THE JAPANESE AIRCRAFT INDUSTRY: STRATEGY AND IMPLICATIONS FOR GLOBAL MARKETS

Thomas Dean Gros
The MIT Japan Program
MITJP 89-06

Center for International Studies
Massachusetts Institute of Technology
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by 

Thomas Dean Gros 

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ABSTRACT 

This thesis argues that Japan will soon overcome most of the technological barriers that have prevented it from becoming a world-class competitor in aerospace, although significant economic and political constraints will remain. This capability--largely the result of a series of joint ventures with US firms--will position Japan to compete in high-value-added component markets and to participate in future joint ventures with the world's aerospace powers on an equal-equity basis. 

Chapter one establishes the analytical framework of this thesis by outlining the three phases in the development of Japanese aerospace strategy. The historical background is also explored. 

Chapter two uses the analytical framework and defines the key players in Japan's aerospace industry. It also explores Japan's acquisition of US aerospace technology as a critical element of the Phase I strategy, starting in the early 1950s. Technology linkages--both with the US and with related indigenous players in electronics and advanced materials--are analyzed. Other characteristics of Phase II in Japan's strategic development, including increasing specialization among major players, are defined. 

Chapter three describes in detail the critical programs that comprise Japan's Phase III strategy, the influence of government support and regulation, and key macroeconomic considerations that constrain Japan's aerospace expansion. A modified Porter analysis is presented, along with the author's projections for likely strategies and counter strategies that may emerge as the global industry responds to the Japanese challenge. 

Thesis Supervisor: Dr. Richard J. Samuels 
Title: Associate Professor, Political Science and Director, MIT - Japan Science and Technology Program
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Exchange rate conversions are calculated on the basis of then-year average rates.
CHAPTER ONE: ARGUMENT AND HISTORICAL PERSPECTIVE

Chapter one establishes the analytical framework of this thesis by outlining the three phases in the development of Japanese aerospace strategy. The historical background is also explored.

Argument

The Japanese aerospace industry is on the threshold of a new era. Building on a base of technology it has acquired largely through a series of joint ventures with US firms since 1952, the industry as a whole will soon overcome most of the technological barriers that have kept it from becoming a world-class competitor.

Economic obstacles, especially those relating to a large-scale entry into the commercial market, remain formidable. Indeed, unless a major realignment occurs within that market, Japanese hopes of becoming a major, prime contractor in the foreseeable future are largely unfounded. However, this does not preclude their significant expansion in the commercial subcontractor role and component markets.

Political constraints--including the prohibition against the export of military goods--currently impede Japan's military aerospace efforts. Ironically, it is the
military market that presents Japan’s most logical entry point for aerospace expansion.

The combined strategy of Japan’s aerospace industry, uninhibited by anti-trust regulation and with the full support of MITI, is best described as "maintaining options". While continuing to rely on US expertise in its efforts to obtain specific technologies and marketing acumen, the industry is completing its indigenous acquisition of a solid research base, requisite capital infrastructure (at least for military market expansion), and adequate design experience. The Japanese want, at the very least, to be able to participate in future joint ventures on an equal-equity basis with the world’s major aerospace powers.

This situation poses an unprecedented challenge to the US aerospace industry. US firms must decide if they should cooperate with Japan, possibly creating a future competitor, or ignore Japan and lose any hope of control over the emergence of an aerospace power.
An Historical Perspective of Japan's Aerospace Industry

Prior to the outbreak of World War II, Japan's aircraft industry ranked among the world's greatest, although it was almost entirely concentrated on the production of military planes. At its zenith, the industry produced some 25,000 aircraft and 40,000 engines annually.\(^1\) The industry was led by Mitsubishi Heavy Industries, which had absorbed Mitsubishi Aircraft Company in 1934.

At the war's end in 1945, Japan's aircraft industry was completely dismantled. Aircraft production was banned, key production facilities were confiscated as reparations, and all remaining facilities were destroyed.\(^2\) For seven critical years as the victorious aerospace powers soared into the jet age, Japan's industry remained idle.

In 1952, as the Korean War raged and Japan's industrial output returned to pre-war levels, Japan's aircraft industry was permitted to resume operations. With virtually no capital infrastructure or indigenous market demand, the reborn industry began repair and maintenance work on aircraft assigned to the US armed forces in Japan. This marked the beginning of Japan's cooperation with US aircraft manufacturers.

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2 Ibid., p. 3.
This new beginning, **Phase I** of Japanese postwar aerospace strategy, is characterized by a broad-based attempt to acquire any Western aerospace technology that could be used as a foundation upon which an indigenous industry could be rebuilt. Further, the technology during this phase is almost entirely limited to the manufacturing and repair segments of the value-added chain. Japanese aerospace firms attempted to coordinate their strategy through the newly formed Aircraft Industry Council (established July 28, 1952) and the Jet Engine Research Group (established October 1, 1952). Coordination was also a by-product of US firms and the US military awarding contracts to different Japanese firms. This take-what-you-can-get strategy most closely resembles Quinn's "logical incrementalism"\(^3\)--a step-by-step approach to strategic development (see Chart One).

**Phase II** of Japanese aerospace strategic development began in 1959 with the all-Japanese YS-11 commercial transport program. This marked post-war Japan's first attempt to build upon its technology acquisition and pre-war expertise in a complete, coordinated manner. The Japanese government lent strong financial support, Japanese industry formed the Nihon Aeroplane Manufacturing Company consortium to manage the effort, and member firms shared responsibility.

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for the entire value-added chain—not simply manufacturing and repair as in Phase I. Phase II is also marked by increasing specialization among the major players, allowing a minimization of redundancy to increase the efficiency of the small industry.

Other indigenous programs were pursued during Phase II including the T-1 and T-2 jet trainers and the C-1 transport. These were relatively unsophisticated designs by comparison with the advanced jet fighters produced in the United States and Western Europe. Still, these programs provided valuable design experience that—in combination with US technology and rising indigenous capabilities in electronics—would provide the foundation for Japan’s aspirations. (These programs are all discussed in greater detail in the following chapters.)

Over the next three decades, Japan’s aerospace industry proceeded gradually in an attempt to overcome a sharp lag in technology caused by the seven year absence from the market. Japan participated in a number of US military aircraft programs through purchases made by the Japanese Defense Agency (JDA).
CHART ONE
DEVELOPMENT OF STRATEGY IN THE JAPANESE AEROSPACE INDUSTRY

Phase I
1952-1959
"Logical Incrementalism"
Concentrate on repair/manufacturing end of value-added chain
Attempt to coordinate players through industry councils
Take-what-you-can-get
Strong technical dependence on US

Phase II
1959-1988
Steady progression of foreign technology acquisition
Apply learned technology to indigenous product
Consortium forming
Begin to approach whole value-added chain
Increase specialization among major players
Japan's Aerospace Industry Today

The decade of the 1980s witnessed Japan's first real surge in aerospace. Aircraft production value jumped from less than Y300 billion in 1981 to more than Y640 billion ($2.68 billion @ Y239=$1) in 1985, according to the Society of Japanese Aerospace Companies (SJAC). This surge was driven by the demand of the JDA: JDA's aircraft expenditures, as published in the Defense White Paper, rose from Y174 billion in 1981 to Y338 billion in 1985.

