coproduction	MPA	F108	100/102/400	TF	22.0-24.0
	Coproduction	MPA	CF6	80C	TF	52.5-60.2
	Coproduction	MPA	CF6	80C	TF	52.5-60.2
	Coproduction	MPA	T407	400	TP	4.0-6.0
	Coproduction	MPA	CFE738	n.a.	TF	5.6-7.0
	Coproduction	MPA	GLC38	n.a.	TP	4.0-6.0
	Coproduction	MP	RM12	C	TF	18.0-20.0
	Coproduction	PA	RB211	524/535	TF	37.0-63.0
	Coproduction	MPA	CFM56	2/3/5A/5B	TF	18.5-24.0
	Coproduction	MPA	CFM56	5C	TF	31.2
	Coproduction	MPA	GE36	C25	PF	14.0-25.0
	Indigenous	DPA	TF39	1/1A/1C	TF	41.0-43.0
	Indigenous	DPA	CT64	820	TP	3.1
	Indigenous	DPA	F118	100	TF	19.0

TABLE 5.9-1 (Continued)

Company	Agreement	Role[1]	Model	Series	Type[2]	Size[3]
General Electric (continued)	Indigenous	DPA	T64	10/14	TP	2.9-4.1
	Indigenous	DPA	F103	100	TF	52.5
	Indigenous	DPA	F404	100/400/402/F	TF	11.0-17.6
	Indigenous	DPA	F110	100/400	TF	27.0-27.5
	Indigenous	DPA	CF7	6/45/50	TF	41.0-54.0
	Indigenous	DPA	CF6	80A	TF	48.0-50.0
	Indigenous	DPA	CF34	1A/3A	TF	9.1-9.2
	Indigenous	DPA	J79	n.a.	TJ	15.6-18.7
	Indigenous	DPA	CF700	n.a.	TF	4.2-4.5
	Indigenous	DPA	F101	100	TF	30.0
	Indigenous	DPA	T700	401/700/T6	TS	1.5-2.1
	Indigenous	DPA	CT58	110/140	TS	1.0-1.4
	Indigenous	DPA	J610	n.a.	TJ	4.2-4.5
	Indigenous	DPA	J85	n.a.	TJ	2.8-5.0
	Indigenous	DPA	F101	102	TF	30.0
	Indigenous	DPA	T58	1/3/8/10/16	TS	1.3-1.9
	Indigenous	DPA	TF34	n.a.	TF	9.0-9.3
	Indigenous	DPA	T64	1/2/6/16/100	TS	3.9-4.8
	Indigenous	DPA	CT7	2/6/10	TS	1.6-2.4
	Indigenous	DPA	CT7	3/5/7/9	TP	1.6-2.4
	Licensor	DP	CT58	110/140	TS	1.3-1.4
	Licensor	DP	J79	n.a.	TJ	15.6-18.7
	Licensor	DP	J79	n.a.	TJ	15.6-18.7
	Licensor	DP	J85	n.a.	TJ	2.8-5.0
	Licensor	DP	GNOME	H.1200/H.1400	TS	1.3-1.7
	Licensor	DP	J79	n.a.	TJ	15.6-18.7
	Licensor	DP	F110	100	TF	27.5
	Licensor	DP	T64	7	TS	3.9
	Licensor	DP	CF6	80A1	TF	48.0
	Licensor	DP	T64	10/10E/10J	TP	2.9-3.0
	Licensor	DP	T64	P4D	TP	4.1
	Licensor	DP	CT58	140	TS	1.4
	Licensor	DP	F404	400	TF	16.0
	Licensor	DP	J85	n.a.	TJ	2.8-5.0
	Licensor	DP	F404	400/402	TF	16.0-17.6
	Licensor	DP	F404	400	TF	16.0
	Licensor	DP	T700	T6	TS	2.1
	Licensor	DP	T700	401	TS	1.7
	Licensor	DP	CT7	6	TS	2.1
	Licensor	DP	T58	10	TS	1.4
	Licensor	DP	CF6	50C	TF	46.5-54.0
	Licensor	DP	T58	10	TS	1.4
Microturbo North America	Licensor	PA	TR160	2	EX	0.8
	Licensor	PA	TRS18	075/076/201	EX	0.2-0.3
P&W, Canada, W. VA. Div.	Licensor	PA	T400	400/401	TS	1.8

TABLE 5.9-1 (Continued)

Company	Agreement	Role[1]	Model	Series	Type[2]	Size[3]
Pratt and Whitney	Coproduction	MPA	578	n.a.	PF	14.0-20.0
	Coproduction	MPA	JT8D	209/217/219	TF	19.0-21.7
	Coproduction	MPA	PW4000	n.a.	TF	52.0-60.0
	Coproduction	P	F402	406/408	TF	22.0-23.8
	Coproduction	P	RM8	A/B	TF	26.0-28.0
	Coproduction	P	TF41	912-B52	TF	23.0
	Coproduction	MPA	V2500	A1/A5	TF	25.0-28.0
	Coproduction	MPA	PW2000	2037/2040	TF	37.0-41.7
	Indigenous	DPA	TF30	n.a.	TF	13.4-25.1
	Indigenous	DPA	TF33	n.a.	TF	18.0-21.0
	Indigenous	DPA	F117	100	TF	41.7
	Indigenous	DPA	JT9D	3/7/20/59/70	TF	43.0-56.0
	Indigenous	DPA	JFTD12	1/4/5	TS	4.1-4.8
	Indigenous	DPA	JT8D	9/15/17/2xx	TF	14.5-21.7
	Indigenous	DPA	JT3D	n.a.	TF	18.0-21.0
	Indigenous	DPA	T73	P-1/P-700	TS	4.5-4.8
	Indigenous	DPA	PW1120	n.a.	TJ	20.0-21.0
	Indigenous	DPA	F100	100/200/220	TF	23.5-23.8
	Indigenous	DPA	J52	8B/408A/409	TJ	8.5-12.0
	Licensor	PA	F404	400/402	TF	16.0-17.6
	Licensor	DP	F100	100	TF	23.8
	Licensor	DP	JT8D	9	TF	14.5
	Licensor	DP	F100	100/200	TF	23.8
	Licensor	P	RTM322	H60	TS	2.1-3.0
Sunstrand	Indigenous	DPA	GEMJET	n.a.	EX	0.04
Teledyne CAE	Indigenous	DPA	305	n.a.	EX	0.04-0.09
	Indigenous	DPA	J69	T9/25/29	EX	0.9-1.7
	Indigenous	DPA	J402	400/700/702	EX	0.6-1.0
	Licensee	PA	F107	100/102/103	EX	0.6-1.0
Textron Lycoming	Coproduction	PA	T407	400	TP	4.0-6.0
	Coproduction	PA	GLC38	n.a.	TP	4.0-6.0
	Indigenous	DPA	T53	P	TP	1.2-1.8
	Indigenous	DPA	T55	8/11/712/714	TS	2.2-5.0
	Indigenous	DPA	ALF502	L/R	TF	6.5-7.5
	Indigenous	DPA	LTP101	600/700	TP	0.6-0.8
	Indigenous	DPA	LTS101	600/650/750	TS	0.6-0.8
	Indigenous	DPA	T53	1/5/11/13/703	TS	1.1-1.8
	Licensor	DP	T53	11/13	TS	1.1-1.4
	Licensor	DP	T53	P	TP	1.2-1.8
	Licensor	DP	T55	11/712	TS	3.8-4.4
	Licensor	DP	AL5512	n.a.	TS	4.1
	Licensor	DP	T53	13/703	TS	1.4-1.8
	Licensor	DP	T53	13	TS	1.4
	Licensor	DP	T53	11	TS	1.1

TABLE 5.9-1 (Continued)

Company	Agreement	Role[1]	Model	Series	Type[2]	Size[3]
Williams International	Indigenous	DPA	F112	100	EX	1.0
	Indigenous	DPA	WR2/WR24	6/6TS/7/8	EX	0.1-0.2
	Indigenous	DPA	F107	100/102/103	EX	0.6-1.0
	Indigenous	DPA	WTS34	n.a.	EX	0.03-0.05
	Indigenous	DPA	FJ44	n.a.	TF	1.5-2.1
	Licensor	DP	F107	100/102/103	EX	1.0
	Licensor	PA	RTM322	H60	TS	2.1-3.0

[1]Role:
- P Parts Manufacturing
- A Assembly
- D Development
- M Program Management

[2]Type:
- TF Turbofan
- TJ Turbojet
- TP Turboprop
- TS Turboshaft
- EX Expendable

[3]Size:
- TF, TJ, EX Thrust - thousands of lbs.
- TJ, TP Power - thousands of HP

n.a. Information not available.

The U.S. engine industry has become increasingly "global" during the eighties. Current activities by the leading U.S. engine manufacturers to increase their East Asian and eastern European coproduction enterprises seem to assure increasing global character into the nineties. In 1986, Arthur E. Wegner, President of Pratt and Whitney, described the globalizing U.S. engine industry: "If you ask someone to tell you who makes engines for large commercial transports today, he'd probably say there are three--G.E., Rolls-Royce, and Pratt. But if you think it through, and consider not just the name plates, but who's involved in sharing the risk--and the rewards, if any--you recite lots of other names: M.T.U., Fiat, SNECMA, J.A.E.C., Volvo, Fabrique Nationale, Kongsberg, Samsung, Eldim. Ten years ago, there were only three nameplates--now there are five when you consider C.F.M.I. and I.A.E. It used to be that Pratt, G.E., and Rolls had virtually 100 percent of the market. If you look at market share by engine content in say 1992, you'll find that the so-called big three will have only about two-thirds of the market--and the others I've mentioned will be sharing a third. Through collaboration, the big three have created the equivalent of another (nameplate) company--another competitor. Interesting ..... almost every kind of cooperation is "typical" today. Simple license arrangements, co-production partnerships, full partnerships .... from product design to product support .... joint venture companies and sales of technology assistance are common."[88]

Although rigorous examinations of U.S. engine industry productivity and technology investment trends are not available, there appears to be general concern that U.S. leadership in these areas is declining. "The revival of the European aviation industry and the possible emergence of a Japanese industry are not in themselves cause for alarm. What is alarming is the appearance of weaknesses in the infrastructure of the American industry. The Aerospace Industries Association (AIA) is concerned about America's 'eroding competitive and technological edge' because the United States has been exploiting its technology reserves without replenishing them. The products on which the current aerospace trade surplus is based draw upon technologies developed from 10-15 years ago. The American government has since reduced its support of aeronautical research and development both as a percentage of GNP and as a percentage of the NASA budget. Technology validation, the longest and most expensive stage in new-technology development, has become the weakest link in the American R&D chain. With the military providing much less validation and NASA not filling the gap, commercial developers no longer have a solid foundation on which to apply new technologies, and there are fewer new technologies in the pipeline. The situation with regard to process technologies is even bleaker. Seed funding for programs aimed at validating risky new processes and transferring them to the shop floor has been sparse and is shrinking."[89]

A third noticeable element of the U.S. engine industry infrastructure is the relative lack of domestic inter-company collaboration compared to Japan and the E.C. Each of the seven U.S. engine manufacturers is involved with at least one other domestic manufacturer, with most of the collaborations involving a degree of codevelopment as well as coproduction.[90] The massive industrial consortia characteristic of the Japanese engine activities and the rapidly increasing intra-E.C. collaborations occuring as EC92 approaches are not evident in the U.S., and currently there does not appear to be movement in this direction. U.S. antitrust legal structure has been one cause limiting collaborations; another is the fact that the U.S. engine industry's primary competition until recently has come from within itself. But during the eighties, "the sentiment of the U.S. government became more positive toward industrial collaborations ..... formed to improve the domestic competitive posture in the international market. The passage of the *National Cooperative Research Act of 1984* (P.L.98-462) intended to stimulate innovative private sector research and development and to clarify the application of the antitrust rule of reason to joint ventures involving research and development. Various sectors of the American industry have capitalized on the government's 'relaxed' sentiment by establishing domestic research and development ventures to overcome foreign competitive pressures. But the U.S. engine industry has evolved toward a high degree of international collaboration involving development and production to protect or enhance its market share. During the past five years, domestic collaborations in the engine industry for development and production have become more commonplace, while domestic collaborations producing a research and development product still remain rare."[91] But intra-U.S. engine industry collaborations are few compared to the intensity of intra-Japanese, intra-E.C., and inter-U.S./E.C./Japanese collaborations.

5.10 Government Support for the U.S. Turbine Engine Industry. The government provides significant fiscal support to the U.S. engine industry in both encouragement for private sector investment, and direct funding. Government support for private sector investment in product and process technology is primarily in the form of tax credits. In the early eighties, the Internal Revenue Service established a credit "equal to 25 percent of the increase in qualified research expenses over a base period of one to three years beginning in 1980. Qualified research expenses include wages, supplies, equipment leasing, and some consultant fees."[92] Another inducement to private sector technology investment is the government Independent Research and Development (IR&D) program, under which the engine companies negotiate a government-paid "surcharge" on military engine sales which is added to the individual company's research investment without much more than simplified "guidelines" from the government regarding its use.

Government support for capital investment to upgrade productivity is primarily in the form of tax credits and accelerated depreciation allowances. The tax credit equals ten percent of the cost of "plants, machinery, tools, and the like."[93] The Accelerated Cost Recovery System (ACRS) allows manufacturers to rapidly depreciate various forms of capital property.

