

**Best
Available
Copy**

United States General Accounting Office

GAO

Report to Congressional Requesters

AD-A280 510



May 1994

ASIAN AERONAUTICS

Technology Acquisition Drives Industry Development



94-19137



BEST AVAILABLE COPY

National Security and
International Affairs Division

B-256707

May 4, 1994

The Honorable Tim Valentine, Chairman
The Honorable Tom Lewis, Ranking Minority Member
Subcommittee on Technology, Environment, and Aviation
Committee on Science, Space, and Technology
House of Representatives

DTIC
ELECTE
SUB D
JUN 23 1994

In recent years, American industries that once enjoyed worldwide preeminence have come under increasing competitive pressure from abroad. In response, a great deal of attention has been paid to identifying the means by which other nations create new technologies and bring them to market. Recent developments—notably the emergence of aircraft manufacturing companies in Europe and Japan—have focused this attention on the U.S. aeronautics industry.

This report responds to your request that we review the aeronautics research and development (R&D) activities of Asian countries. More specifically, we are providing information on (1) the approaches these Asian nations use to develop their aeronautics industries, (2) the level of aeronautics development each country has achieved, and (3) the implications of this development for the U.S. aeronautics industry. This report represents an amalgamation of many pieces of data obtained from dozens of U.S. and foreign sources. However, because of the nature of much of the data, we were unable to verify its accuracy or make an independent assessment of the extent and progress of each country's R&D efforts.

Accession For	
NTIS GRA&I	<input checked="" type="checkbox"/>
DTIC TAB	<input type="checkbox"/>
Unannounced	<input type="checkbox"/>
Justification	
By	
Distribution/	
Availability Codes	
Dist	Avail and/or Special
A-1	

Background

The aeronautics industry is diverse, ranging from large airframe and engine manufacturers to numerous producers of avionics, smaller aircraft, and parts. All segments are affected by changes in the worldwide aviation market. Due to continuing defense cuts and a weak global economy, orders for American military and civil aircraft are decreasing. In the large civilian aircraft market, lower demand for the major U.S. producers—Boeing and McDonnell Douglas—is made more severe by competition with the European-based Airbus Industrie, which reportedly holds about one-third of the current world backlog of firm orders. The Department of Commerce has reported that suppliers of aircraft structures, systems, and components are undergoing unprecedented consolidation and that many companies will leave the industry for good.

DISTRIBUTION STATEMENT A
Approved for public release
Distribution Unlimited

In this environment, U.S. companies are searching overseas for new customers and partners. Increasingly, they are turning to Asia, a region with great growth potential for aviation. In the next two decades, air traffic to, from, and within Asia is expected to account for more than 50 percent of the world market. Asian orders for commercial aircraft are also expected to rise significantly, with Japan and China leading in purchases of passenger jets. Access to Asian markets has become a primary business objective of U.S. and European aircraft manufacturers, and Asian aircraft buyers have responded by demanding a measure of technology transfer with each purchase. This has enabled some Asian companies to become competent in newer and more advanced technologies without incurring all of the risks of development and has allowed U.S. companies to share development costs.

Results in Brief

The four Asian nations we visited—Japan, China, Indonesia, and Taiwan—appear intent on developing their own aeronautics industries. These nations are acquiring technologies developed in the West, building aeronautics products based upon them at lower cost, and trying to improve those products over time. In addition, these countries are attempting to build domestic R&D infrastructures in order to enhance acquired technologies. Carefully applied, this approach allows Asian nations to develop industrial and technological capabilities in a fraction of the time needed to cultivate them from scratch.

Each of the Asian nations we surveyed is employing a similar method of developing its indigenous aeronautics industry. Essentially, this method is characterized by (1) strong government support; (2) importation of technologies; (3) a strong emphasis on applied—as opposed to theoretical or basic—research; and (4) direct, synergistic links between military and civilian aeronautics projects.

Despite the similarity of methods they apply, Asian countries' aeronautics industries are not equally developed and can be expected to continue to develop at varying rates because of differences in their political and economic environments.