In addition to rising numbers of aircraft rolling off the line, the Japanese aerospace industry broadened its product line to include all the major product types sold by the major worldwide aerospace producers: airplanes, helicopters, missiles, remotely piloted vehicles (RPVs), space launch vehicles, and a countless array of components and subsystems.

Despite this surge in production, employment in the aircraft industry has remained relatively flat for the past two decades. With some 26,000 employees in the entire country working in the aircraft industry, Japan's industry is roughly the size of Grumman Aerospace, America's smallest major jet fighter manufacturer. This lack of "critical mass" has led some critics to charge that Japan does not...

5 Ibid., p. 32.
have a sufficient infrastructure to compete with world-class manufacturers.6

The primary employers of this select group, Japan’s "big four" in aerospace, include Mitsubishi Heavy Industries (MHI), Fuji Heavy Industries (FHI), Kawasaki Heavy Industries (KHI), and Ishikawajima-Harima Heavy Industries (IHI). The first three--MHI, FHI, and KHI--have concentrated their efforts in the development of airframes, while IHI has concentrated in the development and production of jet engines. Another player within the Mitsubishi group --Mitsubishi Electric or MELCO--has emerged as the leader in avionics, the onboard electronics systems.

6 A number of sources refer to this lack of "critical mass." Most recent sources include an interview with senior managers at Boeing Commercial Airplanes, held in Seattle on January 18, 1989.
CHAPTER TWO: THE MAJOR PLAYERS

Chapter two uses the analytical framework and defines the key players in Japan's aerospace industry. It also explores Japan's acquisition of US aerospace technology as a critical element of the Phase I strategy, starting in the early 1950s. Technology linkages—both with the US and with related indigenous players in electronics and advanced materials—are analyzed. Other characteristics of Phase II in Japan's strategic development, including increasing specialization among major players, are defined.

Japan's Big Four Led by Mitsubishi Heavy Industries
Executives and engineers at Mitsubishi's Nagoya Aircraft Works, interviewed recently on the condition of anonymity, expect to become world-class contenders in military aviation.

-- Mainichi Shim bun, 17 October 1988

Mitsubishi Heavy Industries (MHI) is a descendant of the Nagasaki Forge of the Tokugawa Shogunate. For the past fourteen years, MHI has been the top contractor for the Japanese Defense Agency (JDA), according to the Yamaichi Research Institute of Securities and Economics. In fiscal 1986, its share of the JDA market was 24.3% or Y291 billion ($1.73 billion @ Y168.5=$1). According to MHI annual reports, total net sales in 1986 were Y3.53 trillion ($20.9 billion). Aircraft and special vehicles contributed 8.9% to a sales base dominated by automobiles (44.8%) (see Chart Two). MHI's affiliated trading company, Mitsubishi Corporation, had trading transactions in 1986 totaling Y17.1

<table>
<thead>
<tr>
<th></th>
<th>JDA Market</th>
<th>Total Net Sales</th>
<th>Aircraft Related Sales</th>
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<tbody>
<tr>
<td>MHI</td>
<td>¥291b</td>
<td>¥3530b</td>
<td>9%</td>
</tr>
<tr>
<td>KHI</td>
<td>¥170b</td>
<td>¥ 700b</td>
<td>17%</td>
</tr>
<tr>
<td>FHI</td>
<td>¥ 22b</td>
<td>¥ 768b</td>
<td>6%</td>
</tr>
<tr>
<td>IHI</td>
<td>¥ 93b</td>
<td>¥ 800b</td>
<td>12%</td>
</tr>
</tbody>
</table>

Source: 1986 data from annual reports and SJAC.
trillion ($101 billion), which translates to a 20.6% contribution from MHI for the year.  

MHI operates relatively independent of Mitsubishi Corporation. In fact, according to Prudential Bache Securities, "decentralization of decision-making has been an important factor in the past success of the company's diversification and restructuring...We expect the company to continue to diversify aggressively into new fields and to expand overseas operations." Yamaichi gives MHI its highest investment rating, "A, very attractive". Dealing from such a strong financial base, MHI has found it easy to dominate Japan's aerospace industry. In 1986, MHI won two of JDA's largest contract awards--the Raytheon Patriot surface-to-air missile program ($668 million) and the McDonnell Douglas F-15J program ($524 million)--according to Aviation Week. Further, MHI has emerged as the most frequent industry contact point in joint ventures with the US, and is frequently the leader in

Japan's aerospace-industrial consortia, dating back to the YS-11 program.

MHI's contracts with the aerospace industries in the United States have included:

- **The US S-55 helicopter program (1954)**, that included a technical assistance agreement for parts manufacture and repair with Sikorsky. MHI learned the basics of then-current helicopter manufacturing technology. Sikorsky later concluded many follow-on agreements with MHI.

- **The US F-86F fighter program (1955)**, that provided MHI the essential techniques for the construction of jet aircraft. MHI manufactured some 77% of the aircraft's parts, the remaining "key" parts being supplied directly by North American.

- **The US F-104J (1962) and F-4EJ (1971) programs**, from which Japan learned basic knowledge of aluminum aircraft structures capable of withstanding the stress of high-g maneuvering and supersonic flight. MHI was responsible for the manufacture of nearly all airframe component parts.
### Chart Three

**MHI Joint Development and Indigenous Programs**

<table>
<thead>
<tr>
<th>Level of Technological Sophistication</th>
<th>Year</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Manufacture and Development of Advanced Design</td>
<td>1954</td>
</tr>
<tr>
<td>Supersonic High-G Airframe Manufacture</td>
<td>1964</td>
</tr>
<tr>
<td>Whole Subsonic Airframe</td>
<td>1974</td>
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<tr>
<td>Subassembly Less &quot;Key&quot; Parts</td>
<td>1984</td>
</tr>
<tr>
<td>Small Parts Manufacture and Repair</td>
<td></td>
</tr>
</tbody>
</table>

**CCV**
- F-15

**F104**
- F-1
- T-2
- F-4

**MU-2**
- YS-11

**F-86F**
- S-55

**Year**

1954 1964 1974 1984

**Key:** Cooperative programs with US = **Bold**
Independent, indigenous program = *Standard*

Source: Analysis of data contained in *Jane's All the World's Aircraft*, years 1957 through 1989.
The US F-15 program (1981), from which Japan gained state-of-the-art knowledge in aircraft fabrication and assembly. Those components that the US refused to give Japan, mainly electronic warfare "black boxes," were replaced by indigenous MELCO components. The first F-15s Japan built were assembled from "knocked-down" kits; all of the later F-15s were built entirely in Japan.

These programs exhibit a key element of the Phase II strategy: a steady progression of technology acquisition starting from small parts manufacture and developing, over the course of three decades, to supersonic airframe design and manufacture. As Chart Three indicates, MHI was quick to apply these technologies in indigenous programs including:

- **The YS-11 short-range transport (1959),** the first true attempt by Japan to integrate the basic manufacturing technologies assimilated from the United States. The YS-11 was actually built by NAMC (Nihon Aeroplane Manufacturing Company), a consortium led by MHI and subsidized by the Japanese government.

- **The MU-2 STOL utility transport (1965),** which extended the basic aluminum airframe lessons of the YS-11 by adding the complexity of STOL (Short Takeoff and Landing) technology primarily in wing design. The
use of STOL was probably an attempt to test a possible niche market entry for a small load (9 passenger), special purpose (short, unprepared runway) aircraft.