Direct funding by the government for research and development emanates primarily from the Department of Defense (DoD) and NASA. The research funds are targeted primarily for product technology, with a smaller emphasis on process technology (manufacturing technology and industrial modernization). As mentioned in Section 5.7, direct funding by the U.S. government has had a major positive impact on both military and civil engine competitiveness, but the impact steadily weakened during the seventies and eighties due to both reduction in funds (primarily the NASA source deteriorated in favor of space development) and reduction in degree of similarity between military and civil engine needs. These factors forced increased dependence upon private sector funds for civil engine full-scale development.

The most distinctive recent impact upon the U.S. engine industry's domestic market made by the U.S. government was passage of the *Airline Deregulation Act of 1978*, which, while removing the U.S. government from regulating fares and routes, forced the basic change from performance-based to price-based competition (reviewed in Section 5.8). Domestic market protection observable in both Japan and the E.C. is not nearly as pervasive in the U.S. In fact, during the early eighties, the IRS's Accelerated Cost Recovery System and investment tax credit system (discussed earlier in this section) included new aircraft acquired by the U.S. airlines, both U.S. and imported, thereby making tax advantages equally positive for foreign imports. These "disincentives" for purchase of domestic aircraft probably continue to exist.

U.S. government support for U.S. engine industry access to foreign markets, other than the indirect support furnished by technology funding and tax incentives reviewed above, is limited primarily to Export-Import Bank (Eximbank) financing and Domestic International Sales Corporations (DISCs). Eximbank provides a variety of financing programs to help U.S. civil aircraft exports, including direct credits, guarantees, and insurance, but, according to Dertouyos, et al: "Some of the policies and practices of the U.S. Export-Import Bank, compared with those of European export credit agencies, put American manufacturers at a disadvantage with respect to their foreign competitors."[94]

"DISCs are specially created subsidiaries of U.S. corporations which receive at least 95% of their income from export-related activities. A DISC itself is tax-exempt, but its parent shareholders (usually a U.S. manufacturing company) are subject to tax. As long as the DISC does not violate a number of restrictive rules, the parent of the DISC is taxed on only 50% of the DISC's income. For major exporters such as the U.S. airframe and aircraft engine industries, the DISC has provided a valuable tax deferral benefit."[95] During the mid eighties, more rigorous qualifications were imposed on the DISCs to remain consistent with G.A.T.T. (see Section 5.3) requirements, which probably reduced their effectiveness in promoting access to foreign markets.

There are several U.S. government "disincentives" (so called by the U.S. International Trade Administration) to the U.S. engine industry's foreign market access. Administrative delays and regulatory impediments top the list of U.S. corporate executives. Most disliked is the *Foreign Corrupt Practices Act*, which makes illegal certain offers of payments and gifts and which establishes general bookkeeping standards for publicly-held corporations. Complaints that "everybcdy does it" are not verifiable, and vagueness in the law regarding legal and illegal practices makes it a significant problem in international competition.[96]

"Antitrust laws represent another area of potential export disincentive. Some thirty countries have antitrust laws, but the U.S. legislation is the oldest and among the most vigorously enforced. While antitrust laws are not themselves credited with many lost export opportunities, the uncertainty caused by their interpretation and applications, combined with the burden of antiboycott measures and the *Foreign Corrupt Practices Act*, can make an export venture seem too complicated, time-consuming, and expensive."[97]

National Security and foreign policy export controls, while intending to limit export of certain goods and technology, present a real disincentive to the U.S. engine industry's exports.[98] A major source of control over export licensing of U.S. engine manufacturers is the Coordinating Committee on Multilateral Export Controls (CoCom). CoCom was founded in 1950 in an effort to coordinate the export control policies of the member nations--currently the members of NATO minus Iceland, plus Japan and Australia--so that militarily significant goods and technology would not leak to the nations of the Warsaw Pact.[99] Allan Wendt, Senior State Department Representative for Trade Controls, said in late March, 1990: "The Bush administration intends to pursue an export control policy that supports political changes in Eastern Europe by relaxing many of the CoCom trade restrictions."[100] Aircraft engine technology will continue to be a critical part of CoCom, and though controls may relax, CoCom controls probably will continue to be a significant part of an engine company's export licensing exercises.

5.11 Engine Industry Similarities and Disparities. The following material summarizes the survey of Japanese, European Community, and United States aircraft turbine engine industries and outlines some of the prominent similarities and disparities. Table 5.11-1 summarizes these similarities and disparities.

TABLE 5.11-1 Japanese, E.C., and U.S. Aircraft Turbine Engine Industries

Similarities and Disparities

	JAPAN	EUROPEAN COMMUNITY	UNITED STATES
National Policy	o Developmental Capitalism - Vision statements - Inter-firm coop. for technology - Inter-firm coop. for product design, development - Vertical organization for development, production, sales	o Nationalized/Subsidized Companies - Tax-supported until profitable - Privatize for world competitiveness - Coalesce for capital, production rationalization, economies of scale	o Free Enterprise - Independent industry - Driven by short-term objectives
	o Technology Exploitation - Linkages with other industries - Long-term market leadership · Emphasize high bypass · De-emphasize shaft/prop	o Intra-E.C. Open Market - Improve position for: · Domestic sales · Intra-E.C. collaborations - Better control of foreign penetration	o No National Policy
Strategies	o Technology Imitation - Codevelopment/coproduction for competence growth	o Immediate: Capitalize on Recent Growth: - Increase U.S. presence - Increase equity shares in U.S. collaborations	o "Globalize" for Market Growth/Risk Abatement - Shift from indigenous to international codevelopment/coproduction collaborations - Increase E.C. presence
	o Technology Innovation - For equity shares in foreign programs - Prepare for lead roles in future	o Eventual, as Strength Increases: - Growing protection of E.C. and East European markets - Transition from collaborations to competition with U.S. for East Asian market	o Shift from Performance to Price Competition - De-emphasis on long-term technology investment - Increased need for productivity investment
	o Lead East Asia to Eventual Regional Indigenous Capability		

TABLE 5.11-1 (Continued)

	JAPAN	EUROPEAN COMMUNITY	UNITED STATES
Infra-Structure	o Conglomerate Ownership - Vertically organized - Codevelopment/coproduction collaborations with foreign firms o Forced Domestic Consortia - Cooperative technology - Rationalized design, production - Economies of scale	o Conglomerate Ownership - Capital source to replace govern-ment financing - Joint ventures among and between each - Equity codevelopment/copro-duction with foreign firms o Intra-E.C. Collaborations - Rationalized, competitive design, production - Economies of scale	o Conglomerate Ownership - Compete for productivity capital o Independent Development/Manu-facture with Sub-Tier Support - Negligible rationalization of pro-duct/process technology,or production - No spread of productivity capital risk - Lost opportunities for economies of scale - Weakening comparative technology base o Minimal Collaborative Research - Legacy of intra-U.S. competition - Discouraged by antitrust legislation, but improving regulations
Government Support	o Guaranteed/Forgiven Loans with Long-Term R.O.I. Incentives - Domestic cooperative develop-ment, productivity enhancement - Foreign codevelopment/copro-duction o Modest Support for Research, but increasing o Tax Relief, Export Inventives o Signatory to Civil Aircraft G.A.T.T.	o Low Cost loans with Repayment Contingent upon Revenue Stream - Intra-E.C. collaborations - Foreign codevelopment/copro-duction o Heavy Support and Government Labs for Research o Tax Relief, Export Incentives o Signatories to Civil Aircraft G.A.T.T. o Increasing Domestic Market Protection	o Direct Funding with Industry Cost Share - Military development - Industrial modernization (military needs only) o Decreasing Support for Product and Process Technology - NASA for civil (minimal) - DoD for military o Tax Relief, Export Incentives (and Disincentives) o Signatory to Civil Aircraft G.A.T.T.

NATIONAL POLICY. Japan's aircraft turbine engine industry has been the beneficiary of its *Developmental Capitalism* and *Technology Exploitation* policies since the late fifties. Led by MITI *vision statments*, heavily subsidized with government resources, and gaining experience by licensed production of military jet engines, Japan considered itself ready by the late sixties to begin indigenous civil aircraft development. The failure of the initial civil venture was obvious by the early seventies, and the Japanese flexed their *Developmental Capitalism* policy from inter-firm competitive design and development toward domestic inter-firm cooperation in most phases of development, design, and production in order to centralize resources and gain efficiency.

Japan's application of its *Technology Exploitation* policy to the turbine engine industry also changed during the early seventies when the government shifted emphasis from relatively low-technology small turboprop engine development to high bypass ratio engine development in an attempt to assure that their engine product technology eventually would be far enough ahead of international competitors to give them a market position for a significant period.

Finally, as the engine development firms gained technical and management skills, Japan shifted from use of trading companies and export cartels and promoted a more vertically-aligned engine industry that exploited its own financial strength and marketing skills to enter collaborations with foreign engine companies.

The E.C. turbine engine industry was guided by basic policies similar to Japan's--nationalized or otherwise heavily subsidized firms that, where necessary, gained competency with licensed production activities. Anticipating EC92, the E.C. aerospace industry is coalescing into large conglomerates that will contain the capital necessary to replace government financial support as the industry moves toward privatization, will increase product rationalization among their subsidiaries, and will coordinate research and development for maximum efficiency. The intra-E.C. economic deregulation and removal of trade barriers to free movement of capital, goods, services, and people among the member nations will create a unified market, half again as large as the U.S. market. These moves by the governments and industries of the E.C. member nations imply an emerging E.C. policy for its aircraft engine industry that combines strengthening corporate structure and creating an open "domestic" market to achieve the objective of becoming a leading world-wide competitor.

In contrast to Japanese and E.C. policies, the industrial policy in the U.S. has as a basic premise the mutual independence of industry and government and, as reviewed in Section 4.7, should not change. This basic disparity between the U.S. and its E.C. and Japanese competitors is evident when comparing the behavior of each. Without a government-led and government-funded long-term program, without a publicly-recognized sense of necessity and purpose for its engine industry, and with industry driven by short-term profit motives, there is no recognizable national policy that would approach the strength of the policies evident in Japan and the E.C.

Prior to airline deregulation in 1978, technology innovation applied to engine production was the keystone of the U.S. turbine engine industry. The Civil Aeronautics Board (C.A.B.), controlling entry, pricing, and route structure, formed a policy structure that provided the necessary "pull" for technology innovation, and the federal R&D programs provided the technology "push." With deregulation, decreasing levels of government-sponsored civil engine research, and reduced "spill-over" of government-sponsored miliary engine R&D, a policy framework no longer exists. Strategies instead are driven by short-term policy incentives and by many independent business arrangements with foreign competitors and customers and with a few domestic competitors.

STRATEGIES. Japan initially employed its *infant industry* strategy to achieve an indigenous small turboprop engine development and production capability, but by the early seventies, the strategy had failed because Japan's domestic light transport market was too small to amortize the development investment, forcing the export price of the YS-11 out of a competitive range. In line with its *Technology Exploitation* policy shift, Japan, in 1971, established Japan Aero Engines, a domestic consortium to explore indigenous development of a high bypass ratio transport engine. However, failure of the YS-11 program and ballooning development costs forced a strategy shift to codevelopment and coproduction, initially with Rolls-Royce, followed by agreements with Pratt and Whitney, M.T.U., and Fiat for the V2500 turbofan development. During the remainder of the seventies, the Japanese used *technology imitation* to gain a foothold in the high bypass ratio turbofan market using coproduction agreements with U.S. and E.C. engine companies for access to this technology. By the early eighties, Japanese competency in manufacturing and product technology had improved to the point that *technology innovation* strategy was given increasing emphasis, and by the mid-eighties, codevelopment was becoming an integral part of its agreements with U.S. and E.C. firms.

Technology innovation and increasing production share (rather than market penetration with indigenously developed and produced engines) currently appears to be Japan's primary strategy for increasing its presence in the aircraft engine business. Japan's plans for its Materials Research Center, Material Research Institute, and its moves toward leadership of an international cooperative program for advanced propulsion for a future high-speed civil transport attest to its current strategy of moving toward equity participation in international engine codevelopment and coproduction collaborations.

With the expected vigorous growth of Pacific Rim and East Asian civil traffic, developing nations in these regions will increase use of their internal markets as leverage for engine license and coproduction arrangements. To the extent that Japan can extend its economic influence with this regional "trading bloc," the Japanese engine industry/government "syndicate" may attempt to lead the "bloc" into an indigenous development/production capability. If successful, Japan could achieve, as the leader of an East Asian engine industry, its 1980 MITI-stated *vision* early in the next century.

Strategy evident recently throughout the E.C. engine-producing nations is that of increasing the presence of its engine industry in the U.S. to accelerate penetration of the U.S. market. Local offices of E.C. firms, heavy advertising, local service facilities, acquisition of U.S. subsidiaries, and collaborations of all types make evident E.C.'s drive for U.S. market expansion.

Strengthening of aircraft engine industry corporate structure is occurring both within and between E.C. nations. A strategy for the immediate future appears to be to position the E.C. engine industry to command an increased equity share in cooperative development and production programs with the U.S. to improve its U.S. market position as well as its "domestic" and east European positions. Recognition of the East Asian market growth potential is evidenced by E.C.'s increasing interest in joining with both the U.S. and Japan in exploiting this potential.

As the E.C. engine industry continues to grow, the strategy may involve increasing protection of its domestic market to a level that now exists with its military engine market. Also, it may involve decreasing its collaborations with U.S. firms so as to employ a more unilateral approach in a drive to dominate the East Asian and East European market sectors.