In the immediate future, it appears unlikely that Asian aeronautics companies will compete directly with American aircraft builders. Some form of cooperation is more likely because (1) U.S. companies claim to zealously guard their critical technologies, even from transfer to their Asian "partners;" (2) Japan is the only Asian nation capable of designing

and producing jet aircraft, but Japan appears unlikely to initiate a new aircraft program without the cooperation of Western companies; and (3) in the large commercial aircraft sector, development costs are so steep that any new programs are likely to require partnership arrangements. Nevertheless, some industry observers are concerned that, in the long term, cooperative aeronautics technology transfer to Asia could help create a new competitor for the U.S. aeronautics industry.

Common Strategy for Industry Development Employed

Four principal features typically characterize the state of the Asian aeronautics industries: (1) the national government strongly supports—and sometimes initiates—industry development; (2) Asian countries usually import product and process technologies, instead of developing such technologies indigenously; (3) Asian nations emphasize applied R&D activities over theoretical research, and almost all research activity is expected to yield downstream commercial benefits; and (4) the countries use acquired technologies interchangeably on military and civilian aeronautics projects. Application of these features has enabled some Asian countries to become active and competitive in some segments of the worldwide commercial aircraft market. Although the focus of the Asian effort is currently on manufacturing aircraft parts, some countries—notably Japan and Indonesia—have acquired the technology and expertise to manufacture short-haul passenger aircraft.

Government Support

In Asia, national governments drive and support the process of developing aeronautics industries. Government offices are established to draw up timetables and to facilitate cooperation between, and award contracts to, manufacturing corporations. In some cases, the enterprises that import technology and design and build aircraft are owned in part or outright by the government. Funding to support these ventures flows from national governments to aeronautics projects via a number of mechanisms that are often difficult to track. Examples of how Asian governments support their aeronautics industries include the following:

- The Japan Ministry of International Trade and Industry (MITI) continues to plan—and in some ways direct—the means by which Japan's largest aeronautics companies proceed in their development. MITI brokers agreements between those companies when they seek to build the same components for aircraft. MITI also arranges collective corporate agreements and favorable financial provisions that reduce the companies' financial risk. For example, the business plan for the Japan Research

Development Corporation, the consortium of Japanese aircraft companies that make parts for the Boeing 767 jet, states that the break-even point for the entire consortium shall be the point at which all of the members are profitable. In addition, some \$350 million of Japanese companies' development costs on the Boeing 777 project are eligible for MITI support. MITI has also proposed a \$750-million initial allocation in its 1994 budget request to the consortium for development of a jet engine to be used on their regional jet aircraft project.

- Taiwan Aerospace Corporation (TAC) is owned in part by the Taiwan government. The government claims the ability to summon enough public and private capital to support the corporation's ambitious aeronautics design and production agendas. Public subsidies, low-interest loans, and tax credits totaling up to 50 percent of total costs have already been provided to aeronautics projects in Taiwan.
- In Indonesia, the aeronautics company is state-owned. It has relied on funding from the national budget for every aspect of its operations and development, including extensive consulting arrangements with Western aircraft manufacturers.

Government support of the aeronautics industry may be affected by changes in international trade agreements. As part of the recently concluded Uruguay Round of the General Agreement on Tariffs and Trade (GATT), a new Subsidies Code, which covers civil aircraft, could restrict governments' ability to subsidize industry, if adopted by GATT members.

Technology Acquired Overseas

All of the Asian countries we reviewed acquire product and process technologies from the United States and Europe. The transfer of technology is often stipulated by Asian organizations when they negotiate to purchase Western equipment, and can be accomplished via a number of cooperative programs, including subcontracting, licensed production, and codevelopment. Because the quality assurance and quality control processes inherent in aeronautics manufacturing are so detailed and rigorous, all forms of cooperative agreements between Asian and Western companies are likely to result, at the very least, in the transfer of important process technology from West to East. Once acquired, these technologies can be honed and improved upon. Consequently, what starts as a subcontract to produce latches on cargo doors, for example, develops over time into fuselage, wing, and avionics manufacturing. Examples of technology transfers follow:

- Japan has demonstrated consistent improvement in its aircraft component-building capabilities, after years of subcontracting from Western manufacturers. Japan's work share on Boeing jets has increased markedly, from the 737 to the 767 to the 777. Furthermore, Boeing and the Japanese aircraft makers may be planning a regional jet project in which Boeing for the first time may play a subordinate role to its Japanese partners.
- Indonesia now produces a regional aircraft it co-designed with a Spanish partner. The design experience gained in this exercise is being put to use on a follow-on aircraft, to be designed and built within Indonesia.
- U.S. aviation companies have promised to allow Taiwan to build aircraft and engine parts, acquire U.S. technology, and receive training and other support for its developing aeronautics industry. These credits, totaling some \$700 million, were granted in exchange for Taiwan's purchase of American aircraft and engines. The People's Republic of China also has obtained such agreements when it has negotiated with Western aircraft makers for the purchase of passenger planes. Typically, China has received the right to build parts equal to 20 percent of the total value of purchased aircraft.
- TAC has tried to buy aircraft production capability outright. The company has attempted to purchase substantial stakes in British Aerospace and McDonnell Douglas in the last 2 years.
- The People's Republic of China is currently in the process of upgrading its existing aeronautics technology base by acquiring advanced machinery and tooling from Western nations. China has entered into a number of coproduction agreements with Boeing and McDonnell Douglas, including licensed final assembly of passenger jets for McDonnell Douglas.
- Over 80 percent of the aeronautics faculty of the National Cheng Kung University, in Taiwan, were educated at Western universities. Other Western-educated students have returned to lead high-technology projects in their home countries. For example, the minister-level head of Indonesia's aircraft company, and the top executives of TAC, received engineering degrees in Germany and the United States, respectively.

Focus on Applied Research

One of the most prominent features of aeronautics R&D in Asia is its emphasis on commercial application. At almost all of the research institutes we visited, the emphasis was on *applied technological research* with direct commercial or military applications. Examples include the following:

-
- The entire research budget of Taiwan's Industrial Technology Research Institute, and the majority of research funding for the Taiwan National Science Council, are devoted to applied research.
 - According to scientists in the People's Republic of China, requests for basic research funding must now describe how such projects ultimately will yield marketable products. This development marks a change from the past, when projects were funded for longer terms and usually had no stated commercial goals.
 - The research arm of the Japan Defense Agency provides funding—up to 20 percent of total costs in some cases—to research projects identified as critical by Japan's private sector corporations. In this way, Japanese companies are assisted in bringing their technologies to market, and the Japanese military is readily able to incorporate technological innovations into its weapon systems.

Military/Civilian Synergies

Asian nations do not strictly separate the manufacturing operations of their military and civilian aeronautics projects. The ability to shift machines, tooling, and trained personnel from military to civil production provides a measure of flexibility to Asian aircraft manufacturers. Examples from the countries we visited include the following:

- The plants of Japan's large aeronautics companies often house military and civil assembly lines side by side. Workers trained on one line are often shifted to another. Expensive composite-material processing equipment, purchased by the government for military projects, is subsequently used to process parts for civil aircraft.
- TAC plans to use Taiwan's principal military aircraft facility to manufacture regional jetliners. This facility, the Aeronautical Industry Development Center, is regarded by experts as one of the most complete and sophisticated aircraft production shops in Asia. Although it currently produces only fighter planes, Taiwan authorities told us that it could readily be converted to regional passenger plane manufacture.
- In the People's Republic of China, sophisticated manufacturing technologies acquired through cooperative programs with the West are being adapted for Chinese military use. For example, flush-mounted riveting, once observed in China only on aircraft jointly manufactured with the West, is now seen on Chinese fighter planes that previously lacked this degree of sophistication.

Asian Countries Differ in Their Levels of Aeronautics Development

Despite their similar approaches, the Asian countries we reviewed do not have equally developed aeronautics industries. For instance, Japan, which began systematically importing aeronautics technology in the 1970s, now leads Asia in the sophistication of its R&D infrastructure and the capacity of its industrial base. Indonesia, which also embarked on its aeronautics program in the 1970s, is designing and producing passenger aircraft now, but has not developed the R&D infrastructure or manufacturing capacity evident in Japan. The authorities in Taiwan, which only recently began its foray into aeronautics, have indicated that they are prepared to commit billions of dollars to carry out an ambitious agenda of aeronautics industry development. And the People's Republic of China is embarking on a plan to modernize its aeronautics industry, but it most likely will need financial and technological help from other nations to eventually succeed in supplying jet transports for its own growing aviation market.