- The F-1 fighter (1967), a strong manufacturing effort hindered by Japan's inexperience in high-performance aircraft design and systems integration. The F-1 was a very well-built, poorly designed fighter that lacked the performance necessary to compete with its primary (Soviet) threat.

- The T-2 CCV (1985), Japan's most important lesson in the development of advanced avionics systems. Although clearly behind the technology of the somewhat comparable US F-15 STOL or US X-29, the CCV, or control configured vehicle, was considered by Japan's aerospace industry to be its qualifying entrant in the world-class fighter arena.
Building on Indigenous Technological Strengths

Supplementing the absorption of foreign technology, Japan's aerospace industry, led by MHI, has aggressively pursued the development of advanced technologies by leveraging against indigenous technological strengths. Indeed, MHI's ability to develop airframe parts made of advanced, lightweight composite materials is due in part to Japan's indigenous strength in the production of carbon fibers. Japan's Toray industries—a member of the Mitsui group—is widely recognized as a world leader in the production of composite materials. Toray was able to assist MHI in the development of an all-composite wing, effectively pushing MHI up the technology development curve—using Foster's terminology, the S-curve—and significantly reducing development risk, time, and cost. Further as Samuels and Whipple point out, the transfer may be especially efficient:

Organizationally, since much of the new technology originates in other industries, Japanese aerospace's tighter intersectoral links should assist its identification and transfer. Managerially, Japanese firms have thirty years of experience with interfirm cooperation, while it is a brave new world for their American counterparts.

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As MHI continues to dominate Japanese airframe manufacture—including composite parts—Mitsubishi Electric Corporation (MELCO) continues to dominate the onboard electronic components or avionics. MELCO also provides a clear example of Japan's ability to *leapfrog existing technology*, (jumping to the next technology development curve) and proceed directly to the next generation. Indeed, with virtually no experience in the design of airborne radar systems, MELCO recently flight-tested an "active array" radar that builds upon Japan's indigenous strengths in advanced (gallium arsenide) electronics technology. This radar is similar to next-generation designs in the United States.

**Capital Investment**

In an effort to enhance its indigenous design and production capabilities, MHI has led the way for Japanese capital infrastructure investment including:

- **New Design Center** at its Oye plant in Nagoya, including a combat simulator and an improved supersonic wind tunnel, according to [Aerospace Japan Weekly](14).

  Wing Newsletter reported that the 1,800 square meter facility cost some Y4 billion.15


2.1 *New Anechoic Chamber* at its Komaki South plant in Nagoya, large enough to accommodate an entire fighter aircraft—Japan’s fifth largest.¹⁶

- *Numerically Controlled Machines* including three-spindle, five-axis profilers, automated welders, and presses, according to Aviation Week.¹⁷

- *Large-scale expansion* in 1987 with floor space additions totaling 15.3 acres, according to Aviation Week.¹⁸

- *New Stealth Facility*, according to Wing Newsletter.¹⁹

Clearly with such significant investment in development and production facilities, MHI intends to maintain its lead in Japanese aerospace. The investment is especially significant in light of the 1986 recession within the

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Japanese economy. In 1982, the average yen-dollar exchange rate was 249-1; in 1987, the average yen-dollar exchange rate was 145-1, indicating a rise in yen strength of nearly 72% in just five years! Such a rise is devastating for an export-driven economy. The other players in the big four have had to deal with this problem as well (as described in detail in a later section).
Kawasaki Heavy Industries
Japan does not export armaments...Hitherto the policy has been largely academic...because few of its post-war military products would have generated overseas demand. Given a competitive pricing policy, however, the Kawasaki XT-4 would probably be an exception....
--Flight International, 2 January 1988

Kawasaki Heavy Industries (KHI) was originally established in 1878 as a shipbuilding firm, a business sector it continues today in addition to its operations in aircraft and other heavy machinery. In 1986, KHI ranked second to MHI in JDA contracts with programs valued at over $1 billion, according to Aviation Week.20 Recent annual net sales for KHI have been approximately ¥700 billion ($4.15 billion @ ¥168.5=$1), or one-fifth that of Mitsubishi Heavy Industries. Aircraft sales account for roughly 17% of KHI's total sales.21

Like MHI, KHI has benefitted from a steady progression of technology acquisition starting from small parts manufacture and developing, over the course of three decades, to supersonic airframe design and manufacture. KHI's contracts with the aerospace industries in the United States and Western Europe have included:

20 Op. Cit., "MHI Leads Top..."
- The US T-33A trainer and F-94C fighter programs (1955), which gave KHI the opportunity to repair, overhaul, and eventually manufacture relatively unsophisticated airframes. The technical foundation provided by the T-33A, in particular, was directly applicable to KHI's independent production of its own XT-4 trainer.

- The US Bell Model 47 (1955) and Boeing-Vertol 107 (1962) helicopter programs, which provided KHI first-hand knowledge of helicopter manufacture well ahead of its domestic competitors. The technology acquired through these programs clearly formed the foundation for KHI's later joint venture with MBB.

- The US P2V-7 (1959) and P-3C (1981) programs, which included a specific technological assistance contract. The P2V-7 was initially assembled from US components. These programs provided in-depth knowledge of relatively low-tech, subsonic airframe design.\(^22\)

- The BK-117 helicopter (1981), jointly developed with MBB of West Germany. This joint venture established KHI as Japan's indigenous helicopter designer, a specialty that may remain unchallenged by the other

indigenous players. Further, this joint agreement provides access to European technology and markets.

Following the Phase II characteristics also displayed by MHI, KHI has aggressively applied the lessons learned from foreign technology in indigenous designs. As Chart Four indicates, these indigenous designs have included:

- **P2J Antisubmarine patrol plane (1965)**, a relatively unsophisticated airframe based heavily upon the Lockheed Neptune. The P2J nonetheless showcased KHI's manufacturing capabilities, based on its P2V-7 experience.

- **The C-1 transport (1969)**, similar in design sophistication to the P2J, the C-1 represented a strong independent effort to develop a large, subsonic airframe and avionics suite.

- **The Asuka STOL (1980)**, a modest technological advance countered by excessive delays and cost overruns, this aircraft might have been useful as an entrant into the commercial market. This 150-seat short takeoff and landing (STOL) airliner cost more than Y35.5 billion to modify from an existing C-1, according to *Flight International*.23

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### CHART FOUR
KHI JOINT DEVELOPMENT AND INDIGENOUS PROGRAMS

#### Level of Technological Sophistication

<table>
<thead>
<tr>
<th>Total Manufacture and Development of Advanced Design</th>
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<tr>
<td>Supersonic High-G Airframe Manufacture</td>
<td>XT-4 ASUKA</td>
</tr>
<tr>
<td>Whole Subsonic Airframe</td>
<td>C-1 P2-J</td>
</tr>
<tr>
<td>Subassembly Less &quot;Key&quot; Parts</td>
<td>Helicopters P2-V</td>
</tr>
<tr>
<td>Small Parts Manufacture and Repair</td>
<td>Bell 47 BV 107 F-94C T-33</td>
</tr>
</tbody>
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<table>
<thead>
<tr>
<th>Year</th>
<th>1954</th>
<th>1964</th>
<th>1974</th>
<th>1984</th>
</tr>
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</table>

**KEY:** Cooperative programs with US = **Bold**
Independent, indigenous program = Standard

Source: Analysis of data contained in *Jane's All the World's Aircraft*, years 1957 through 1989.
o XT-4 jet trainer (1985), a world-class trainer by many accounts that may prove pivotal in earning respect of potential clients. The jet trainer is a logical first step toward the development of a more advanced supersonic fighter.