The U.S. turbine engine industry grew during the fifties and sixties under an umbrella consisting of: (1) a vigorous technology-driven domestic military and civil market without significant foreign competition; and (2) a heavily-subsidized civil research program and military applied research and engineering development program with large "spill-over" to civil needs. By the early seventies, it had matured into a highly-competitive group of seven prime manufacturers, each with an independent indigenous development and production capability, supported by an equally competitive network of sub-tier producers also enjoying a substantial share of development and production work according to particular specialized skills. Operating as independent competitive entities, the U.S. industry dominated world production, but by the early eighties the domination was eroding. Nevertheless, U.S. engine manufacturers continue today in essentially the same competitive rather than cooperative mode of operation with their domestic counterparts. Although each of the seven U.S. engine manufacturers is collaborating with at least one other domestic manufacturer, and most collaborations involve both codevelopment and coproduction, they are few compared to the widespread intra-Japanese, intra-E.C., and inter-U.S./E.C./Japanese collaborations.

The U.S. engine industry has become increasingly global during the last two decades, with U.S. manufacturers trading U.S. product and process technology, production share, and U.S. market share to foreign producers for development risk abatement and access to foreign markets. As with the E.C. in the U.S., the U.S. engine industry is increasing its presence in the European countries by means of local service organizations, local marketing offices, and acquisition of foreign subsidiaries.

Without the technology "pull" of C.A.B.-regulated domestic airlines and the spread of the associated costs to airline customers via regulated fare increases, market success has become increasingly dependent upon engine unit price and "creative" financing criteria rather than technology content with its attendent long-term product quality. De-emphasis of U.S. long-term technology investment will be difficult to avoid, thus jeopardizing long-term market position in favor of immediate cost-cutting needs, and making even more critical the productivity investments necessary to remain price-competitive. By the eighties, almost without exception, the seven prime engine manufacturers were divisions of large conglomerates or holding companies, where, without significant government assistance, each competes with its "sister" divisions for productivity capitalization to maintain individual price-competitiveness with both domestic and foreign engine manufacturers.

INFRASTRUCTURE. The Japanese aircraft industry (including its engine industry) consists of collaborations (forced by government political and financial pressures) of elements of three leading large "Heavy Industry" conglomerates. Its share of the international engine market is as yet insignificant (less than one percent of new engine production value in 1988). Until recently, licensed parts production and assembly comprised the bulk of Japan's engine revenues, but coproduction revenues are becoming a significant part of its annual new engine production value, reflecting its earlier emphasis shift to production-share objectives with international coproduction collaborations rather than market-share objectives with indigenous production. The "forced" domestic collaborations promote cooperative technology generation, rationalized elements of design and production among the collaborators, and more efficient economies of scale. Conglomerate ownership of the engine manufacturers makes available private capital, which, with massive injections of government-backed or forgiven long-term productivity and development loans, positions them as lucrative prospects for international codevelopment and coproduction collaborations. Becoming increasingly vertical in their organizational structure so as to independently control and execute their marketing strategy rather than depend upon export cartels and trading companies, the Japanese engine industry is rapidly gaining the competence necessary to challenge successfully their major E.C. and U.S. counterparts.

Intra-E.C. collaborations are the norm for its aircraft industry in general and its engine industry in particular. The collaborations capitalize on rationalized design and development efficiencies and combine with this activity vigorous competiition among the collaborators for specific parts of the development and production programs. The current trend toward increased conglomerate ownership will provide the capital resources necessary to replace government subsidies as the industry progresses toward privatization. Also evident is an increase in intra-E.C. joint ventures comprised of various divisions of the different conglomerates to strengthen the position of the industry in its drive to increase its equity share in U.S. collaborations. Seventeen companies comprise the bulk of the E.C. engine prime manufacturer base, with Rolls-Royce and SNECMA the largest developer-producers. Burgeoning coproduction in the eighties is primarily responsible for the growth in E.C. production strength, from under $2 billion in 1970, to about $3.3 billion in 1980, to about $3.8 billion (1989 dollars), or 70 percent of the E.C. total annual new engine production value in 1988. This growth occurred while E.C. exclusive production diminished from less than $1.5 billion in 1970 to less than $1 billion (1989 dollars) in 1988.

As previously noted, the operating strategies of the U.S. engine industry have forged its infrastructure to a group of seven independent, inter-competitive, prime manufacturers, supported by a large sub-tier supplier network. The few domestic collaborations among these seven have thus far produced a negligible amount of product/process technology rationalization, and production rationalization probably is more evident within the international collaborations than within the domestic. Without government-furnished or guaranteed productivity capital, and unwilling or unable to abate productivity risk among the domestic manufacturers, each engine company is forced to compete for productivity capital within its own conglomerate, often competing with divisions offering attractive short-term returns on their capital investment proposals. Opportunities for economies of scale benefits that characterize Japanese and E.C. domestic collaborations at the sub-assembly and parts levels are lost to the U.S. industry.

The U.S. domestic technology base, both product and process, appears to be weakening. Exploiting technology reserves through foreign codevelopment and coproduction collaborations and shrinking government support of research and development are resulting in an eroding competitive technological edge. A leading technological edge is the only inducement, other than U.S. market share and risk abatement, for maintaining a U.S. presence in future foreign collaborations.

GOVERNMENT SUPPORT. Both Japan and the E.C.engine industries have access to low-cost capital and, in many cases, outright grants for domestic cooperative development and productivity enhancement. Japan's guaranteed loan program has specific incentives for long-term returns--in some cases, loans with return-on-investment in excess of seven years are forgiven. The E.C.'s system of low-cost loans with repayment contingent upon a resulting revenue stream accomplishes the same objective--incentivizing long-term objectives.

As EC92 approaches, a tendency toward privatization is evident as the engine industry gains competency. The industry, preparing to undertake a greater share in risk capitalization and to operate with the efficiencies of commercial corporate enterprises rather than as government agencies, appears to be coalescing into conglomerates, holding companies, and joint ventures among the E.C. nations.

Risk capitalization by the U.S. government is practically nonexistent, with the exception of tax incentives and depreciation allowances. Japan and the E.C.

nations also provide a substantial degree of tax relief, but a comparative examination of similarities and differences in them is beyond the scope of this survey.

The governments of all three entities subsidize technology with government laboratories and direct funding. Japan has not emphasized this aspect in its engine industry, but may be expected to increase emphasis as *technology innovation* becomes an increasingly important aspect of the nation's strengthening industry. The E.C. nations have a record of heavy, often inter-locked, government/industry research activities. The U.S., with a history of heavy support to both its military and civil engine research and development, is decreasing its government support. NASA support to civil engine research is minimal and DoD support is declining. As with comparative tax incentives, a quantitative comparison of government direct support to engine research is beyond the scope of this survey.

Domestic market protection is not a government issue in Japan; rather, its market access appears to be an indirectly negotiated factor in the Japanese industry's international codevelopment/coproduction collaborations. Opinion differs in the U.S. regarding E.C. market protection measures to expect in post-EC92 Europe. But, as the E.C. engine industrial base continues to strengthen and political "buy domestic" pressures increase, the E.C. governing bodies probably will make it difficult for the U.S. to improve its E.C. market share.

The U.S., Japan, and the E.C. nations are signatories to the 1980 *Agreement on Trade in Civil Aircraft* of the *General Agreement on Tariffs and Trade* (G.A.T.T.), which eliminates import duties on civil aircraft and parts and addresses other trade barriers. Although cumbersome and a victim of compromise, this Agreement does provide a degree of "fair trade" among the signatories.

6.0 CONCLUSIONS. The DoD depends upon engine industry sales-derived resources for more than half of the funding necessary to meet the research objectives of its Integrated High Performance Turbine Engine Technology initiative. The DoD thus has a vital interest in the prospects for the U.S. engine industry's position in the world jet engine market. Neither the DoD nor any other government agency can direct, fund, or regulate the activity necessary to assure U.S. market leadership in the manner of the E.C. and Japanese actions because of the relative independence of government and industry as compared with the E.C. and Japan. But, with a clear view of the recent and current market position and trends, the DoD (and other agencies) may encourage, adjust regulations, appropriately fund, or otherwise advocate and participate to assist the engine industry in its drive to maximize market share.

A basic conclusion to be drawn from examining the U.S. engine industry's performance in the domestic and foreign markets is that the apparent excellent health of the engine industry implied by media reports is overoptimistic. Almost daily can be found references to a "best-ever" balance of trade position of the U.S. aerospace industry, and to U.S. aerospace as the national leader in returning the U.S. to an overall favorable trade balance. These reports may promote a dangerously complacent attitude regarding the future prospects of the engine industry on the part of the American public and probably a significant segment of the government and industry. The information surfaced by the U.T.C. survey does not support a conclusion that the U.S. engine industry currently is in the precarious position suffered by such industries as machine tools, automotive, and electronics; but it does show that both domestic and foreign market shares are eroding and that unless the conditions that are causing these trends change, the engine industry may find itself in a decade or so in a position now existing among some its more unfortunate sister industries.

Coproduction blossomed during the mid and late 80's; by 1988 accounting for almost half of the western world new engine production value. Coproduction probably was a major factor responsible for reducing the rate of U.S. share erosion during the 80's. Strategic decisions by elements of the U.S. engine industry regarding coproduction were productive, if alternate decisions for head-to-head competition with the E.C. would not have resulted in U.S. products with cost and quality advantages too sharp to be ignored by the world market. From the E.C. viewpoint, codevelopment and coproduction arrangements with its U.S. counterparts were fundamental to its growth in development/manufacturing competance and market share. In the current decade, with the U.S. and E.C. approaching parity with engine development and production capability and capacity, with East Asia, Pacific Rim, and East Europe becoming important market targets, and with the increasing industrial consolidation within the E.C., does extensive U.S./E.C. codevelopment/coproduction remain a viable strategy?

A degree of market share erosion from the position of a virtual monopoly of world trade in the sixties is to be expected and is, in the long view, to the advantage of both the U.S. industry and the consumer. Europe, East Asia, and the Pacific Rim should be expected to increase competency and international presence in high-technology industries. The resulting increase in worldwide industrialization will promote a growing engine market and should force increasing product quality, production efficiency, and marketing acumen in the U.S. engine industry. The trick is to perceive, at least a decade before, the point at which the cause of market share erosion would shift from primarily gains in foreign competence to primarily degradation of the U.S. capability, and to plan and execute accordingly. Machine tools, automotive, and electronics missed the trick; will the engine industry?

Telling influences in the rise of Japanese machine tools, in the recent improvement of the Japanese engine industry, and in the E.C. rise to serious engine competition have been the abilities of the respective governments to shoulder the capital risk of product/process technology, product development, and productivity investments, and to constrain the industries to invest in long-term objectives. A telling influence in the downfall of U.S. machine tools was the inability of the industry, without a paternalistic government, to resist investing for short-term profit motives rather than for long-term technology and productivity objectives. The U.S. engine industry faces a similar challenge. Without depending upon the existance of a paternalistic government to shoulder risk and force long-term return on investment strategy, can the U.S. engine industry devise the strategy and acquire the capital necessary to assure that a decade and more from now it will retain a controlling share of the world market?

Because of the separation (within limits) of industry and government and the free enterprise system, the challenge is primarily industry's to deal with. But success in dealing with the threat to the U.S. share in the engine market will require, in addition to industry leadership, critical roles to be played by the government (both the regulative and legislative bodies), and perhaps most importantly, by the general public. The Aerospace Industries Association (A.I.A.) currently is engaged in activities to establish and implement policies and programs to enhance the U.S. engine industry's position in the international market. A trade association such as A.I.A. could provide an "umbrella" under which the engine manufacturers could chart and execute a unified campaign to prevent market leadership from moving offshore. Industry representatives, with advisory support from appropriate government agencies, could identify and resolve pertinent market-share issues. This group would have both fact-finding and policy/strategy objectives.

Fact-finding issues need resolution to provide specifics upon which to justify policy and strategy and to gain public support for changes in both private sector capital investment objectives and public sector adjustments of pertinent legislation and regulatory interpretations. The history leading to current activity and announced intentions for U.S., E.C., and Japanese technology development (both product and process) and productivity enhancements needs identification and comparative examination. Similarly, tax abatement, antitrust, and export/import trade issues need identification and comparison. Such information undoubtedly exists within the separate confines of the U.S. manufacturers and various government agencies. The information could be pooled and organized into powerful arguments benefitting the participants as a whole, compromising neither individual company competitiveness nor individual agency regulatory jurisdiction.

Policy and strategy need to be formulated regarding these same issues, with particular attention paid to the problem of drawing public attention and support for needed changes. A basic shift in policy and associated strategies needs to occur in the private sector: from acquiring development risk abatement abroad with primary competitors in return for production share, to acquiring development risk abatement domestically and limiting foreign coproduction to industrial development in intended market sectors. In the public domain, policies and strategies need to recognize the shift in competition from primarily intra-U.S. to U.S./E.C. now, with a significant Japanese/East Asian threat after the turn of the century. Legislation and regulatory implementation originally established to assure and protect the individual competitiveness of industry in the U.S., now often obstructs the competitiveness of U.S. firms with their overseas adversaries, which jeopardizes the very industries the laws are designed to protect.