Japan

Japan is now among world leaders in aeronautics subsystem manufacturing, and appears to have the capability to design and build passenger aircraft on its own. This is the result of systematically importing Western aeronautical technology after failing to successfully market an indigenously designed and produced airplane, the YS-11. For years Japanese aircraft companies have acted as subordinate partners to American companies, particularly Boeing. The Japanese work share on Western planes has increased markedly over the years. Japan is currently negotiating to lead the development of a regional jet, with either Boeing, China, or European entities acting as subordinates. Some industry observers told us that such an arrangement would mark the emergence of Japan as an aeronautical competitor against the United States.

Our review indicates that Japan, with strong government support, has created the best-developed aeronautical research, development, and production infrastructure in Asia. U.S. industry representatives told us that Japan's manufactured components for American passenger airplanes are the best in the world. Japan has heavily invested in its infrastructure and has made enough advancements in other areas to be recognized as a world leader in several technological fields critical to developing new aircraft. Examples include the following:

- Japanese companies have a 23-percent share of a joint international effort to produce a high-performance, low-noise, low-pollution fanjet engine (the V2500) for a 150-passenger transport. The same companies also have work shares on the General Electric 90, Pratt & Whitney 4000, and Trent 800

engines that will be used to power large commercial passenger jets such as the Boeing 777.

- Japanese companies will invest \$226 million in new and/or upgraded facilities for their work associated with the Boeing 777 program.
- Mitsubishi Heavy Industries is developing a new aircraft power plant, the hypersonic Liquid Air Cycle Engine. Basic design and ground tests are scheduled to begin in 1995.

Japan's current economic recession has slowed the development of the aeronautics industry, according to Japanese industry representatives. The government of Japan continues to support this industry and shield it from a measure of financial risk, but according to Japanese government officials, the recent change in ruling political parties in Japan may indicate an impending change in the relationship between government and industry there.

In addition, Japan's sophistication and industrial capacity are perhaps mitigated by its complex relationship with the United States. The need to keep trade imbalances in check, and the stated aversion of the Japanese to compete directly against Boeing, may temporarily keep Japan from designing and building passenger jets. However, according to U.S. government officials, Japan may be able to address these issues and proceed toward indigenous capability by taking Boeing on as a major partner in a Japanese aircraft-design project. This sort of arrangement reportedly is being discussed by representatives of Boeing and the Japanese aeronautics companies.

Indonesia

Indonesia has collaborated extensively with European and American aircraft manufacturers since the 1970s, and has developed a sophisticated regional aircraft R&D and production infrastructure as a result. Industri Pesawat Terbang Nusantara (IPTN), Indonesia's state-owned aeronautics company, is planning to produce a 64-seat turboprop aircraft in 1995, and plans to embark on a 100-seat commuter jet program thereafter. Officials at IPTN told us that this progress would not have been possible without the partnerships IPTN established with Western companies. Although IPTN's products do not compete directly against any U.S.-manufactured aircraft, the company is notable for the pace at which it has developed and the cooperation with Western companies that has facilitated that development.

In 1990, Indonesia spent \$1 billion to upgrade the IPTN facility. IPTN manufactures a variety of aircraft components and sections, ranging from wing trailing flaps for Boeing's 737 aircraft to cockpits, fuselage, and fin connections for Airbus¹ aircraft. IPTN also produces (under licensing agreements) the 35-seat CASA CN-235 aircraft and a variety of helicopters, including the Bell 412, Eurocopter B0105, and the NES-332 Superpuma. The licensed production of the CN-235 was instrumental in providing Indonesia the design and production technology capability needed to proceed with the development of the larger, 64 seater due out in 1995. Total program costs for this aircraft, the N-250, are estimated at \$1.2 billion, and the per aircraft cost is expected to be \$10 million to \$11 million. IPTN has taken tentative orders for 157 N-250s, and recently opened an office in Seattle to promote sales of the aircraft in the United States. Indonesia has developed an aircraft engine overhaul and repair facility at IPTN. In addition, IPTN's Universal Maintenance Center is rapidly becoming a major competitor in the southeast Asian engine overhaul and repair business.