Though clearly second to MHI in technology, market share, and spending, KHI has continued to invest in development and production facilities including a new high speed wind tunnel at Gifu, costing some Y3 billion, according to Wing Newsletter.24 Further, KHI's president, Kenko Hasegawa, highlighted aerospace as a key area for R&D investment in a recent annual report.25

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24 "KHI to Build High Speed Wind Tunnel," Wing Newsletter, 10 September 1986.

Fuji Heavy Industries
The Aircraft Division (at FHI) holds the greatest possibility for development because of its high technologies and the two potentially large markets of commercial aircraft production and the fledgling Japanese space industry.

-- 1987 FHI Annual Report

Fuji Heavy Industries (FHI) sprung from Japan's Aircraft Research Laboratory, which was founded in 1917. FHI is JDA's eighth largest supplier with 1986 contracts valued at only $128 million. FHI's net sales for the year totaled Y768 billion ($4.6 billion @ Y168.5=$1), just larger than those of KHI. In 1987, 84% sales were produced by its automobile division (Subaru), with aircraft contributing less than 6%.

Despite the small scale indicated by these statistics, FHI has played a significant role in a number of joint ventures with US firms including:

- **Beechcraft Mentor (1953) and Cessna L-19 (1953)**

License and technical assistance agreements with these two US general aviation manufacturers allowed Fuji to reassemble its aircraft manufacturing capability while acquiring very unsophisticated, low-speed technology.

26 Op. Cit., "Mitsubishi Leads Top..."

Bell 204B helicopter (1962), provided FHI its first significant technological exposure to rotary-wing flight. The 204B was originally sent to Fuji in kit form.

Fuji/700 business plane (1975) developed jointly with the US firm Rockwell International. This twin-prop is one level of sophistication over the single-prop Beech and Cessna aircraft.

205A-1 helicopter, developed jointly with Bell in the US, first flew in 1988. This helicopter presents the only real domestic challenge to Kawasaki's dominance.

Following the Phase II characteristics as indicated in Chart Five, FHI has applied these technologies to indigenous programs including:

T-1 (1957) and T-3 (1978) jet trainers similar to the early efforts of MHI and KHI, the trainer aircraft represents a logical first step in the development of integrated aircraft technology. Both of these programs built upon the basic aluminum airframe technologies of the Beech and Cessna aircraft.

### CHART FIVE
FBI JOINT DEVELOPMENT AND INDIGENOUS PROGRAMS

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<tbody>
<tr>
<td>Supersonic High-G Airframe Manufacture</td>
<td>KM2 T-1 FA-200 T-3 205A 204B L-19 Mentor</td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Whole Subsonic Airframe</td>
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<td>Subassembly Less &quot;Key&quot; Parts</td>
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</tbody>
</table>

**Year**

**1954** **1964** **1974** **1984**

**KEY:** Cooperative programs with US = **Bold**
Independent, indigenous program = **Standard**

**Source:** Analysis of data contained in *Jane's All the World's Aircraft*, years 1957 through 1989.
o **FA-200 light aircraft (1965)**, a clear outgrowth of Fuji's work with Beech and Cessna, this low-speed, general aviation aircraft contains rather simplistic technology.

o **KM-2 Kai trainer**, which made its first flight in 1988, builds upon the T-3 experience.29

All of these programs served to keep FHI's hand in play and enabled the firm to develop specific areas of technological expertise, including the manufacture of composite airframe parts. According to the Comline News Service, FHI has developed a new technology for processing composite materials, dramatically reducing processing time.30 Comline has also reported that FHI plans to build a new aircraft plant to support future aircraft production.31


Ishikawajima-Harima Heavy Industries

Japanese aerospace companies are using their participation in international high-technology development programs to learn modern techniques of sales, marketing and after-sales support with a view to being able to provide these components of total aerospace programs in the future. A case in point is the Japan Aero Engines Corp.

Aviation Week, 21 September 1987

Ishikawajima-Harima Heavy Industries started operations in 1853. Today, IHI is Japan’s leader in the production of jet engines. It is also the leader of the Japan Aero Engine Corporation (JAEC)—Japan’s engine consortium comprised of IHI, KHI, and MHI. IHI was fourth in the ranking of 1986 JDA contracts with agreements valued at $551 million, according to Aviation Week.32 Net sales for 1986 were Y800 billion ($4.7 billion @Y168.6=$1), slightly more than those of FHI. Aero engines contributed 12% to sales in 1986, according to annual report data.33

IHI has gained virtually all of its jet engine technology from joint ventures with the United States. It manufactures, under US license, engines for essentially all of Japan’s fixed-wing military aircraft. Yet despite this incredible product range and near monopoly, jet propulsion technology remains Japan’s greatest technological weakness in aircraft production. This weakness can be traced back to

32 Op. Cit., "Mitsubishi Leads Top...".

33 Ishikawajima-Harima Heavy Industries, Annual Report 1986, p. 27.
the seven-year lag after World War II during which jet engine technology was initially refined in the West. To this point, IHI has not made the investment in developmental facilities or manpower necessary to overcome this weakness on its own. Instead, IHI is relying on foreign assistance from the worldwide technology leaders.

IHI apparently believes that the key to overcoming this technology lag is the V2500 international jet engine program with Pratt and Whitney of the United States, Rolls-Royce in the United Kingdom, and others. JAEC, led by IHI, has a 23% interest in the V2500, which powers the all-new European Airbus A320 commercial airliner. IHI hopes to acquire state-of-the-art technology from its Western partners while developing indigenously the less sophisticated portions of the engine.

The JAEC consortium is a critical component of this strategy. According to Aviation Week, "JAEC coordinates the activities of these three companies, controls the financing for their share of the engine development work, including government loans, and provides some of the engineering staff."34 Such careful coordination eliminates duplication of effort, maximizing efficiency.

According to industry experts\textsuperscript{35}, IHI probably has the capability to manufacture any jet engine currently in production. Indeed, the manufacturing director at Pratt and Whitney believes this to be the case. IHI's primary stumbling block lies in development. Experts disagree on whether or not the V2500 will lift IHI significantly in its attempt to become a world-class player in jet propulsion.

\textsuperscript{35} Interview with a manufacturing manager at Pratt and Whitney, in Boston on January 23, 1989.
Analytical Comment

As the three technology charts (Charts Three, Four, and Five) confirm, foreign technology acquisition is a key component to Japan’s Phase II strategic challenge to develop an independent capability in aerospace. It is also interesting to note the slope of MHI’s development versus that of KHI and FHI. MHI’s level of technological sophistication has continued to rise throughout Phase II, while KHI and FHI have seemed to slow down. This trend largely explains MHI’s continued dominance of Japan’s aerospace industry.