The world aircraft engine market is large, will expand during the nineties, and is one that the U.S. cannot afford to neglect. The value of new engine production is approaching $15 billion annually; the spare parts, maintenance, and service segments of the market probably amount to at least as much, which would trend in a manner similar to new engine production. Thus, the U.S. aircraft engine industry is competing in a $30-plus billion annual market, in which it now holds a competitive (though not commanding) position. The E.C. is gearing to take a commanding position, and Japan has its strategy in place for the future; the extent of their success depends in large part upon the actions of the U.S. during the next decade.

7.0 RECOMMENDATIONS. Under the auspices of a trade association such as the Aerospace Industries Association, the United States aircraft turbine engine industry should establish the policy and execute the strategy necessary to assure that U.S. engines are produced with superior quality at lower cost than can be achieved by any of its international competitors for the foreseeable future. A panel of representatives of the seven primary U.S. turbine engine corporations with advisory support from appropriate government agencies should be chartered with both fact-finding and policy/strategy responsibilities.

Fact-Finding Issues:

- Product/Process Technology Development and Productivity Enhancement: Examine information existing within the various engine companies and government agencies, and generate comparative U.S./E.C./Japanese activity levels, funding levels, and priorities.
- Tax abatement, Antitrust Regulation, Export/Import Trade: Compare U.S./E.C./Japanese legislation, interpretation, and applications of regulations.

Policy/Strategy Issues:

- Product/Process Technology Development, Product Development:
  - Expand IHPTET to assure both military and civil objectives in both product and process technology.
  - Establish criteria for rationalizing technology development among the companies.
  - Formulate collaborative technical areas and execution criteria.
  - Establish campaign criteria and issues for acquiring government direct support.
  - Devise strategy for spreading product development risk domestically and rationalizing domestic/foreign coproduction rights.

- Productivity Enhancement:
  - Establish priorities and funding needs to assure a long-term international lead.
  - Develop rationalization criteria to spread capital risk while maintaining necessary domestic competition.
  - Develop strategy to enhance individual company competitiveness within its own conglomerate for productivity capital.
  - Identify needs common to civil and military products and devise strategy for conducting government funding campaigns.
- Tax Abatement/Antitrust Regulation:
  - Identify practical/defendable changes in regulations and legislation.
  - Establish strategy for advocating changes.
  - Advocate antitrust changes needed to shift emphasis from protection of intra-U.S. competitiveness to protection of international competitiveness.
- Export/Import Trade:
  - Identify financial and regulative changes needed to "level the playing field."
  - Establish strategy for advocating changes.
- Public Relations:
  - Recognize and address needs and opinions of both stockholders and the general (taxpaying) public.
  - Develop issues needing public support.
  - Apply advertising skills to inform and acquire support.

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APPENDIX A
SUMMARY OF THE COMMERCE PROPULSION DATABASE SYSTEM

A.1 Introduction. Universal Technology Corporation (U.T.C.) generated the Commerce Propulsion Database (C.P.D.) to organize, calculate, and display information accumulated and assembled by the United States Department of Commerce concerning the U.S. machine tool and aerospace industries and focusing upon the U.S. aircraft turbine engine industry. Table A.1-1 lists the various Department of Commerce reports and publications from which U.T.C. extracted the information entered into the C.P.D.

The C.P.D. employs the database management and communication tasks of the Lotus "Symphony" spreadsheet system and operates on an IBM-compatible microcomputer with a hard disk, at least 640K memory, and a floppy disk drive. Installation information is available in Lotus "Symphony" release two or higher, "Getting Started" manual, Chapters 4 and 5. The six floppy disks comprising the C.P.D. files are to be entered into the "SYMP" subdirectory containing the "Symphony" program.

The C.P.D. system is controlled by a database administrator (DBA), responsible for maintaining its integrity. The DBA institutes and executes applicable contract policies and procedures, and:

1. Performs periodic backups;
2. Archives files;
3. Coordinates and schedules new releases;
4. Investigates and corrects problems;
5. Remains familiar with software and operations and sets parameters for efficient operation;
6 Remains familiar with the data structure and retains responsibility for data integrity;

7. Coordinates transfers of information to required interfaces;
8. Defines and implements a problem-reporting system;
9. Retains responsibility for system security and monitors access;
10. Reviews new requirements and requests for changes and assists in pre-organizing changes;
11. Validates added features prior to installation and assures their integration;
12. Tests bug fixes;
13. Reviews documentation.

TABLE A.1-1 C.P.D. Data Sources (Department of Commerce Publications)

Item No.	Report No.	Applicable Period	Report Title
1.		1970-1988	GNP and Aerospace Deflators. U.S. Department of Commerce, Bureau of Economic Analysis
2.	MC 87-1-37B	1970-1988	Census of Manufacturers, Aerospace Equipment Including Parts.
3.	MC87-1-35C	1970-1988	Census of Manufacturers, Metal Working Machinery and Equipment
4.	MQ37D	1970-1983	Current Industrial Reports: Backlog of Orders for Aerospace Companies.
5.	MA37D	1984-1988	Current Industrial Reports: Aerospace Industry (Orders, Sales, Backlogs)
6.	FT150	1970-1983, 1986	U.S. General Imports, Schedule A, Commodity Groupings by World Areas.
7.	FT210	1970-1984	U.S. Imports, Standard Industrial Code (SIC)-Based Products, by World Areas.
8.	FT246	1970-1988	U.S. Imports for Consumption and General Imports, T.S.U.S.A. Commodity, by Country of Origin. (Tariff Schedules of the U.S. Annotated)
9.	FT410	1970-1977	U.S. Exports, Schedule E, Commodity by Country.
10.	FT446	1978-1988	U.S. Exports, Schedule B, Commodity by Country.
11.	FT450	1970-1984 1986-1987	U.S. Exports, Commodity Groupings by World Area, Schedule E: Grouping of Commodities and Method of Transportation.
12.	FT610	1970-1984	U.S. Exports, Domestic Merchandise SIC - Based Products by World Areas.
13.		1970-1988	U.S. Industrial Outlook (Import/Export Information)
14.		1970-1988	Surveys of Current Business

A.2 Basic Structure. The C.P.D. consists of six independent spreadsheet files arranged in the hierarchy depicted in Figure A.2-1

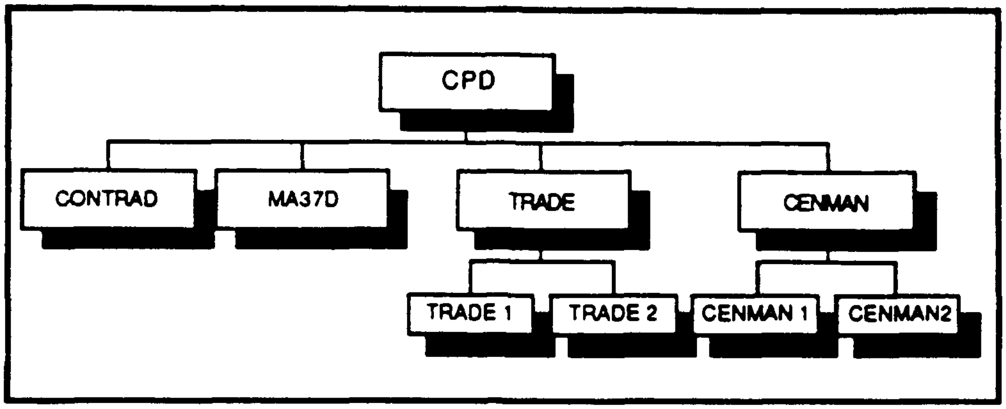

FIGURE A.2-1 Commerce Propulsion Database System Structure

The following briefly describes each of the files. The files, as displayed on the C.P.D. system, are self-explanatory; detailed information concerning their content becomes evident when viewing them.

CONTRAD (Country Trade). U.S. import and export data for aircraft engines and parts are catagorized by year from 1970 to 1988, by country, and by region. The regions are: "European Community," "Other European," "Asian" (including Japan), and "Other."

MA37D. This file lists U.S. sales, new orders, and backlogs, by year from 1970 to 1988, for each of the Standard Industrial Codes (SIC)comprising the U.S. aerospace industry. This file is defined in more detail in the following material to exemplify the C.P.D. structure.

TRADE 1. Also described in more detail in the following material, this file contains import and export data, by year from 1970 to 1988, for Machine Tools, Aircraft, and Aircraft Engines and Parts.

TRADE 2. The data of TRADE 1 is manipulated into various ratios and entered into this file.

CENMAN 1 (Census of Manufacturers). This file contains the response of manufacturers comprising the various Standard Industrial Codes of the Aerospace Industry. Such aggregate information as labor costs, material costs, labor hours, number of employees, wages, and value added is catagorized and listed by year from 1970 to 1988.

CENMAN 2. The data of CENMAN 1 is manipulated into various ratios and entered into this file.

A.3 MA37D File Structure and Content. This file consists of twenty-four separate tables containing information concerning aerospace industry orders, sales, and backlog. The file is organized into an aerospace deflators table (see Figure A.3-1 for its format), a column of ten tables displaying data for aerospace industrial sectors in then-year dollars, a second column of ten tables converting the first column to 1988 dollars (see Figure A.3-2 for table formats), and a column of three tables containing certain ratios of second-column data (see Figure A.3-3 for the format of these tables). The aerospace industry sectors are listed in Table A.3-1. The ratio tables column headings identify the parameters comprising the ratio functions.

Year	Aerospace Deflators 1982 = 100	Aerospace Deflators 1988 = 100	Assumptions
1970	36.6	31.0	Base Year 1988
|	|	|	Base Value 118.2
1988	118.2	100.0	

FIGURE A.3-1 Constant Dollar Deflators Table Format

INDUSTRIAL SECTOR			
YEAR	NET NEW ORDERS	SHIPMENTS	BACKLOG END OF YEAR

NET NEW ORDERS						
Total	Military			Civil		
	Total	U.S. Gov.	Other	Total	U.S. Gov.	Other

SHIPMENTS						
Total	Military			Civil		
	Total	U.S. Gov.	Other	Total	U.S. Gov.	Other

BACKLOG END OF YEAR						
Total	Military			Civil		
	Total	U.S. Gov.	Other	Total	U.S. Gov.	Other

FIGURE A.3-2 Table Formats for Industrial Sectors of the Aerospace Industry, 1970 - 1988

INDUSTRIAL SECTOR												
Year	**Ratio to Shipments**						**Ratio to Backlog**			**Military to Civil Ratios**		
	New Orders			Backlog			New Orders			Orders	Shipments	Backlog
	Total	Military	Civil	Total	Military	Civil	Total	Military	Civil			
1970 | | 1988												

FIGURE A.3-3 Table Format for Industrial Sector Ratios

TABLE A.3-1 Aerospace Industry Sectors Comprising the MA37D File

SECTOR TABLES	RATIO TABLES
Aerospace Industry Complete Aircraft and Parts Aircraft Engines and Parts Missile Systems and Parts Space Vehicle Systems and Parts Engines/Propulsion Units for Missiles Engine/Propulsion Units for Space Vehicles Other Aircraft Space Vehicles and Missile Activities Research and Development All Other Products and Services	Aerospace Industry Complete Aircraft and Parts Ratios Aircraft Engines and Parts Ratios

The data sources for the MA37D file are the Current Industrial Reports published by the Department of Commerce, Bureau of the Census, and, for the aerospace deflators, from information generated by the Commerce Department's Bureau of Economic Analysis. Between 1970 and 1983, the data sources were Current Industrial Reports MQ37D, "Backlog of Orders for Aerospace Companies;" subsequent to 1983, the sources were Report MA37D, "Aerospace Industry (Orders, Sales, and Backlog)."

Current Industrial Reports document periodic surveys of establishments primarily engaged in developing and/or manufacturing aerospace products, which include aircraft and parts, aircraft engines and parts, missiles and parts, space vehicles and parts, plus missile/space vehicle propulsion units. An establishment is "primarily engaged" if the value of the aerospace products exceeds that of its other products. The number of companies included in the survey varies from year to year but usually approximates fifty.

Shipments represent consolidated company sales receipts of billings, net after discounts and allowances. Value of work may be based on either multiplying the percentage of work completed during the year by the contract price, or net billings for work done during the year.

Net new orders include: the sale value of orders received during the current reporting period for products and services to be delivered at some future date; the sale value of orders for immediate delivery which have resulted in shipments during the current reporting period; and the net sales value of contract change documents which increase or decrease the sales value of the original contract. The sales value of cancellations of existing orders is deducted. Only those orders that are supported by binding legal documents are included as orders. Backlog includes all orders that have not been filled as of the end of the year.

The categories in which the Commerce Department groups the data have changed over the years. These changes are summarized in Table A.3-2.

The "U.S. Government, Military" category includes all contracts with U.S. government agencies for equipment built to military specifications. Contracts under the Foreign Military Assistance Program are excluded. The "Other Government, Military" category includes contracts for products built to military specifications for governments other than the U.S., including contracts with the U.S. government for which the ultimate customer is a foreign government. The "U.S. Government, Nonmilitary" category includes contracts with U.S. government agencies for products not built to military specifications. The "Other Customer, Nonmilitary" category includes contracts for products not built to military specifications for all customers other than U.S. government agencies.