For now, political and economic conditions in Indonesia appear favorable for continued progress toward IPTN's goals of designing and building aircraft indigenously.

Taiwan

Taiwan plans to develop its aeronautical industry in two ways: (1) manufacturing and testing of components and (2) airframe manufacturing. Authorities in Taiwan believe they can raise the capital needed for these ventures from the island's privately held foreign reserves.

Taiwan's Center for Aviation and Space Technology is coordinating the training and certification of companies that intend to produce aircraft parts for Taiwan's aeronautics industry. The Center disseminates research results and is cooperating with Boeing on the construction of a laboratory that will verify the quality of parts produced in Taiwan. TAC intends to build passenger jets using Western technology. TAC's plans include the purchase of Western aircraft assembly lines and conversion of Taiwan's military aircraft plants to civilian use. To date, TAC has attempted to strike deals with two foreign companies—McDonnell Douglas and British Aerospace—but has not succeeded.

¹Airbus is a consortium of the major civil aircraft manufacturers in France, Germany, the United Kingdom, and Spain.

According to U.S. officials, the development of TAC appears to have been aided by strong, one-party rule in Taiwan. Recently, however, opposition parties have been effective in blocking funding for large technology infrastructure projects, such as high-speed rail. The emergence of viable opposition politics may presage a change in the relationship between government and industry. Consequently, time frames once considered feasible may slip.

Taiwan officials stated that their relative lack of experience in civil aeronautical design and manufacture may also slow industry development. Although apparently capable of funding large projects, Taiwan's plans require that a number of burdensome financial and regulatory timetables be met. Furthermore, without British Aerospace or McDonnell Douglas, TAC will need a new business partner if it is to develop rapidly.

China

The Chinese aviation industry, which operates under the central control of Aviation Industries of China (AVIC), is marked by overcapacity and comparatively lower technology. To counter this, AVIC is taking steps to modernize the industry to enable it to operate in a market economy. AVIC factories employ some 500,000 workers throughout China, but securing customers for AVIC's aeronautical products and services is difficult. To compensate for this, roughly 70 percent of AVIC's industrial output is non-aeronautical in nature, and includes automobiles, bicycles, motorcycles, and motor parts. AVIC's metal-forming, composite materials, and aircraft assembly equipment are older and less sophisticated than analogous equipment we observed elsewhere in Asia. Consequently, it appears that China may be the slowest among the Asian nations we surveyed to develop an aeronautics industry competitive with the United States.

China's current condition notwithstanding, AVIC is taking significant steps to develop an aircraft industry to help fulfill the needs of China's growing air travel market. These include a 3-year plan to make AVIC financially self-supporting, and a number of ongoing and planned cooperative ventures with Western aeronautics companies, including Boeing, Aerospatiale, McDonnell Douglas, and General Electric. We observed wing components for Boeing and Aerospatiale aircraft being manufactured, and McDonnell Douglas MD-82 aircraft going through final assembly, in AVIC facilities.

China may look beyond its borders not only for technology, but also for financing as it develops its aeronautics industry. Several officials told us that China, Hong Kong, Singapore, and Taiwan could pool their capital and manufacturing capacities to fund, design, and build passenger aircraft for the Chinese market.

The largely outmoded nature of China's aeronautical industrial infrastructure, as well as political obstacles—notably the lack of normalized relations between Taiwan and China—will most likely slow the progress of China's aeronautics industry. Still, because the Chinese market for passenger aircraft is expected to grow rapidly in the next 20 years, investments aimed at meeting demand at least in part through domestic production probably will continue. Although the TAC-McDonnell and TAC-British Aerospace deals were never completed, development capital earmarked for aeronautics continues to flow into mainland China from Taiwan, Hong Kong, Singapore, and elsewhere.