It is also important to note that while each major program is associated with the prime contractor, in nearly every case substantial portions of the program were the responsibility of subcontractors. Unlike the anti-trust regulation in the United States, cartelization of the Japanese aircraft industry was a matter of policy beginning with the First Aircraft Industry Promotion Law of 1954. The Japanese subcontractors have generally included the other members of Japan’s big four.

As Japan’s aerospace industry—led by MHI but complemented by the individual technological strengths of collaborating firms—progressed through Phase II, the ultimate goal of being a world-class player became more
clear. At the same time, key technological gaps—especially propulsion, airframe and avionics design and development, and systems integration—began to emerge. The big four also began to perceive weaknesses in critical portions of their aerospace value-added chain, including marketing and after-sales service. **Phase III,** which I define as starting in 1988 with the formalization of the FS-X program, is characterized by a direct attempt to fill these gaps; it represents a fine-tuned version of Phase II, with the ultimate goal more clearly in sight (see Chart Six). The FS-X program represents, for Japanese industry, the key element of its Phase III strategy, as the next chapter describes.
### CHART SIX
#### DEVELOPMENT OF STRATEGY IN THE JAPANESE AEROSPACE INDUSTRY

<table>
<thead>
<tr>
<th>Phase I</th>
<th>1952-1959</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>&quot;Logical Incrementalism&quot;</td>
</tr>
<tr>
<td></td>
<td>Concentrate on repair/manufacturing end of value-added chain</td>
</tr>
<tr>
<td></td>
<td>Attempt to coordinate players through industry councils</td>
</tr>
<tr>
<td></td>
<td>Take-what-you-can-get</td>
</tr>
<tr>
<td></td>
<td>Strong technical dependence on US</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Phase II</th>
<th>1959-1988</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Steady progression of foreign technology acquisition</td>
</tr>
<tr>
<td></td>
<td>Apply learned technology to indigenous product</td>
</tr>
<tr>
<td></td>
<td>Consortium forming</td>
</tr>
<tr>
<td></td>
<td>Begin to approach whole value-added chain</td>
</tr>
<tr>
<td></td>
<td>Increase specialization among major players</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Phase III</th>
<th>1988-</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Strategy linked to specific programs such as FS-X</td>
</tr>
<tr>
<td></td>
<td>Cooperate in global ventures as co-equals</td>
</tr>
<tr>
<td></td>
<td>Build foundation for independent industry</td>
</tr>
<tr>
<td></td>
<td>Approach world-class aerospace status</td>
</tr>
<tr>
<td></td>
<td>&quot;Maintaining options&quot;</td>
</tr>
</tbody>
</table>
Chapter three describes in detail the critical programs that comprise Japan's Phase III strategy, the influence of government support and regulation, and key macroeconomic considerations that constrain Japan's aerospace expansion. A modified Porter analysis is presented, along with the author's projections for likely strategies and counter strategies that may emerge as the global industry responds to the Japanese challenge.

The FS-X Program
Pressure from U.S. Defense Secretary Casper W. Weinberger has convinced Japanese Prime Minister Yasuhiro Nakasone that production of a U.S. aircraft... will be the price for normal trade relations between the two countries.

-- Aviation Week, 18 May 1987

Just as the V2500 international engine program is a key to Japan's engine development, the $7-8 billion FS-X fighter program, with General Dynamics in the United States, is the key to Japan's development of world-class military airframes and avionics. The joint US-Japan FS-X program, which was formally agreed to on November 29, 1988, was the subject of intense controversy between the two countries and among factions in the Japanese bureaucracy. The program also marks Japan's entry into Phase III of its strategic development.

The Japanese aerospace industry, supported by MITI and the Air Staff Office in the JDA, had lobbied strongly for a purely indigenous program to replace its obsolescent F-1 fighter force with an all-new fighter of the 1990s, FS-X.
The industry, led by MHI, argued that the T-2 CCV, MELCO's advanced radar program, and other industry successes proved that they were capable of developing their own next-generation fighter (albeit with a US engine). Bowing to pressure from the US Administration and Congress, Japan agreed that FS-X would be loosely based on the US F-16 design, with the United States responsible for some 35- to 45-percent of the total workshare; the remaining workshare belonged to Japanese industry led by MHI.

The key to the FS-X agreement, however, was that for the first time in history, the United States would provide Japan with assistance in the design and development of a state-of-the-art fighter—not simply licensed production of a US-designed product. Instead of going through years of expensive, independent development, Japanese industry will be guided by US industry through the complex maze of design and systems integration allowing the Japanese to overcome almost all of the remaining technological obstacles to their development of a world-class aerospace industry. Further, Japan is only now capable of participating in such an advanced program due to the strong technology base it has acquired through decades of coproduction agreements with the United States (as indicated in the company profiles in chapter two).
In short, FS-X is the key element of Japan's Phase III strategy. The program will address all of Japan's most critical technological gaps, except for propulsion. Further, the program will allow Japan to gain experience with a new foreign partner, General Dynamics. From General Dynamics perspective, the FS-X program offers an opportunity to gain access to Japanese "electronics" technologies.36

There is considerable debate whether or not the FS-X program will provide benefits to the United States or if it simply represents another net technology loss from the US to Japan. Abegglen and Stalk argue that the Japanese aerospace threat is more imagined than real.37 US Senator Danforth has led the fight in Congress against the FS-X agreement, claiming it will damage US interests. Former US Commerce Department official Clyde Prestowitz believes that "because of this (FS-X) agreement, (the Japanese) will have taken a giant step to becoming a world-class aircraft manufacturer, and we will help them to do it."38 The respected industry

36 It is not clear if General Dynamics (GD) has targeted specific Japanese technologies. In conversations with a manager at GD in the fall of 1988 in Boston, this issue remain unresolved. This author is concerned that like US partners that have preceded GD, the US firm may not be in a position to select knowledgeably those Japanese technologies that may offer it the highest benefit.


journal, *Aviation Week and Space Technology*, recently published an editorial titled "U.S. Technological Lead at Risk" that stated their concern that the FS-X agreement "will be used to bolster Japan's already impressive manufacturing base." Samuels and Whipple point out that the FS-X program demonstrates that the real challenge to American interests may lie in lost share of military or "dual-use" markets, not strictly commercial markets.

I believe that the FS-X program does present a serious challenge to US interests that, if properly managed, may also present opportunities. The key to exploiting these opportunities lies in genuine technology exchange. The United States can no longer afford to sell technology to potential competitors since it is no longer the world technology leader in many areas.

Clearly, the Japanese have aerospace *product* and *process* technologies from which US firms may benefit. Japanese *product* technologies which may be of particular interest to US firms may include MELCO's next-generation attack radar (which builds upon Japan's indigenous strengths in microelectronics) and Mitsubishi's co-bonded composite


wing technology. Process technologies such as FHI's composites techniques may also be of interest. Other technologies not directly related to current aerospace applications--such as artificial intelligence--could also add a level of flexibility to technology exchange agreements.

The challenge to US firms lies in their ability to select knowledgeably and negotiate aggressively for those Japanese technologies that offer the highest benefit. US firms that passively rely on Japanese offerings of technology in exchange for US technology will likely be disappointed. After all, the Japanese in general are extremely competent negotiators, supported by MITI, which claims many of Japan's top university graduates each year.