TABLE A.3-2 Category Name Changes

AEROSPACE SECTOR	SECTOR BREAKOUT	
	1970-1979	1980-1988
Aerospace	U.S. government Other customers	Military: U.S. government Other governments Nonmilitary: U.S. Government Other customers
Complete Aircraft and Parts	•	•
Aircraft Engines and Parts	•	•
Missile Systems and Parts	•	•
Other Aircraft, Space Vehicles, and Missile Activities	•	•
All Other Products and Services	•	•
Research and Development	(Not published)	•
Space Vehicle Systems and Parts	U.S. Government: Military Nonmilitary	•

	1970-1979	1980-1985	1986	1987-1988
Engines and/or Propulsion Units for Missiles and Space Vehicles	(Not published)	Military	Military U.S. government Other government Nonmilitary	Military U.S. government Other government Nonmilitary U.S. Government Other customers
Engines and/or Propulsion Units for Missiles	(Not published)	Nonmilitary		"
Engines and/or Propulsion Units for Space Vehicles	(Not published)	Nonmilitary		"

U.T.C. was compelled to make some assumptions when entering data into the "Aerospace Sector" tables (Figure A.3-2). The data from 1970 to 1979 were not broken out into the major categories of "Military" and "Nonmilitary." U.T.C. entered the "U.S. Government" category under the "Military, U.S. Government" column in the tables because most government contracts were for military products, and entered the "Other Customers" catagory under the "Civil, Other" column in the tables because most contracts were with commercial customers. The "Military, Other" and "Civil, U.S. Government" columns contain "n/a" (not available) from 1970 - 1979 because data were not classified in these categories during that time period.

U.T.C. generated worksheet functions to translate then-year dollar tables to 1988 dollar tables and to calculate the data entered into the ratio tables. These functions:

1. Convert the 1982-based Aerospace deflator to a set of 1988-based deflators;
2. Calculate military, civil, and overall totals for net new orders, shipments, and backlog;
3. Convert then-year data entries (then-year column of tables) to 1988 dollars in the second column of tables; and
4. Determine the ratios listed in the ratio tables.

A.4 TRADE 1 File Structure and Content. U.T.C. established twenty-one separate tables in the TRADE 1 file to enter and display information on aerospace and machine tool imports and exports. The tables and their source documents are listed in Table A.4-1. Two tables are devoted to each product classification listed: one displaying then-year dollars, the other displaying 1988 dollars. The general format of these tables is described in Figure A.4-1, except that four tables (based on FT410 data) have only export data available.

TABLE A.4-1 TRADE 1 Tables and Source Documents

TABLE NAME	SOURCE DOCUMENTS
Constant Dollar Deflators	Bureau of Economic Analysis
Machine Tools	FT150; FT450
Machine Tools	U.S. Industrial Outlook
Airplanes	FT150; FT450
Aircraft Engines and Parts	FT150; FT450
Airplanes	FT210; FT610
Aircraft Engines and Parts	FT210; FT610
Aircraft	FT246; FT446
Aircraft Engines and Parts	FT246; FT446
Airplanes	FT410
Aircraft Engines and Parts	FT410

TABLE NAME	DOLLAR TYPE
	1970 1988
Report Name (U.S. Imports) Classiciation #, Classification Name Classication #, Classification Name (etc.)	
Total Imports	
Report Name (U.S. Exports) Classification #, Classification Name Classification #, Classification Name (etc.)	
Total Exports	

FIGURE A.4-1 General Format of Import/Export Tables

In many cases, various product classification codes have changed, been cancelled, been initiated, and/or re-grouped during the 1970-1988 time period. Most of the trade categories of TRADE 1 are displayed in duplicate tables, each displaying data from separate reports covering different and often overlapping time periods. For instance, "Aircraft Engines and Parts" import/export data are displayed in three tables (see Table A.4-1), reflecting similar data from three different sources (FT150/FT450, FT246/FT446, and FT410). Examination of these tables reveals that the classifications into which the various engine types and parts are placed, although similar, differ between the tables, and the time periods for which the data are available differ. Furthermore, within each table, codes and classifications change during the 1970-1988 time period. However, with the information displayed for review, rational conclusions may be drawn regarding the overall import/export behavior of the machine tool and aircraft engine industries.

Department of Commerce treatment of its import/export statistics and the assumptions made may be understood by referring to the appropriate reports and their offices of origin. The following material concerning import statistics is not intended to substantiate information, but to present a general overview of the manner in which the Department of Commerce retrieves and organizes information.

Import statistics reflect government and nongovernment merchandise sent from foreign countries to the U.S. Customs territory, which includes the fifty states, the District of Columbia, and Puerto Rico. Import statistics are compiled by the Bureau of the Census from copies of the import entry and warehouse withdrawal forms which importers are required by law to file with Customs officials. The value of imports is appraised by the U.S. Customs Service according to the legal requirements of the Tariff Act of 1930. The assigned value generally represents a value in the foreign country. If assistance was given to a foreign manufacturer for use in producing a product which is imported, the value of the assistance is required to be included in the customs value. Data on imports valued at $251 or less are estimated (by the Commerce Department).

FT246 (see Table A.1-1) classifies products according to the classifications presented in the Tariff Schedules of the U.S. Annotated (TSUSA). FT210 converts the TSUSA classifications into the Standard Industrial Classification (SIC) system to permit comparisons of the import data with the Census of Manufacturers data. When a direct match could not be made between some of the TSUSA and SIC codes, the Commerce Department used judgment to transfer to the SIC codes, avoiding significant overcounting or undercounting. FT150 converts the TSUSA product classification codes into Standard International Trade Classification (STIC) codes. As with the TSUSA-SIC transfer, when the TSUSA codes and the STIC codes were not directly comparable, the Commerce Department used judgment to convert the data.

APPENDIX B
USER'S GUIDE FOR THE PROPULSION DATABASE SYSTEM

B.1 Introduction. Universal Technology Corporation (U.T.C.) generated the Propulsion Data System (P.D.S.) to organize, calculate, and display economic information concerning aircraft gas turbine engines produced by the western world since 1970. The System uses the DataEase relational database management system and contains information generated internally by U.T.C. and data extracted from documents published by Forecast International/DMS (F.I.) of Newtown, Connecticut. The menu-driven software package automates routine data processing tasks and simplifies data search. U.T.C. grouped the engine production data into six geographical regions to allow comparison of regional as well as national performance. The regions, companies, and nationalities comprising the P.D.S. are listed in Table B.1-1. Table B.1-2 lists the parameters contained in the P.D.S. and the primary limitations and assumptions associated with each. Table B.1-3 describes terms that are used frequently throughout the Guide.

The P.D.S. contains eleven tables of information. Each person granted access to the P.D.S. has certain privileges and constraints involving these tables. The Database Administrator (DBA) has access to the entire system, is responsible for removing and adding users to the system, and defines access privileges for each user. "Users," granted access to P.D.S. by the DBA, are granted various security levels for manipulating the P.D.S. data. Each user has a "user name" and a password. The DBA, responsible for maintaining the integrity of the database, institutes the contract policies/procedures applicable to the P.D.S. and:

1. Performs periodic backups;
2. Archives files;
3. Coordinates and schedules new releases;

4. Investigates and corrects problems;
5. Remains familiar with software and operations; sets parameters for efficient operation;
6. Remains familiar with the data structure; retains responsibility for data integrity;
7. Coordinates transfers of information to required interfaces;
8. Defines and implements a problem-reporting system;
9. Retains responsibility for system security and monitors access;
10. Reviews new requirements and requests for changes and assists in pre-organizing changes;
11. Validates added features prior to installation and assures their integration;
12. Tests bug fixes;
13. Reviews documentation.

The P.D.S. in its current form must be installed on an IBM-compatible microcomputer with a hard disk, at least 640K memory, and a floppy disk drive. The following procedures should be followed:

1. Obtain a copy of the DataEase software package and install it using the steps listed in the DataEase Manual, Volume I, User's Guide, pages 1 through 5.
2. Copy the P.D.S. files from a floppy disk marked P.D.S. to the computer hard disk using the instructions included in the DataEase Manual, Volume 1, User's Guide, pages 4 through 21. The name "P.D.S." should be substituted for the "Old DataEase Name" in the descriptive text.

Only the main menu and a few forms are used in this guide to exemplify basic capabilities of the P.D.S. Capabilities and applications in addition to those discussed will occur as the user becomes familiar with the P.D.S. Menu and form revisions may be made to the P.D.S. as needed. The basic techniques for accessing and entering data, however, remain the same.

TABLE B.1-1 Companies Assembling Engines Exclusively or Under License and Coproduction Agreements, and Licensed or Coproducing Parts Manufacturers, Comprising the Total Value of Annual New Engine Production

Source: Forecast International/DMS.

REGION	COMPANY	NATION	REGION	COMPANY	NATION
E.C	Fabrique Nationale	Belgium	OTH. EUR.	Valmet Corporation	Finland
-	KHD Luftfahrttechnik	F.R.G.	•	Norsk Jetmotor	Norway
-	Motoren-und-Turbinen-Union	F.R.G.	•	Volvo Flygmotor	Sweden
-	Alsthom	France	•	Sulzer Brothers	Switzld
-	Microturbo SA	France	OTHER	Hawker de Havilland	Australia
-	SNECMA	France	•	Hawker-Siddeley Orenda	Canada
-	Societe Turbomeca	France	•	Pratt & Whitney Canada	Canada
-	Hellenic Aerospace Industries	Greece	•	AOI Engine Factory	Egypt
-	Alfa Romeo	Italy	•	Hindustan Aero Ltd	India
-	Fiat	Italy	•	Bet-Shemesh Engines	Israel
-	Rinaldo Piaggio	Italy	•	Intreprinderea de Constructii	Romania
-	Casa	Spain	•	Intreprinderea Turbomecanica	Romania
-	Industria de Propulsion	Spain	•	Atlas A/C Corporation	S Africa
-	Ames Industrial	U.K.	•	Turk Ucak Sanayii	Turkey
-	Noel Penny	U.K.	•	DMB Yugoslavia	Yugoslavia
-	Normalair-Garrett	U.K.	•	Orao-Vazduhoplovni Zavod	Yugoslavia
-	Rolls-Royce	U.K.			
JAPAN	Ishikawajima-Harima		U.S.	Allison Gas Turbine Div., G. M.	
-	Kawasaki		•	Garrett Eng. Div., Allied Signal	
-	Komatsu/Mitsubishi St/Woodward		•	General Electric Engine Div.	
-	Mitsubishi		•	Microturbo North America	
OTH. ASIAN	Shanghai Engine Factory	China	•	P&W Canada, W. Va. Div.	
-	Xian Aircraft Ind.	China	•	P&W Div., U.A.C.	
-	Singapore Aircraft, Inc.	Singapore	•	Teledyne C.A.E.	
-	Samsung Precision Ind.	S Korea	•	Textron Lycoming	
-	Aero Industry Dev Center	Taiwan	•	Williams International	

TABLE B.1-2 Propulsion Database System: Frequently-Used Terms

PARAMETERS	LIMITATIONS/ASSUMPTIONS
Engine Model	Data on a few early engines were not available and were not included in the database.
Engine Series	Data were not taken down to the series level for most of the engine models. Production data are related mainly to one engine model which covers a group of engine series.
Engine Thrust	Engine thrust varies for different series. When F.I. production data were limited to the model level, a thrust range was established for each engine model to cover the included series. A minimum and maximum thrust value are included in the database.
Engine Price	F.I. estimates price level by reviewing contract awards, price ranges given by engine manufacturers, and by comparing engines in similar classes which have a known price. When necessary, U.T.C. estimated engine prices in a similar manner.
Engine Type	U.T.C. classified some small aircraft engines (less than 1000-lb. thrust) under the expendable designation in order to keep all small engines in a single class.
Engine Application	In some instances, when the F.I. data were insufficient to relate a specific series to a specific aircraft, U.T.C. assigned a specific application to an application class.
Engines Produced per Year (1970-1988)	F.I. obtained engine production data from engine manufacturers, order books, government procurement contracts, and estimates based on aircraft deliveries. When yearly breakouts were not available, U.T.C. estimated those from its own resources.
Military/Civil Production	When possible, military engines were classified under the military designation. Civil engines also used for military applications have an entry called "percent civil" to designate the portion of the engines that are civil, with the remainder assumed to be military. When necessary, U.T.C. estimated the civil/military split.
Engine Manufacturers	Some engine manufacturer names changed between 1970 and 1988. The current name or the name of the company when engine production ceased is used in this database.
Manufacturing Work Share	F.I. obtained revenue/work share splits on the joint engine programs from the engine manufacturers. When unavailable from F.I. data, U.T.C. estimated the revenue splits.

TABLE B.1-3 P.D.S. Terminology

TERM	DESCRIPTION
Boot up	The process of loading the operating system into the computer to prepare the computer to run programs.
Character	A single letter, symbol, or blank space.
Save	Writing data and/or changes to database data.
Cursor	A flashing line (-) on the screen indicating current position.
DBA	A person responsible for the maintenance of the database--known as a Database Administrator.
DBMS	Software that organizes, structures, and manages database data. Known as Database Management System
Default	Information entered by the system software instead of the user.
Delete	Removing character(s).
Field	A storage area for a single item of data on a form.
Form	A screen display used to group fields together.
Insertion	Adding new data.
Menu	A screen display listing options for the user. Choosing a menu option will result in the display of a form, the printing of a report, or another menu screen.
Operating System	A program placed in the computer's memory to enable users to operate the computer.
Query	The process of retrieving data from the database.
Record	A set of related fields.
Table	A collection of records.
Update	Added or revised character data.
Wildcard	Notation used to represent one or more unknown characters.