Implications for the U.S. Aeronautics Industry

The aeronautics industry in the United States is immense, and provides direct and indirect benefits throughout the entire economy. The industry employs roughly a million workers and is a key exporter. Furthermore, it acts as a technology driver, spinning off advanced process and product technologies with applications to other industrial sectors.

Development of Asian industries is linked to the acquisition of Western technology, as American companies provide already developed technology in return for Asian business. Such technology transfer has both benefits and drawbacks. For example, by developing the manufacturing capabilities of Asian companies, American jet builders add to their stable of reliable suppliers. Also, by creating close links with Asian companies, U.S. firms believe they stand a better chance of selling their finished products—commercial jets in this case—in the growing Asian market, where they face competition from Airbus. And finally, after the proficiency of new suppliers has advanced sufficiently, U.S. companies can actually save a measure of new aircraft development costs by shifting design work overseas. Cooperative ventures involving U.S. aeronautics companies exist throughout Asia—from engine overhaul factories in Taiwan, to final assembly plants in China, to sophisticated computer-aided design facilities in Japan.

This last example—saving money by sending work abroad—has potential drawbacks. First is the socio-economic and technology development

impact on U.S. suppliers. Foreign supplier competition has been a contributing factor to the downsizing of the U.S. supplier base. Such competition is forcing U.S. suppliers to either become more competitive—without direct government assistance—or go out of business. For example, a Japanese firm that received technical and manufacturing assistance from a U.S. firm to produce F-15 actuators,² won the contract for the actuators on the Boeing 777 over a U.S. firm that had previously supplied the component for Boeing aircraft.

Near-Term Competition From Asia Is Unlikely

For reasons of technological sophistication and politics, it appears unlikely that any Asian aeronautics company will compete directly against U.S. passenger jet makers for at least several years. Indonesia, China, and Taiwan lack the necessary experience in jet manufacturing to successfully compete directly with the United States. And although Japan may possess the needed experience and sophistication to compete, Japanese officials have expressed their desire to work cooperatively—and not competitively—with the West for the foreseeable future. Furthermore, Japan currently lacks the marketing and repair infrastructure widely believed to be critical to selling aircraft internationally.

Long-Term Implications of Asia's Emergence in Aeronautics Is Subject to Debate

The long-term implications of aeronautical technology transfer from West to East are the subject of much debate. Industry representatives believe that global competition in aeronautics will occur with or without U.S.-Asian cooperation, and that such cooperation provides both market access and a competitive edge in price to U.S. companies. Some U.S. industry officials said that they transfer technology primarily to ensure continued market access in Asia, and noted that they do not transfer their most critical process and product technologies, or “core competencies.”

Others, however, claim that this process builds competitors in Asia and that the short-term gains brought by technology transfers may be outweighed by down-the-road losses in economic sectors that provide thousands of jobs. They suggest that the success of Japan's technology drive shows that Asian nations will become competitive in aeronautics even if so-called critical U.S. technologies are safeguarded. That is, the development of domestic technology infrastructure will allow Asian nations to become competitive, and importing technology is merely the first, low-cost step in that process.

²Actuators are mechanical devices for controlling movable surfaces on an aircraft, such as flaps, ailerons, and landing gear.

These observers also suggest that American aeronautics companies are at a marked disadvantage because they must generate profits without direct government assistance, which is not the case in Asia. As noted earlier, the new GATT agreement may alter a government's ability to subsidize its industry. Observers believe Asian forays into aeronautics may not be motivated by profit in the near or mid-term, but by the intention to increase a country's baseline technology level and create jobs. Despite the record of losses incurred by large companies in civil aeronautics,³ Asian countries are nonetheless pushing into this sector. Several industry observers suggested to us that American companies could not afford the large capital expenditures incurred by Asian companies for aeronautics work. The systematic way that Asian governments shield their strategically important industries may protect Asian companies from economic shocks—for example, slowdowns in growth or reductions in military orders—that have resulted in thousands of lost jobs in the United States.