...Nobuyoshi Namiki, a former MITI official and one of its best-known theorists, defends research cartels in the targeted industries as Japan's only way to compete with the United States' much larger and richer research and development establishment.
-- Chalmers Johnson in California Management Review, Summer 1985

According to Chalmers Johnson, MITI has the primary responsibility in the Japanese government to formulate and execute national industrial policy. The United States has no comparable equivalent. MITI's four primary tasks, according to Johnson, are:

- Formulate medium-term econometric forecasts.
- Arrange for the preferential allocation of capital for selected industries.
- Target those industries it believes Japan must develop in the future and create a package of policy measures to promote such development.
- Develop industrial policies for structurally recessed industries, like shipbuilding.41

While MITI's contribution to the development of Japan's aerospace industry is significant, I believe that Johnson's argument and widely-held public perceptions of MITI's role are probably overstated. Clearly, the "invisible hand" of market forces is swayed somewhat by MITI's influence with the consent of the major industrial players to provide for the mutual accommodation of governmental and industrial interests—a process described as "reciprocal consent" by Samuels.\(^4^2\) In a similar fashion, Friedman explains the influence of MITI as resting somewhere between the all-powerful "bureaucratic regulation thesis" and the laissez-faire "market regulation thesis."\(^4^3\)

Regardless of its ability to control aerospace strategic development, MITI has long published a "wish list" that included high aspirations for the aerospace industry. In 1988, along with technologies like artificial intelligence and biotechnology, MITI listed development of hypersonic planes as a priority. According to the Wall Street Journal, MITI is expected to request initial funding of ¥40 billion ($313 million @¥128=$1) for an eight-year


project to develop the engines and airframe for an "Orient Express".44

According to the Wing Newsletter, MITI has provided direct subsidies of 50- to 75-percent to Japan's aerospace industry to develop commercial aircraft.45 MITI's enabling law recently changed so that now manufacturers get loans through MITI and the Japan Development Bank, rather than through direct subsidy. An amendment to the law also changed MITI's objective from promoting the "aircraft industry through the advancement of domestic aircraft production" to promoting the "aircraft industry through the advancement of international joint development".46

I believe that this MITI pronouncement is a recognition of a strategic shift by Japan's aerospace firms that was formalized by the FS-X program. This shift demonstrates a key element of Phase III: namely, that Japan's technological independence in aerospace can only come through international joint ventures in which Japan plays the role of a co-equal partner. Accordingly, MITI shifted its funding to the aerospace industry from indigenous R&D to

46 Ibid.
support for international joint ventures—an unprecedented change.

The regulatory environment in Japan also promotes the development of the aerospace industry in a fashion contradictory to US anti-trust law. Consortia, such as the Japan Aero Engine Corporation and the FS-X group (MHI, KHI, FHI, IHI, and MELCO), allow the industry to speak with a stronger voice when dealing with the Japanese government or foreign partners. Consortia also permit development and production efficiencies essential to an industry plagued by small scale and limited indigenous demand. Further, by presenting a unified voice with government support, the industry is also able to take advantage of "related demand": for example, Boeing's consideration of a joint venture with MHI may well be strongly influenced by the fact that Japan Airlines (JAL) is its single largest 747 customer—a fact that MITI is likely to remind Boeing of during the course of negotiations.

In the development of military aircraft, the Japanese Defense Agency has played a role similar to that played by the Department of Defense in the United States. However, JDA has been willing to pay a significant surcharge (usually between 40% and 150%, depending on the system) to allow Japanese industry to produce US systems under license in order to gain an understanding of the technology. Critics have long argued, for instance, that Japan pays at least 40%
more to manufacture the F-15 in Japan than it would cost to buy a complete F-15 directly from the United States. Others argue that the technology gained from indigenous manufacture more than compensates for this surcharge.

Another key difference in the procurement of military aircraft is that in Japan, the military market is responsible for some 80% of aerospace production. (This percentage probably does not include the significant funds spent on space launch vehicles, which are considered to be for "commercial use only." ) According to SJAC, JDA’s demand has comprised some 80% of the market for nearly two decades. Domestic commercial demand and export demand have each traditionally amounted to less than 10%.

With demand so clearly dominated by military programs, the capital infrastructure within Japan’s aerospace industry logically reflects this bias. Production facilities are geared toward the manufacture of small (by airliner standards) aircraft and small (by F-16 production standards) production runs. This raises a serious barrier to entry for an industry with aspirations of entering world commercial aircraft markets. (The implications for the possible removal of this barrier are discussed in a later section.)

The Commercial Aircraft Market: The 7J7 Program

The 7J7/YXX partnership is the logical progression for our friends who have been program participants in the Boeing 767 production. We are delighted that they have agreed to join us in the development, production, and marketing of an exciting new concept in commercial aviation.

-- Boeing President Shrontz in Wing, 12 March 86

Japan's "qualifying entry" into the world commercial market was to have been the 7J7 (originally YXX) program with Boeing in the United States. The Japan Aircraft Development Corporation (JADC) was Japan's 7J7 industry consortium--led by MHI--established to handle the industry's 25% equity share in the program. Japan sent some 250 engineers to Boeing's main facility in Seattle to begin development work on the 150-seat 7J7 airliner, according to Wing Newsletter.48

In 1987, Boeing delayed indefinitely the development of the 7J7 program citing its concerns over the aircraft size, engine, price, production rates, and market uncertainty, according to Aviation Week.49 JADC was left empty-handed with no sizeable commercial program in sight. From a strategic viewpoint, the postponement meant that a critical goal of Phase III--namely, filling the gaps in the value-


49 "Boeing Delays 7J7 Program; Mid-1993 Certification Expected," Aviation Week and Space Technology, 31 August 1987, p. 28.
added chain such as marketing and after-market support— would remain unfulfilled (see Chart Seven).

According to Boeing officials, the primary benefits they seek in a joint venture with the Japanese include risk sharing, market access, financing, and additional manufacturing capacity. Japanese quality and performance during ventures with Boeing have been excellent; in fact, Boeing usually does not double source Japanese components—a quality-assurance practice it follows on joint ventures with many other partners.

It is interesting to note that Boeing has taken little advantage of the vast process technology of its Japanese partners, particularly in light of Boeing's recent production difficulties. I believe that Boeing, like most (and possibly all) major US aerospace firms, has not established the internal linkages between its manufacturing, engineering, and international business departments that could make such beneficial technology absorption possible.

From the Japanese perspective, the 7J7 postponement put new emphasis on the FS-X program and the need to keep Japanese industry working on a next-generation aircraft design, albeit a military one. Combined with the

50 Interview with senior managers at Boeing Commercial Airplanes, held in Seattle on January 18, 1989.
concomitant crash of a JAL 747 for which Boeing accepted responsibility, JADC members were forced to reconsider their relationship with Boeing. The Japanese also undoubtedly reexamined their commercial aircraft strategy, and must have seen the formidable barriers before them.
CHART SEVEN
AEROSPACE VALUE-ADDED CHAIN

SYSTEM R&D

AIRFRAME -- AVIONICS -- PROPULSION
R&D > COMPONENT FABRICATION > TEST > SUBSYSTEM ASSEMBLY > TEST > SYSTEM ASSEMBLY > TEST

SYSTEM ASSEMBLY AND INTEGRATION

INTEGRATED SYSTEM TESTING

MARKETING, SALES, AND DISTRIBUTION

OPERATIONS, MAINTENANCE, AND TESTING

AFTER-SALES SERVICE
Barriers to Entry in the Commercial Market

Firms cannot abandon the international market, (US Deputy Assistant Secretary for Commerce) Brubaker said. Return on sales is faster than in domestic programs, allowing more rapid re-investment in new technology research and development, he said.