B.2 Propulsion Database System Structure. The P.D.S. structure in IDEFIX notation is shown in Figure B.2-1. Each block represents a corresponding data file in the P.D.S., and the lines connecting the blocks show the interrelationships between the data files.

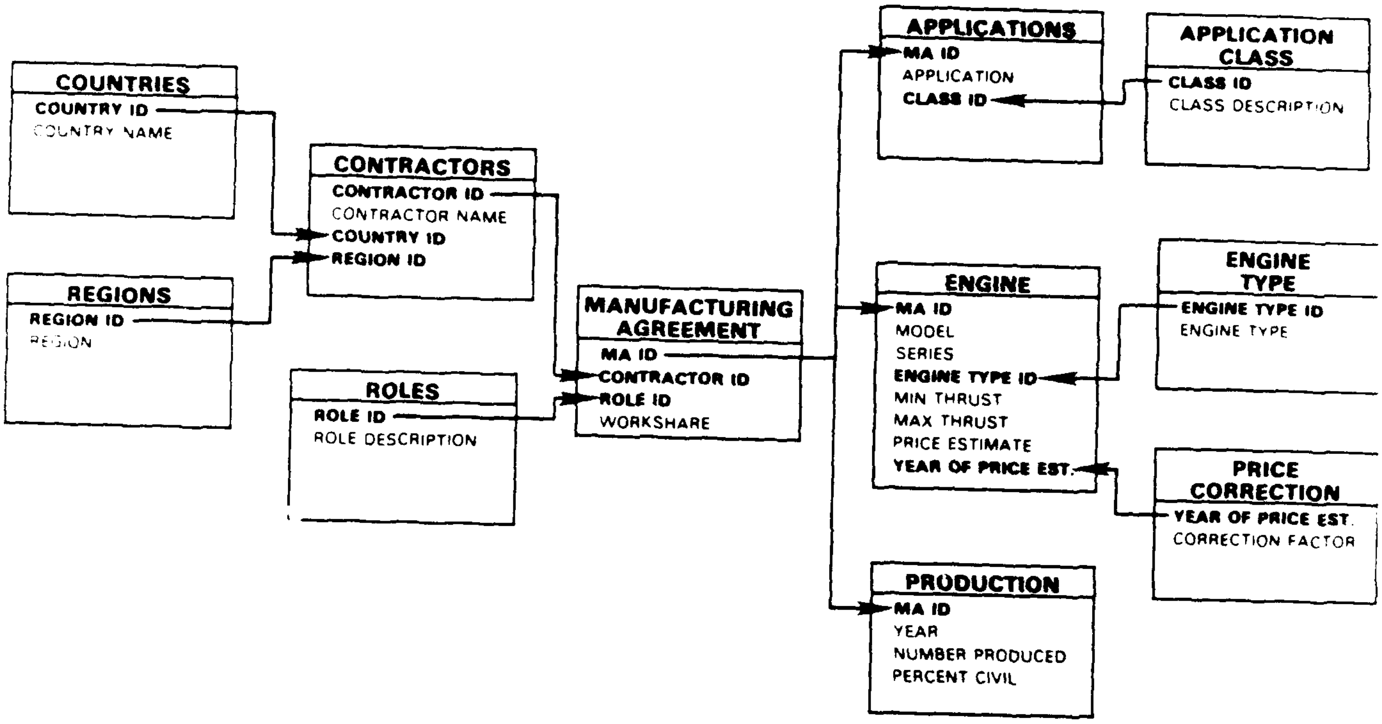

FIGURE B.2-1 P.D.S. IDEFIX Diagram

Identification symbols are assigned to each country, region, and engine company. The "Countries" and "Regions" files link each symbol to its corresponding country and region, and the "Contractors" file links each company to its corresponding symbol and ties each company to its country and region symbols. Table B.2-1 illustrates these three files in formats similar to those in the P.D.S. The complete files may be viewed in the P.D.S.

TABLE B.2-1 Formats for the "Countries," "Regions," and "Contractors" Files

COUNTRIES		REGIONS	
Country ID	Country Name	Region ID	Region
AA	Australia	EC	European Community
AU	Austria	JP	Japan
BL	Belgium	OA	Other Asian
BZ	Brazil	OE	Other European
CA	Canada	OT	Other
(Etc.)		US	United States

CONTRACTORS			
Contractor ID	Contractor Name	Country ID	Region ID
AC	ACEC	BL	EC
AI	Aero Industry Development Center	TI	OA
AL	Allison Gas Turbine	US	US
AM	Ames Industrial	UK	EC
AO	AOI Engine Factory	EG	OT
(Etc.)			

Each engine company is assigned a role for each engine model, describing its manufacturing involvement. The "Roles" file describes the roles and assigns an identification symbol for each. A Manufacturing Agreement Identification Code (MA ID) is assigned each engine model. The code consists of the model designation prefixed by either "S," "L," or "J" to designate whether it was designed and assembled by a single contractor, under a license agreement, or by some type of collaborative agreement between manufacturers. The "Manufacturing Agreement" file lists the engine models by their MA ID, links each to its corresponding contractor and role identification symbols, and assigns a "workshare" fraction to each which allocates the model production value among the manufacturing participants. Table B.2-2 illustrates the "Roles" and "Manufacturing Agreement" files in formats similar to those in the P.D.S. The complete files may be viewed in the P.D.S.

TABLE B.2-2 Formats for the "Roles" and "Manufacturing Agreement" Files

ROLES	
Role ID	**Role Description**
A	Engine Assembler
DP	Developer/Parts Manufacturer
DPA	Developer/Parts Mfg'r/Assembler
M	Engine Program Manager
MP	Manager/Parts Manufacturer
MPA	Manager/Parts Mfg'r/Assembler
P	Parts Manufacturer
PA	Parts Manufacturer/Assembler

MANUFACTURING AGREEMENT			
MA ID	**Contractor ID**	**Role ID**	**Workshare**
J1042	GA	MPA	.700
J1042	AI	PA	.300
L250	AL	DP	.670
L250	MU	PA	.300
SFJ44	WI	DPA	1.000
SGAZELLE	RR	DPA	1.000
	(Etc.)		

Engine production is annualized according to the F.I. data when available, and according to U.T.C. estimates when data were not available. Similarly, the fraction of production entering the civil market is allocated and entered with annualized production for each engine model in the "Production" file. The various aircraft types are assigned a class identification symbol in the "Application Class" file. The "Applications" file associates the MA ID with a specific aircraft application and the Application Class ID. Figure B.2-3 illustrates these three files in formats similar to those in the P.D.S. Complete files may be viewed in the P.D.S.

TABLE B.2-3 Formats for the "Applications," "Application Class," and "Production" Files

APPLICATIONS			APPLICATION CLASS	
MA ID	Application	Class ID	Class ID	Class Description
SPT6A	Beech Starship 1	LT	BJ	Bizjet
SPT6A	Cessna Conquest 1	LT	BM	Bomber
SPW100	EMBRAER EMB-120	LT	DR	Drone
SPW100	Dornier Do.328	LT	HE	Helicopter
SRB211	Lockheed L-1011 - 100/200/250/500	HT	HF	Heavy Fighter
SRB211	Boeing 747 - 200/300/400/SP	HT	HT	Heavy Transport
SRB211	Boeing 767 - 200/200ER/300/300ER	HT	LA	Light Aircraft
SRB211	McDonnell Douglas MD-11	HT	LC	Lighter-than-Air
	(Etc.)			

PRODUCTION			
MA ID	YEAR	Number Produced	Civil Fraction
J731	1983	10	.80
J731	1984	30	.80
J731	1985	60	.80
J731	1986	110	.80
J731	1987	140	.80
J731	1988	180	.80
JADOUR	1970	6	0.00
JADOUR	1971	40	0.00
JADOUR	1972	60	0.00
	(Etc.)		

Each type of aircraft turbine engine (jet, shaft, etc.) is assigned an identification symbol in the "Engine Type" file, and an appropriate symbol is assigned each engine model in the "Engine" file. A price correction factor to convert "current dollar" value estimates to "constant dollar" estimates may be entered in the "Price Correction" file. The inflation/deflation rate from year to year entered in this file would correct previously-entered value data to a now-year estimate. All value data currently in the P.D.S. are in 1989 dollars; the correction factor consequently is set at 1.0 to output information in 1989 dollars. Engine type, size, and value data are contained in the "Engine" file. Table B.2-4 illustrates the

"Engine Type," "Price Correction," and "Engine" files in formats similar to those in the P.D.S. Complete files may be viewed in the P.D.S.

TABLE B.2-4 Formats for the "Engine Type," "Price Correction," and "Engine" Files

ENGINE TYPE

ID	Engine Type
EX	Expendable
PF	Propfan
TF	Turbofan
TJ	Turbojet
TP	Turboprop
TS	Turboshaft

PRICE CORRECTION

Year	Factor
1989	1.000

ENGINE

MA ID	Model	Series	Engine Type ID	Min. Thrust	Max. Thrust	Price Estimate	Year of Estimate
JT407	T407	400	TP	4,000	6,000	1,250,000	1989
L250	250	C20	TS	420	420	100,000	1989
LCF6A	CF6	50C	TF	46,500	54,000	5,100,000	1989
LCF6B	CF6	50A1	TF	48,000	48,000	5,200,000	1989
S109A	F109	100	TF	1,330	1,330	390,000	1989
SJT15D	JT150	1/4/5	TF	2,200	2,900	550,000	1989
SLTP101	LTP101	600/700	TP	600	750	130,000	1989
SNPT	NPT	171	EX	170	170	20,000	1989
SARRIEL	ARRIEL	1	TS	630	772	150,000	1989
(etc.)							

B.3 Operating Instructions. The Guide presents the user with basic techniques for entering and maintaining information in the P.D.S. Figures describing screen displays illustrate menu choices and data to be entered. P.D.S. sessions are shown as instructional exercises; each described in a numbered sequence of instructions accompanied where necessary with un-numbered explanatory text and screen display illustrations. The exercises are presented in a logical and related sequence, which the user should follow to learn the system.

The user may discontinue the exercises at designated points and begin the next exercise in sequence.

Special function keys are differentiated from typed input. Function keys are capitalized between "greater than/less than" symbols (e.g. <RETURN>). Typed input is capitalized and in quotes (e.g., "GE"). [WARNING: DO NOT TYPE THE QUOTATION MARKS--ONLY THE INFORMATION CONTAINED WITHIN THEM.]

B.3.1 Start-up, Help/Menu Functions, Forms. Exercise #1 demonstrates the "start-up" procedure for the P.D.S.

Exercise #1

1. Boot-up the computer and wait for the C:\> prompt to appear.
2. Type "CD DEASE\PDS" at the C:\> prompt, then press <RETURN>.
3. Type the following text substitutng the user's DataEase user name and password when indicated, then press <RETURN>:

DEASE PDS user name password

The P.D.S. main menu will appear on the screen as shown in Figure B.3.1-1. At this point, the P.D.S. system may be exited by pressing <ESC> followed by the letter "Y" when prompted.

```
Universal Technology Corporation Propulsion Database System

1. Application Class
2. Applications
3. Contractor
4. Countries
5. Engine
6. Engine Type
7. Manufacturing Agreements
8. Price Correction
9. <More Menu Choices>

--------1 to 9 -------- UP -------- DOWN -------- RETURN -------- END
```

FIGURE B.3.1-1 P.D.S. Main Menu - Part 1

Help Functions. DataEase has built-in help screens throughout the program providing information concerning the procedures currently being performed. The <F4> key and the <ALT> and <F1> keys are used to access the help screens. Strike the <ALT> and <F1> keys to get help on the current function being attempted. The <ALT> and <F1> help function may have two pages. Page 1 of the help screen is shown in Figure B.3.1-2. The help screen is the same for all sections of the program. The second help screen provides information on the functions associated with the current screen. When moving from one section of the program to another, Page 2 of the help screen may change or not exist.

Pages 1:1-18 - 1:1-19

		HELP
ALT-F1	HELP	Provide help on current function
	SELECTING FROM MENUS	
F1	MORE	Scroll menus
ESC	EXIT	Exit menu
	UP	Previous menu item
	DOWN	Next menu item
HOME	HOME	First menu item
END	END	Last menu item
PGUP	PREV. PAGE	Previous menu page
PGDN	NEXT PAGE	Next menu page
	RETURN	Select highlighted item
	ENTERING DATA IN A FIELD	
F6	CLEAR FIELD	Clear the current field
	LEFT	Delete previous character
	RIGHT	Next character in field
	BACKSPACE	Delete previous character
	RETURN	Next field
INS	INSERT	Insert mode On/Off
---- ALT-F1 EXIT----- F1 MORE HELP ----- CTRL-F1 ON AUTO HELP-----		

FIGURE B.3.1-2 Page 1 of the Help Screen

Figure B.3.1-3 shows the Page 2 help screen associated with the record entry section of DataEase. If the screen being displayed has a second help page, this page will come up first when <ALT> and <F1> are pressed. To switch to the first help page, press <F1>.