Scope and Methodology

To obtain information for this report, we interviewed officials and reviewed materials at the U.S. Departments of Commerce and State; the National Aeronautics and Space Administration (NASA); the Aerospace Industries Association; the National Science Foundation; the American Institute in Taiwan; and the Washington-based embassies for Japan, Indonesia, and the People's Republic of China. We also traveled to Japan, Indonesia, Taiwan, and the People's Republic of China to interview government officials and industry representatives.

We also reviewed relevant studies, reports, and other documents and interviewed officials of U.S. embassies, Asian government ministries, aeronautics companies, industry associations, and higher education establishments. We were unable to independently verify the accuracy of all the information. We did not have access to pertinent strategic planning information, contract data, and/or company financial records. As a result, we could not make an independent assessment of the scope and relative priority of ongoing or planned aeronautical R&D efforts in each of the countries. The organizations we interviewed are listed in appendix I.

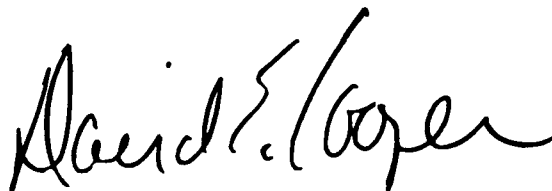
We conducted our review between January 1993 and February 1994 in accordance with generally accepted government auditing standards. We did not obtain written comments on the report from U.S. agencies. However, we provided detailed country summaries on the results of our

³Lockheed, for example, no longer makes regional or larger passenger jets. Furthermore, some studies have concluded that only Boeing has produced aircraft that have been profitable.

work to appropriate government and industry officials in each country we visited and incorporated their comments in this report where appropriate. We also briefed NASA officials on the content of this report.

Unless you publicly announce its contents earlier, we plan no further distribution of this report until 30 days after its issue date. At that time, we will send copies to the NASA Administrator, the Secretaries of State and Commerce, and other appropriate congressional committees. Copies will also be made available to other interested parties upon request.

Please contact me on (202) 512-4587 if you or your staff have any questions concerning this report. Major contributors to this report are listed in appendix II.



David E. Cooper
Director, Acquisition Policy, Technology,
and Competitiveness Issues

Organizations Contacted During Our Review

United States

Department of State
Department of Commerce
National Aeronautics and Space Administration
National Academy of Sciences
Aerospace Industries Association
National Science Foundation
American Institute in Taiwan, Virginia office
Japan Program, Massachusetts Institute of Technology
Kennedy School of Government, Harvard University
United Technologies - Pratt & Whitney
Morgan Stanley (aviation industry analysts)
Dow Jones (industry news reporters)
Embassies of the following nations:

- Japan
- Indonesia
- People's Republic of China

Taiwan

Coordinating Committee for North American Activities
Taiwan Aerospace Corporation
Council for Aerospace Industry Development
Council for the Advancement of Science and Technology
Ministry of Economics
Taiwan National Science Council
Air China

Japan

Ministry of International Trade and Industry
Japan Defense Agency
Science and Technology Agency
Mitsubishi Heavy Industries
Kawasaki Heavy Industries
Fuji Heavy Industries
Boeing Japan
Lockheed
General Electric
United Technologies - Pratt & Whitney
McDonnell Douglas
U.S. Air Force

**Appendix I
Organizations Contacted During Our Review**

**The People's Republic of
China**

Aviation Industries China:

- Beijing headquarters
- Xian Aero Engine Company
- Xian Aircraft Company
- Harbin Aircraft Manufacturing Company
- Shanghai Aviation Industrial Company

Beijing Aerospace University
Beijing Aviation Materials Research Institute
China Aviation Administrative Committee
Air China

Hong Kong

U.S. Consulate General
AVMARK (U.S. aviation consultants)
Morgan Stanley (aviation industry financial analysts)

Singapore

Ministry of Economics
Singapore Aerospace
Dowty-Haw Par Industries

Major Contributors to This Report

**National Security and
International Affairs
Division, Washington,
D.C.**

**James F. Wiggins
George A. Jahnigen
Katherine V. Schinasi**

**Far East Office,
Honolulu, Hawaii**

**James L. Morrison
Conor B. O'Brien
Paula J. Haurilesko**