-- Aviation Week, 1 September 1986

The scale needed to compete as a prime contractor in the worldwide commercial aircraft market is enormous. As a result, there are only a few players: Boeing and McDonnell Douglas in the United States and Airbus Industries, a West European consortium. The US players developed over the past few decades aided by research conducted by NASA and the military. Airbus, the most recent member to this elite club, has been sustained by massive government subsidies. A number of industry journals indicate that development costs for a new commercial airliner and engine total nearly $4 billion.

My analysis, which is based on Porter's five forces,51 leads me to believe that if Japan chose to enter the commercial market as a prime contractor, it would face severe hurdles including:

- Lack of indigenous market -- Japan's airlines alone would not provide sufficient demand to justify commercial aircraft development, except on a very

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51 Michael Porter's five forces are suppliers, competitors, customers, potential entrants, and substitutes. These are described in detail in his book, Competitive Strategy: Techniques for Analyzing Industries and Competitors (New York: Free Press, 1980).
limited scale. Both the United States and Western Europe have sufficient indigenous market sizes to justify independent development. It is interesting to note here that the major aircraft producers do not know the precise break-even point in aircraft production, although numbers like 500-600 are often given.

- **Need to invest tens of billions of dollars in infrastructure** -- Japan does not currently possess the physical plant necessary for commercial development, although it certainly has the financial capability to acquire these resources in the future if it so chooses. There exists a large body of literature that suggests that the cost of capital is lower for Japanese firms than for Western firms largely because Japanese industrial groups (keiretsu)--such as the Mitsubishi group--are generally centered around banks which have a stake in their success and an intimate knowledge of their operations.52

- **Severe competitor reaction** -- The major aerospace firms in the United States and Europe would be in a strong position to isolate Japan from technology and

52 There are many sources referring to a lower cost of capital for Japanese firms, but the most concise may well be *Kaisha* by Abegglen and Stalk (*New York: Basic Books, 1985*), pp. 15, 152, 161, 178.
market access. While Boeing may not have been prepared for the Airbus challenge, both Boeing and Airbus appear to be prepared for a possible Japanese challenge. In short, the window of opportunity may be closed.

- **Undeveloped marketing and service network** -- Japan has virtually no experience in commercial aircraft marketing and sales, critical keys to success. In light of the 7J7 postponement, there appears to be no other program in the near future that could assist in filling this value-added chain gap. Some argue that the same situation held when Sony first entered the television business. However, given safety considerations and the high initial and opportunity costs of an airliner, it is unlikely that airlines would be as tolerant of lapses in product marketing and service as television buyers.

- **Unproven track record** -- Lack of proven reliability could lead to certification difficulties and customer mistrust. Again, the consumer good analogy is not applicable given safety considerations and costs involved.

- **Insufficient research (and probably manpower) base** -- Japan has never had to "go-it-alone" in commercial aircraft development, leading some to charge that its
core research and manpower base is insufficient. Japan does graduate more engineers than does the United States, but it graduates only about one-ninth the number of scientists and mathematicians. Further, few of Japan's engineering degrees are in aerospace relative to electrical, automotive, and mechanical engineering degrees. Finally, with the number of employees in the aerospace industry remaining relatively flat, the market for aerospace engineering has been limited.

**O Overdependence on US Technology** -- Japanese aerospace firms may be trapped by their past reliance on US manufacturers. A similar phenomenon was observed in the Japanese automotive industry by Cusumano: "In retrospect, it appears that Nissan's reliance on direct technology transfer from the United States caused managers to become more dependent on foreign techniques and less innovative in process development..."54

**O Technological lag in propulsion** -- Japanese industry and MITI have long recognized this major technological weakness, and have taken few


effective measures to correct this lag. Experts disagree over IHI's ability to close this gap through the V2500 engine program. It is important to note that designing an aircraft to accommodate an off-the-shelf engine adds little or no additional technical complexity to an aircraft program. Indeed, many aircraft are designed to accommodate a number of engines made by different manufacturers. However, one may ask if it is possible to possess a world-class aerospace industry without the capability to design a jet engine independently.

This analysis has presented obstacles that, by themselves, may be overcome. However, given all these obstacles and current market conditions including the positions of major competitors, I believe that it is highly unlikely the Japan will attempt to enter the commercial market as a prime contractor in the foreseeable future. However, these conditions do not preclude Japan's growth as a major subcontractor. Indeed, based on this analysis and including the historical factors described in detail in chapter two, Japan's strategy appears to be:

- Concentrate on international joint ventures in order to gain technology and marketing expertise.
Acquire the ability to form joint partnerships on a more even-equity basis, gaining more control over the program and earning the reputation as a world-class commercial player.

Build a foundation upon which an independent commercial aircraft industry could be based if market forces in the future allowed.

These three elements form the core of Japan's aerospace strategy for the period I have defined as Phase III.

It is important to note that the Japanese may well be considering longer term economic rents than those clearly indicated in a simple analysis based on aerospace industry profitability alone. One such economic rent, as defined by von Hippel, includes the importance of aerospace as an innovating "lead user" in a number of markets critical to the Japanese economy—including machine tools, advanced materials, electronic displays, and minicomputers. In fact, the very first numerically controlled (NC) machine tool produced in Japan was financed by MHI's Nagoya Aircraft Factory. Such "spin-off" or "spun-on" technology is difficult to quantify, but it is clearly important, especially from the longer-term Japanese perspective.

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Japan and the Military Aircraft Market

Japan's industrial giants, which dominate the world's consumer electronics, semiconductor and automotive markets, are quietly preparing to enter the one arena in which the United States is still dominant -- the $500 billion-a-year global arms bazaar.

-- Boston Sunday Globe, 30 October 1988

The Japanese self-imposed restriction on the export of armaments confronts directly their rising capabilities and aspirations to compete in global aircraft markets, even at the component level. The small indigenous market for military aircraft, comprised solely of the demand generated by the Japanese Defense Agency, is not sufficient to support independently a military aircraft industry. Yet, that industry continues to produce aircraft (albeit at a significant premium), invest significant funds in development and manufacturing infrastructure, and incite unwavering support within much of the Japanese bureaucracy, especially MITI. Exports, it would seem, might well be the key to profitability through the extension of production runs to achieve reasonable economies of scale.

From a cultural standpoint, the Japanese people as a whole are probably not ready to accept the export of military hardware. Indeed, the recent public debate over defense expenditures rising above 1% of GNP reflects the taboo associated with anything military. However, some firms have already attempted to circumvent the social taboo and legal restrictions. In 1981, for instance, a Japanese
A firm attempted to export guns to Korea by describing the merchandise as "steel tubes". 57

As the big four in aerospace come to realize that the export restriction is stifling their growth--and perhaps the attainment of international prestige--export of military components may well become a carefully-studied option. Clearly, the existing capital infrastructure is geared toward the production of military aircraft. A likely Japanese strategy, taking advantage of this infrastructure, appears to be:

- Use the FS-X to gain world-class credentials in military aircraft.

- Become more aggressive in the export of so-called dual-use components, especially those components associated with high-performance aircraft.