Pages 2:2-15-2:2-30

	TO MOVE CURSOR		
	One space left or right		Field above or below
HOME-END	First or last field		Next or previous field
	Next field	PGUP PGDN	Previous or next page
	TO EDIT TEXT		
INS	Turn insert mode On/Off	DEL	Delete current character
	RECORD PROCESSING		
SH-F1	Display table view	F6	Clear field
F2	Save a record	SH-F6	Default for field
SH-F2	Save default record	F7	Delete current record
F3	View next/selected record	F8	Modify current record
SH-F3	View previous record	F9	Quick reports menu
ALT-F3	Continue selected view	SH-F9	Print current record
CTRL-F3	View by record number	ALT-F9	Auto derivation Off/On
F4	Display command menus	CTRL-F9	Rederive all field
F5	Clear all fields	F10	Go to a related file
SH-F5	Read default record	ALT-F10	Ad-hoc multiform
ALT-F5	Enter UNCHECKED mode	CTRL-F10	Lookup to related file
CTRL-F5	Undo record changes	ESC	Exit

--- ----- ALT-F1 EXIT------ F1 MORE HELP ---------CTRL-F1 ON AUTO HELP------------------------------------

FIGURE B.3.1-3 Records Entry Help Screen - Page 2

The other way to get help is to use <F4>. The help provided by this function depends on the screen being displayed. The help functions are divided into subsections. These subsections will be displayed across the top of the computer screen. Using the left and right arrow keys, the help available with each subsection is displayed as the cursor moves among the menu choices. Figure B.3.1-4 shows the help screen associated with the record entry section of DataEase (the cursor on the exit subsection). These help screens can be displayed as assistance is needed.

Exit	Edit	Tools	Search	Table	Multi Form	Report	Default	Multi-User

Exit	ESC
More Help	ALT-F1

FIGURE B.3.1-4 Record Entry F4 Help - Exit Function

If the cursor is moved to the search subsection, the computer screen will look like Figure B.3.1-5.

Edit	Tools	Search	Table	Multi Form	Report	Default	Multi-User

Enter search criteria	ALT-F5
Begin search for criteria	F3
Continue search for criteria	ALT-F3
Next consecutive record	F3
Previous consecutive record	SH-F3
Go to record number	CTRL-F3

FIGURE B.3.1-5 Record Entry F4 Help-Search Functions

Menu Functions. The P.D.S. has menus to help the user operate the database. There are two ways to select a menu option. Either enter the number associated with the menu option or move the curser position with up and down arrow keys to the desired option and then press <RETURN>.

The P.D.S. main menu consists of two parts. The first part is displayed on the computer screen after employing the start-up procedures (B.3-1). Figure B.3.1-1 shows Part I of the P.D.S. main menu, and the selections that can be made are listed on Table B.3.1-1. To reach Part II of the main menu, select option 9. The second main menu screen is shown in Figure B.3.1-6. The selections that are available on Part II are listed in Table B.3.1-2.

TABLE B.3.1-1 P.D.S. Menu Options

Menu Option	Description
1-8	Allows access to the forms indicated at the right of the option number
9	Allows access to Part II of the P.D.S. main menu

```
1. Production
2. Regions
3. Roles
4. <Reports>
5. <DataEase Main Menu>

-------- 1 to 5 --------- UP --------- DOWN -------- RETURN --------- END-------
```

FIGURE B.3.1-6 P.D.S. Main Menu - Part II

TABLE B.3.1-2 Main Menu Options

Menu Option	Description
1-3	Allow access to the forms indicated at the right of the choice number
4	Allows access to defined report procedures
5	Allows access to the DataEase main menu

The P.D.S. report menu may be selected with menu option 4 on Part II of the P.D.S. main menu. Figure B.3.1-7 shows the report menu screen. The selections that can be made on the report menu are listed in Table B.3.1-3.

```
                              Reports

1. Est. value of new units:        Single assembler
2. Est. value of new units:        Co-Dev/Prod
3. Est. value of new units:        Expendable
4. Est. value of new units:        Licensed engines
5. Est. value of new units:        Turboprop/shaft/propfan
6. Est. value of new units:        Turbofan/Turbojet
7. Est. value of new units:        All engines

------- 1 to 7 --------- UP --------- DOWN --------- RETURN --------- END ------
```

FIGURE B.3.1-7 P.D.S. Report Menu

TABLE B.3.1-3 Report Menu Options

Menu Option	Description
	Calculates and prints the estimated value of production on a world regional basis for engines designated as:
1	Manufactured by single assemblers
2	Manufactured through co-development/ production agreements
3	Expendable
4	Manufactured through license agreements.
5	Turboprops, turboshafts, or propfans
6	Turbofans or turbojets
7	All engines in the database

The DataEase main menu is reached by selecting menu option 5 from Part II of the P.D.S. main menu. Figure B.3.1-8 shows the DataEase main menu screen. Brief descriptions of the DataEase main menu options are listed in Table B.3.1-4. The menu definition option (option 5 on the DataEase main menu) is used to define and revise menus. The DBA-defined menus for the P.D.S. are the P.D.S. main menu, Parts I and II, and the P.D.S. reports menu. Revisions made to the P.D.S. may require modifications to the DBA-defined menus.

```
DataEase - Main Menu

1. Form definition and relationships
2. Record entry
3. Query by example - quick reports
4. DQL advanced processing
5. Menu definition
6. Database maintenance
7. System administration

------ 1 to 7 -------- UP -------- DOWN -------- RETURN -------- END --------
```

FIGURE B.3.1-8 P.D.S. Main Menu

TABLE B.3.1-4 DataEase Main Menu Options

Menu Option	Description
1	Form definition and relations: Allows access to the form definition menu, which has options to define, modify, delete, and reorganize forms
2	Record entry: Allows access to the DataEase record entry menu, in turn allowing access to the database forms for input or update
3	Query by example/quick reports: Allows access to the QBE (quick reports menu), allowing the user to define, load, save, or run a report
4	DQL advanced processing: Allows access to the DQL menu, permitting the user to define, load, save, or run a DQL procedure
5	Menu definition: Allows the DBA to define or update menu screens
6	Database maintenance: For use by the DBA, allowing access to the maintenance menu, which permits the DBA to determine the database status, backup or restore the database, lock-unlock the database, and run DOS commands
7	System administration: For use by the DBA, to define users, computer system configuration, printers and styles, and to access database utilities functions

For more information on the menu options, refer to the DataEase Manual, Volume I, User's Guide, pages 1-11.

Basic Form Information. A form displayed on the screen is similar to traditional paper forms on which blanks are filled in with pen or pencil. Instead of filling in the blanks on a paper form, standard keys on the computer keyboard are used to fill in the screen "blanks." A form consists of field names and field data entry locations. Figure B.3.1-9 illustrates a form used in the P.D.S. The CONTRACTORS form contains four individual fields. "Contractor ID" is an example of a single field. A field is simply a holding place for a single item of data and is similar to a single blank on a paper form.

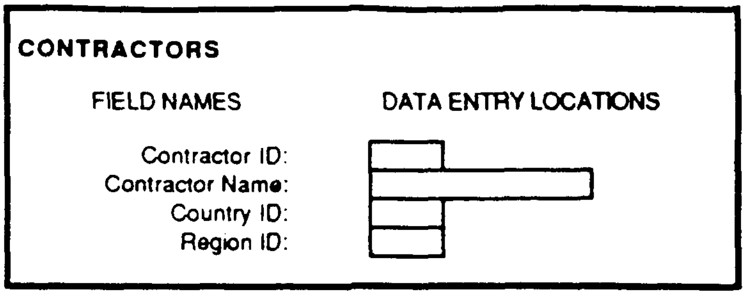

FIGURE B.3.1-9 CONTRACTORS Form Structure

If a form other than those currently installed in the P.D.S. is needed, selecting option 1, "Form Definition and Relationships," from the DataEase main menu places the user at the form definition menu. Select option 1, "Define a Form," from the menu choices. The computer will prompt the user for the form name; simply type a name to get started. Next, type text and field names on the form. To define the field, press <F10> after typing in a field name. The field definition screen will appear; use it to determine the characteristics of the field. Listed in Table B.3.1-5 is a brief description of possible field characteristics. For more information on defining forms, refer to the DataEase Manual, Volume II, Section 2.

TABLE B.3.1-5 Field Characteristics

CHARACTERISTIC	DESCRIPTION
FIELD TYPE	Type of data to be stored: Text, numeric string, number, date, time, dollar, yes or no, or option
REQUIRED?	Mandatory for the user to make a data entry
INDEXED?	Allows the field to be stored for efficient record retrieval
UNIQUE?	Allows the field to be designated as part of a record's primary key
DERIVATION FORMULA:	Allows the user to enter formulas that calculate values for a field

(continued)

TABLE B.3.1-5 Field Characteristics (continued)

PREVENT DATA-ENTRY?	An option that allows the user to define a field that refuses data entry
LOWER LIMIT:	An option that allows the user to define a minimum acceptable value for a given field
UPPER LIMIT:	An option that allows the user to define a maximum acceptable value for a given field
VIEW SECURITY:	A restrictive option that allows only certain defined users in the database to see certain fields on the screen
WRITE SECURITY:	A restrictive option that allows only certain defined clearance level users to enter data in given fields
FIELD HELP:	An option that allows the user to define custom help messages
FIELD COLOR:	An option that allows the user to define coloring alternatives
HIDE FROM TABLE VIEW:	An option that allows user to keep the given field from being displayed

Forms may require modifications to incorporate changes to the P.D.S. To modify a form, select option 1 "Form Definition and Relationships," from the DataEase main menu. This action will bring up the form definition menu. Select option 2 "View or Modify a Form," to edit a previously defined form. Next, select the name of the form to be modified from the list that appears on the computer screen. Changes can be made to the field names using typical editing procedures in conjunction with the editing functions. The editing function keys are displayed on the computer screen. To edit the field entry locations, move the cursor to field position and press <F10>, thus displaying the field definition screen and allowing changes to the field characteristics. Table B.3.1-5 shows the characteristics that can be changed for a given field. After the necessary changes have been made, press <F2> to save the modifications. For more information on modifying forms, refer to the DataEase Manual, Volume II, Chapter 2.

B.3.2 Reviewing Data. Reviewing data involves retrieving the data from the database on the hard disk and viewing the data through a form displayed on the screen. Searches for data in the database are initiated using either <F3> or <ALT> and<F5>.

Unqualified Search. With an unqualified search, the user does not specify a search value when obtaining data from the database, but simply retrieves the first available set of information. To review data, first load a form on the computer screen. A form can be accessed by the P.D.S. main menu or by the record entry option available on the DataEase main menu. Once the form is displayed, press <F3> to retrieve the first record. Subsequent records are displayed by successively pressing <F3>. When the last record has been retrieved, the computer will generate a message reading, "no record on screen" in the system message area. Exercise #2 demonstrates the process for conducting an unqualified search.

Exercise #2

1. Load the CONTRACTORS form on the computer screen (from the P.D.S. main menu).
2. Press <F3> to call up the first record (see Figure B.3.2-1).
3. Press <F3> again to retrieve the next record.
4. Continue to press <F3> until the record is found or the end of the record entries is reached.

CONTRACTORS

Contractor ID:	TE
Contractor Name:	Teledyne CAE
Country ID:	US
Region ID:	US

FIGURE B.3.2-1 CONTRACTORS Form After Record Retrieval

Qualified Search. A qualified search is a query in which the user specifies criteria (values) in one or more fields to retrieve information about a particular set of data. The criteria specified by the user may be any value for one or more of the enterable fields in a form, depending on how specific the user wants the query to be. The qualified search procedure saves time because the search retrieves only those records specified with certain field values, eliminating the necessity to "thumb through" each record. If specific pieces of data are desired, a query value must be typed exactly as the data are shown in the database. (Exception: The user need not specify upper or lower case lettering when searching the database.) The P.D.S. will search for the data exactly matching the query (if data are mistyped, the P.D.S. will search futilely for the mistyped entry).

Another way to specify a qualified search, is by using the wildcard character--the asterick (*). When specifying a value in a field during a qualified query, (*) represents any number of unknown characters. For example, to see all records beginning with the letter "A" in the CONTRACTORS form, enter "A*" in the "Contractor Name" field. The wildcard character may be used many times in the same field and in multiple fields during the same query.

To conduct a qualified search, the form on which the search will occur must be loaded on to the screen. A form can be accessed through the P.D.S. main menu or the record entry option of the DataEase main menu. Once the form is on the computer screen, press <ALT> and <F5> to start the search. This action will cause the computer to show the message "unchecked" in the system message area. Move the cursor to the field or fields of interest and type in the search values. Next press <F3> to initiate the search for the matching records. Only the first matching record will appear on the screen. To see the other matching records, press <ALT> and <F3>. When all the matching entries have been displayed, the computer will show "no more data" in the system message area. Exercise #3 demonstrates the process for conducting qualified searches.

Exercise #3

1. Load the CONTRACTORS form on to the computer screen.

2. Press <ALT> and <F5>. The computer will show "unchecked" in the system message area.

3. Type "GE" in the "Contractor ID" field.

4. Press <F3> to conduct the search. Figure B.3.2-2 shows the computer screen after the search has been completed.

CONTRACTORS

Contractor ID:	GE
Contractor Name:	General Electric
Country ID:	US
Region ID:	US

FIGURE B.3.2-2 CONTRACTORS Form after "GE"Query

5. Press <ALT> and <F5>. This action will cause the fields to clear and the message 'unchecked" to come up in the system message area.

6. Type "G*" in the "Contractor ID" field.

7. Press <F3> to conduct the search. The first matching record will be displayed. See Figure B.3.2-3 to review the results of the query.

CONTRACTORS

Contractor ID:	GA
Contractor Name:	Garrett Engine Div.
Country ID:	US
Region ID:	US

FIGURE B.3.2-3 CONTRACTORS Form After "G*" Query

8. Press <ALT> and <F3> to continue the search. The second record will be brought up to the computer screen. See Figure B.3.2-4 to review the result of the continued query.

CONTRACTORS

Contractor ID:	GE
Contractor Name:	General Electric
Country ID:	US
Region ID:	US

FIGURE B.3.2-4 CONTRACTORS Form After Continuing the "G*" Query

B.3.3 Inserting Records. To insert data in a form, first display the form into which the data are to be inserted. Forms can be accessed from the P.D.S. main menu or through the record entry option available on the DataEase main menu. After selecting a form, the computer will display it and position the cursor on the first data field entry location. Switching from the form environment to the table environment is accomplished by pressing <SHIFT> and <F1>. Data entry may be easier in the table environment for some projects. <INSERT> may be toggled on and off depending on user preference during data entry. When <INSERT> is off, information in the field will be replaced; when <INSERT> is on, new characters will be inserted in the field.

The information being entered into the field must match the defined field characteristics or an error message will be generated by the computer. To identify the field characteristics, view the field definition by following the procedure described in Section B.3-1. Exercise #4 demonstrates the procedure for inserting data into fields.

Exercise #4

1. Select the CONTRACTORS form from the P.D.S. main menu. The form will look like Figure B.3.1-9
2. Enter "CW" in the "Contractor ID" field. With that field now full, the computer will move you to the next field.
3. Enter "Curtiss Wright" in the "Contractor Name" field. Press <RETURN> when the name is completely typed to enter the data and move to the next field.
4. Press <F2> to save the data inputs.

The above creates a new record on the CONTRACTORS table. Figure B.3.3-1 displays the form with the newly input data.

CONTRACTORS	
Contractor ID:	CW
Contractor Name:	Curtiss Wright
Country ID:	
Region ID:	

FIGURE B.3.3-1 CONTRACTORS Form After Data Entry

5. Press <SHIFT> and <F1> to switch to the table environment.
6. Move the cursor to the "Country ID" field to enter "US."
7. Enter "US" in the "Region ID" field.
8. Press <F2> to save the record. The computer screen should look like figure B.3.3-2.

ID	CONTRACTOR NAME	CO	RE
NK	Norsk Jetmotor	NO	OE
SB	Sulzer Brothers	SZ	OE
XI	Xian Aircraft Ind.	CH	OA
JP	Komatsu/Mitsubishi St./Woodward	JP	JP
PW	P&W Canada West Virginia Div.	US	US
SH	Shanghai Engine Factory	CH	OA
IC	Intreprinderea de Constructii	RO	OT
MA	Microturbo North America	US	US
SU	Sunstrand	US	US
CW	Curtiss Wright	US	US

FIGURE B.3.3-2 CONTRACTORS Table After Data Entry

B.3.4 Modifying Records. To change existing information in the database, first find the information that requires modification by calling up the form that was used to enter the data into the database. Once the form is loaded onto the screen, search through the previously entered records to find the one needing modification, using either an unqualified or a qualified search (Section B.3.2). If a large amount of data exists, the qualified search should be the quickest way to locate the desired record. Once the search has been completed, the record requiring modification will be shown on the computer screen. The record can be modified in the form environment or the table environment. In the form environment, either type over the existing data or delete and insert data, then press <F8> to save. In the table environment, either type over the existing data or delete and insert data, and press <F2> to save. <INSERT> will allow a choice between the type-over and insert modes. Notice that the save method in the form environment differs from that of the table environment. If <F2> is pressed in the form environment, a new record is created or the computer prints "record already exists" in the system message area. The <F8> function is not available in the table environment. Exercise #5 demonstrates modifying existing data.

Exercise #5

1. Load the CONTRACTORS form onto the computer screen.
2. Press <ALT> and <F5>.
3. Enter "CW" in the "Contractor ID" field.
4. Press <F3> to conduct the search. The computer display should look like Figure B.3.4-1.

CONTRACTORS	
Contractor ID:	CW
Contractor Name:	Curtiss Wright
Country ID:	US
Region ID:	US

Figure B.3.4-1 CONTRACTORS Form After Data Search

5. Change "CW" in the "Contractor ID" field to "SO."
6. Change "Curtiss Wright" in the "Contractor Name" field to "Solar Turbine." The computer screen should look like Figure B.3.4-2.
7. Press <F8> to replace the old record with the new record.

CONTRACTORS	
Contractor ID:	SO
Contractor Name:	Solar Turbine
Country ID:	US
Region ID:	US

Figure B.3.4-2 CONTRACTORS Form After Data Modification

8. Press <SHIFT> and <F1> to switch to the table environment.

9. Change "SO" in the first column to "CW."

10. Change "Solar Turbine" in the second column to "Curtiss Wright."

11. Press <F2> to save the modified record. The computer screen should look like Figure B.3.4-3.

ID	CONTRACTOR NAME	CO	RE
NK	Norsk Jetmotor	NO	NO
SB	Sulzer Brothers	SZ	OE
XI	Xian Aircraft Ind.	CH	OA
JP	Komatsu/Mitsubishi St./Woodward	JP	JP
PW	P&W Canada West Virginia Div.	US	US
SH	Shanghai Engine Factory	CH	OA
IC	Intreprinderea de Constructii	RO	OT
MA	Microturbo North America	US	US
SU	Sunstrand	US	US
CW	Curtiss Wright	US	US

FIGURE B.3.4-3 Modified CONTRACTORS Table Record

For additional information on modifying record entries, refer to the DataEase Manual, Volume 1, User's Guide, Chapter 2.

B.3.5 Deleting Records. If a record is unnecessary, it may be deleted from the database from either the form environment or the table environment.

To delete a record, first find it. Bring up the form that was used to enter the data originally, either through the P.D.S. main menu or the record entry option on the DataEase main menu. After displaying the form, use the search methods described in Section B.3.2 to find the record to delete. If large amounts of data have been input, a qualified search would be the quickest way to find the desired record. Once the record is found, it will be displayed on the screen. To delete a record from the form enviornment, simply press <F7>. The computer will prompt, "Are you sure you want to delete the record?" Type a "Y" to indicate yes. This action will cause the record to be deleted. To delete a record from the table environment, press <F7>. The computer will highlight the record to indicate that it has been marked deleted. The deletion will not occur until you press <F2>, after which the record will disappear from the screen. Exercise #6 demonstrates the deleting process.

Exercise #6

1. Load the CONTRACTORS form onto the computer screen.
2. Press <ALT> and <F5> to start a query.
3. Enter "CW" in the "Contractor ID" field.
4. Press <F3> to conduct the search. The record appearing on the screen should look like Figure B.3.5-1

CONTRACTORS

Contractor ID:	CW
Contractor Name:	Curtiss Wright
Country ID:	US
Region ID:	US

FIGURE B.3.5-1 CONTRACTORS Form After Query

5. Press <F7>. The computer will prompt for a yes or no answer. Type "y" to delete the record. The computer will indicate that the record has been deleted. The form will still display the record that was deleted.
6. Press <F2> to reinstate the deleted record.
7. Press <SHIFT> and <F1> to switch to the table environment. The computer screen should look like Figure B.3.4-3 at this point.
8. Press <F7> to mark current record for deletion. This action will cause the record to be highlighted.
9. Press <F2> to remove the record from the screen and the database. The computer screen should look like Figure B.3.5-2.

ID	CONRACTOR NAME	CO	RE
NK	Norsk Jetmotor	NO	OE
SK	Sulzer Brothers	SZ	OE
XI	Xian Aircraft Ind.	CH	OA
JP	Komatsu/Mitsubishi St./Woodward	JP	JP
PW	P&W Canada West Virginia Div.	US	US
SH	Shanghai Engine Factory	CH	OA
IC	Intreprinderea de Constructii	RO	OT
MA	Microturbo North America	US	US
SU	Sunstrand	US	US

FIGURE B.3.5-2 CONTRACTORS Form After Record Deletion

If more information is needed on how to delete records, refer to the DataEase Manual, Volume 1, User's Guide, Chapter 2.

B.3.6 Report Procedures. Reports are used to output data from the database. A report can be written to extract, perform processing, or make calculations with information contained in the database. The output can be directed to the screen, printer, or disc file. There are three ways to generate reports: DataEase quick reports, DataEase DQL procedures, and the P.D.S. reports menu.

DataEase Quick Reports. To access the quick reports menu, select option 3 from the DataEase main menu. The quick reports menu can create, modify, load, delete, and run reports. A set of reports was generated for the P.D.S. When a user tries to load a report, a list of the currently available reports will be displayed on the screen. More information on how to work with Quick Reports is available in the DataEase Manual, Volume 1, User's Guide, Chapter 3.

DataEase DQL Reports. The DQL menu, accessed by selecting option 4 from the DataEase main menu, controls creating, modifying, loading, and displaying various DQL reports. Reports developed by the DataEase quick reports procedure may be converted to DQL procedures. Reports currently contained in the P.D.S.and retrievable through the DQL menu are:

1. **P.D.S. Data Table Reports.** The following eleven report procedures output data contained in the corresponding tables:

Applications	Manufacturing Agreement
Application Class	Price Correction
Contractors	Production
Countries	Regions
Engine	Roles
Engine Type	

2. **P.D.S. Revenue Reports - Engine Types.** The following seven report procedures calculate total (both civil and military) production value associated with the listed engine types, by region, from 1970 through 1988:

Engines	Coproduced
Expendable	Licensed
Turbofan/jet	Single Manufacturer
Turboprop/shaft	

3. **P.D.S. Revenue Reports - Civil Production:** Annual values of the civil segment of production, by region, from 1970 through 1988 are calculated and displayed for each of the engine types listed in paragraph 2.

4. **P.D.S. Revenue Reports - Military Production:** In a manner similar to paragraph 3., annual value of production for the military market is calculated and displayed for each of the various engine types.

5. **P.D.S.Revenue Reports - Other:** These four reports break out annual production value for coproduced shaft and jet/fan engines and for licensed and single manufacturers of jet/fan engines, by region, from 1970 through 1988.

6. **P.D.S. Data Manipulation Reports:** The single report currently existing in this category displays information by region, listing engine manufacturer, manufacturer production role, engine model and series, engine type, power rating, and country of manufacture.

Additional information concerning DQL processing procedures is contained in the DataEase Manual, Volume 3, "DataEase Query Language Guide."

P.D.S. Report Menu. The P.D.S. report menu was developed to produce reports that are run frequently. The menu allows the user to run the reports listed on the menu screen. Table B.3.1-3 provides a brief description of the information generated by each menu choice. Table B.3.6-1 shows the relationship between the DQL report procedures and the P.D.S. report menu choices.

TABLE B.3.6-1 DQL Procedures Associated with Report Menu Choices

P.D.S. Report Menu Choice	DQL Report Procedure
1. Est. value of new units: Single Assembler	All single manufacture
2. Est. value of new units: Codev/prod.	All coproduced
3. Est. value of new units: Expendable	All expendable
4. Est. value of new units: Licensed Engine	All licensed
5. Est. value of new units: Turboprop/shaft/propfan	All turboprop/shaft
6. Est. value of new units: Turbofan/Turbojet	All turbofan/jet
7. Est. value of new units: All engines	All engines

B.3.7 Exit Procedures.

Current Screen. When ready to leave the screen being displayed, make sure to save the work, then press <ESC>. This action will transfer the display to the previous screen. If the work was not saved before pressing <ESC>, the computer will prompt with: "Do you want to abandon the record on the screen?" Type "Y" for yes, or "N" for no, after which the computer will transfer to the previous screen display.

P.D.S. When ready to leave the P.D.S., save the work, then press <ESC> until the computer prompts with: "Exiting DataEase--Are you sure?" Type "Y" to leave the P.D.S. If the work was not saved, the computer will prompt with: "Do you want to abandon the record on the screen?" Type "Y" for yes, or "N" for no, after which the computer will transfer to the previous screen. [WARNING: IT IS VERY IMPORTANT THAT THE P.D.S. BE EXITED PROPERLY TO HELP PREVENT ERRORS FROM OCCURRING IN THE DATABASE. BE SURE TO EXIT PROPERLY BEFORE TURNING OFF THE COMPUTER.]

B.3.8 Error Handling. Errors may be generated by the user, DataEase software, or computer hardware. User error messages typically will be displayed on the screen with a brief explanation of the problem. Hardware/software errors may result in unrecognizable characters, the P.D.S. not performing properly, computer "lock-up," or error messages displayed on the screen. If errors are encountered, document the circumstances surrounding the problem. Record the date, time, and the activity being performed when the error occurred, and report the information to the DBA and the assigned P.D.S. support developer. Listed below are a few suggestions regarding the actions to take if an error occurs.

User Errors. User errors will be shown on the screen when they occur. The generated error message usually contains sufficient information to correct the problem. If the error message on the screen is not descriptive enough, the error messages section of the DataEase Manual, Volume 1, User's Guide, Appendix B, may provide additional information. If unable to correct the problem, contact the DBA.

Hardware and Software Errors. If there is difficulty in "booting up," the cause of the problem may be either the hard disk or incompatibilities between the hard disk/directory definitions and the AUTOEXEC.BAT file.

If the computer screen becomes "locked up" and no activity can take place, reboot (reset) the computer. Follow the start-up procedure (B.3.1) to restart. If this does not resolve the error, Appendix B of the DataEase Manual, Volume 1, User's Guide, may provide the solution to the problem. If unable to correct the problem, contact the DBA.

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