Both of these points represent logical extensions of the strategy observed during Phase II. They do not, by themselves, violate legal provisions or corporate objectives. Given success in these two areas, Japan's aerospace industry might well consider exporting a purely military component as a test case, paying careful attention to the existing trade climate. As an extreme, the aerospace

industry (or specific firms within the industry) might then be prepared to enter the military market if the export restriction were lifted, even if only in a de facto sense.

The military market does not represent an easy market for the Japanese to enter. Indeed, the low end of the market—the likely entry point for a new manufacturer—is crowded with producers who dominate North America, Europe, and the Middle East. Nevertheless, the military market is clearly more receptive than the commercial market, where buyers attach particular significance to product history—a characteristic that a Japanese aircraft would clearly lack.
Countering Macroeconomic Problems

In addition to confronting social taboos and legal restrictions, the big four have to address significant macroeconomic problems created by the rising value of the yen, the fluctuating domestic economy, and trade frictions--especially those with the United States. In a general sense, the individual firms have followed similar strategies in attacking these issues.

To counter the rising yen and the domestic recession, the firms have tried to cut costs by slowing planned capital investments, allowing employee rolls to decrease through retirement and other forms of "natural attrition," and transferring employees to more profitable sectors within the firm. It is important to note that the aerospace sectors of these firms tend to be very profitable--it is their sectors such as shipbuilding that have suffered the most from the recession. Further, with exports accounting for such a small portion of aerospace output, the rising yen has not had a significant impact on profitability in these areas.

Trade frictions represent a key concern. Indeed, if not for the pressure imposed by the United States government, the FS-X fighter program would have been a purely indigenous effort. The Japanese recognize--as does the US Congress--that aerospace is one of the few sectors where the US consistently runs a trade surplus vis-a-vis Japan. While the Japanese are pleased to accept US
technology, they are somewhat less willing to accept US guidance on the operation of their industry.

As long as major aircraft sales are decided by high-ranking government officials, Japanese industry is somewhat limited in its exercise of any counter strategy. Despite this limitation, the key to the counter strategy must lie in Japan's ability to convince its Western partners that a realignment has taken place. As Samuels and Whipple describe it,

The shift towards aerospace industrial development via increased defense production is best seen as part of a larger, nascent Japanese industrial policy and national security strategy stimulated in large part by declining American hegemony and the realignment of power in the international political economy. ... the FS-X agreement (for example) is simply a reflection of the shifting terms of trade in advanced technology.


59 Ibid., p. 22.
Conclusion: A Rising Challenge to US Industry

The rising capabilities and aspirations of the Japanese aerospace industry pose an unprecedented challenge to the US aerospace industry. US firms must decide if they should cooperate with Japan, possibly creating a future competitor, or ignore Japan and lose any hope of control over the emergence of an aerospace power. The choice is by no means clear.

The FS-X will be a key indicator of success in Japan’s emergence. If the program falters seriously, the Japanese will likely not be prepared to compete as a prime contractor in the next generation of aircraft. If FS-X is a resounding success, the Japanese are likely to be emboldened, awaiting the slightest misstep (such as a major program failure or a withdrawal from the market altogether) of an existing world-class competitor to provide its entry point. I believe that such a misstep would be a necessary (but not sufficient) condition to provide Japan a minimum level of confidence to enter the worldwide aircraft oligopoly.

While the increased export of high-value-added avionics components represents the most likely Japanese approach to world markets, it will also be interesting to watch for a "commercialized" version of aircraft like the successful XT-4. In addition, any explicit or de facto change in the existing export restrictions would signal a major change in
strategy. The big four will continue to wait, absorbing all the foreign technology they can acquire and building upon their indigenous strengths in electronics, advanced materials and optics. "Maintaining options" is clearly a key element of Phase III.
APPENDIX A

Response of US Industry: Boeing as a Case Study

From Boeing's perspective, joint ventures with the Japanese offer both opportunities and challenges. My analysis, based on interviews with senior Boeing executives and others within the aerospace industry, leads me to conclude that the opportunities include:

- **Risk sharing** -- The 7J7 program, in which the Japanese held a 25-percent equity stake, is a clear example of risk sharing in an all new, multi-billion dollar project.

- **Market Access** -- Similarly, the 7J7 program was a recognition that Boeing highly values its sales to the Japanese airlines. Indeed, those airlines (Japan Airlines and All Nippon Airlines) comprise Boeing's single largest customer for its 747 model--Boeing's "cash cow." By involving Japanese manufacturers, Boeing helps to ensure continued access to this lucrative market.

- **Financing** -- The Japanese are clearly in excellent position to provide low-cost financing in the multi-billion dollar scale demanded by the aerospace industry.
Control -- By working with the Japanese, Boeing could be in a position to direct some of Japan's developmental efforts. Further, Boeing's association with them allows for a continual information flow, allowing the firm to observe the Japanese emergence.

Block Airbus -- The Japanese link could serve to block Boeing's primary rival, Airbus, from attempting to establish a similar linkage. It is important to note that Boeing no longer possesses a monopoly over aerospace process and product technologies. As a result, Boeing can no longer exert complete control over Japan's foreign technology acquisition.

Technology Access -- Boeing recognizes that the Japanese have specific product and process technologies that could provide the firm with a strategic advantage with respect to its American and European competitors.

Increased Service Network -- By having a manufacturer based in the Far East, Boeing's spare parts response time to key customers could be reduced.
These opportunities are countered by challenges including:

- **Create Potential Competitor** -- The analysis in chapter two clearly indicates that technology transfer from the United States has been the key element in allowing Japanese aerospace to rise to its current level of sophistication. By continuing this relationship, particularly in allowing the Japanese to cooperate on current, state-of-the-art programs, the likelihood increases that Japan will become a serious competitor in global aerospace markets.

- **Limited Technology Access** -- Some US managers are concerned that Japanese aerospace firms will not transfer their latest technology to the US. Indeed, as the FS-X negotiations illustrated, it is much more difficult to arrange technology barters than it is to simply sell technology. The Japanese cite the US refusal to transfer certain "black box" technology as a justification for limiting access to their advanced technology.

- **Limited Usefulness of Foreign Technology** -- The US bias toward "not-invented-here" perceptions limits the usefulness of foreign technologies acquired through joint ventures. At the same time, Japanese receptivity
to adopting and adapting foreign technology makes any technology they acquire infinitely more valuable.

My attempt to produce a linear model incorporating the opportunities and challenges described above was precluded by a lack of consensus among US aerospace industry executives with respect to the weights that each one of these factors should be given. This lack of consensus—even within a single firm—confirms my belief that a concerted response to the Japanese challenge is not likely to evolve in the near future.
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INTERVIEWS:

BOEING: Conversation with Mr. Tak Seto, Senior Manager of International Business at Boeing Commercial Airplanes, held in Seattle on January 18, 1989. Also present during this interview was Mr. Roy Phillips, Director of International and Joint Program Developments at Boeing and others.

GENERAL DYNAMICS: Conversations with Ms. Maryjo Morris, a manager at General Dynamics, currently a Sloan Fellow, in Cambridge, fall 1988.


PRATT AND WHITNEY: Conversation with Carl Thomas, Director of Manufacturing at Pratt and Whitney and others, in Boston on January 23, 1989.