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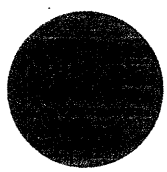

DEFENSE PRODUCTION AND INDUSTRIAL DEVELOPMENT:
THE CASE OF JAPANESE AIRCRAFT

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I. THE ARGUMENT

Japanese industry and government have targeted aerospace as one of three "key technologies" (*kiban gijutsu*) for the twenty-first century. In its famous 1970 Vision, MITI elevated aerospace as the equal of nuclear power and the information industry, a status reaffirmed in 1980. Coveted for its technological linkages with a wide range of high value-added industries and its potential to lift prominent firms out of declining sectors, aerospace enjoys considerable public support. By the early 1980's, formal government subsidies for commercial jet engine development were nearly equal to those for computer research and greater than those for telecommunications, energy, and "next generation base technologies."[1] By the late 1980's, MITI had supported a decade of commercial collaboration with leading Western aerospace firms. Some scholars and the press have suggested that this support, like that for steel, machinery, and electronics before it, will transform commercial aerospace into the next Japanese export success. Others are more pessimistic.[2]

But we believe that this debate misses a critical point, for the aerospace industry is unlike any other in one very important respect: it has been created and sustained by the military and its derivative air and space programs, not by commercial markets for civilian products. Commercial aviation is a large and expanding business, but it has played a minor role

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in the development of the manufacturing enterprise that enables it. Accordingly, we argue that an analytic focus restricted to commercial aviation overlooks essential characteristics of the aerospace industrial development process. In Japan as elsewhere, military production will predominate for the foreseeable future.

The military side of Japan's aerospace sector also merits attention for another reason. The global transformation of the industry's primary activities -- from bending metal to integrating advanced materials, microelectronics, computers, telecommunications and high technology in general -- has converged with growing Japanese strength in these fields, and with long-developed strengths in small-lot precision manufacturing and quality control. Domestic and overseas military markets now present major opportunities for Japanese firms to profit from the extended application of technologies originally developed for commercial purposes. Such opportunities for "dual-use" are especially prevalent in electronics, but exist for a broad spectrum of manufacturing industries. The Japanese call this technology transfer "spin-on," emphasizing the difference from the experience elsewhere, in which technology has historically "spun-off" from military to civilian applications. Commercial technology is now vital to all Western military aerospace industries. The US Department of Defense and MITI have both expressed an intense interest in the technology base of the Japanese commercial electronics and materials industries.

Japan's military aerospace industry arms the nation, serves as the bellwether for commercial aerospace and provides an important new market for the application of civilian high technology. For these reasons, among others to be explored below, Japan's military aerospace sector is growing in size and importance. As it grows, Japan must juggle the conflicting imperatives of commercial opportunity, international relations, and the legacy of demilitarization. In this paper, we explore the evolving linkages between military production, industrial development, and Japanese strategies in aerospace.

II. THE BACKGROUND

Aerospace emerged from a WWII alliance among the military, the scientific community, and the aviation, electronics, and instrumentation industries. Airliners and space programs have attracted more attention in the intervening decades, but military production remains the core activity. Commercial production is secondary and rests firmly on a military-industrial infrastructure. American aerospace, by far the world's largest, most diversified and commercialized national industry, typically sells over 60% of output to the Department of Defense and a significant fraction of the remainder to other government agencies and foreign military establishments. The Japan Defense Agency procures over 80% of Japanese output, in a market where the largest domestic producer of jet engines has never sold one for commercial use. Military production dominates the European aircraft industry despite the Airbus project. Over the last twenty years, military

aircraft production has overwhelmed civilian production worldwide by a margin greater than two to one. Only five of twenty-two aircraft manufacturers have survived in postwar commercial markets, and only one does more business with the airlines than with the armed forces. Both foreign experience and Japan's own industrial development suggest that Japan cannot afford to nurture commercial aerospace apart from military production.[3]

It could have been otherwise had Japan's planners succeeded, for they have tried repeatedly to participate in the postwar commercial aircraft business. The first major effort attempted to establish an independent presence via design and production of the YS-11, Japan's first and thus far only indigenous commercial aircraft. Government and industry initiated the YS-11 project in 1957 with the creation of the Nippon Aircraft Manufacturing Company, a "national policy company" (*kokusaku gaisha*).[4] This project engaged all of Japan's heavy industrial and related components manufacturers in a consortium in which the state assumed 50% of the equity and guaranteed full subsidization of development costs. By most accounts, this formula also guaranteed that there was little incentive for market analysis or cost reduction. While acclaimed as a technological success, fewer than 200 planes were sold, two-thirds to domestic airlines which would have bought more had it not been for severe production delays. The program ultimately suffered losses four times its capitalization and when it wound down in the early 1970's, the planners retreated from their independent approach to consider less ambitious strategies for commercial aviation.

By 1980 government and industry had swapped indigenous development for international collaboration and allied themselves strategically with the Boeing Commercial Airplane Company and with the International Aero Engines Consortium led by Rolls-Royce and Pratt and Whitney.[5] But despite a successful and historically unprecedented junior partnership in the development and production of Boeing's 767, the collaborative strategy is succeeding slowly, at best. Even measured in devalued dollars, the Japanese commercial aircraft business remains about one-fortieth the size of its American counterpart, and accounts for merely .04% of Japanese manufacturing value. Indeed, after a decade of subsidized cooperation, the total value of Japanese commercial aircraft production remains less than 2% of the sales of Toyota Motors. Nor has international cooperation been profitable. Slow sales of the 767 have forced Japanese firms to produce at one-third the planned rate and spread tooling costs over far fewer units than anticipated. The high yen and dollar-denominated contracts have forced them to supply parts -- for Boeing's 747 as well as for the 767 -- at a loss.[6] To make matters worse, the crown jewel of collaboration was snatched away in late 1987 when Boeing dramatically cut back the follow-on for the 767, the 7J7 co-development project. The 7J7 (the letter "J" standing for Japan) was the largest and most promising component of the collaborative strategy; its effective cancellation after years of planning has reopened debate over appropriate strategies for the Japanese commercial airframe business.

Similarly, problems at the IAE consortium do not bode well for Japanese engine manufacturers. The consortium's slow-selling V2500 engine repeatedly failed development tests and resumed progress towards government

certification only after the temporary substitution of old technology in a key subsystem from Rolls Royce. IAE will need to recertify the V2500 when the production model is ready, and will deliver engines late and below specification. In 1987, IAE angered an important customer and lost credibility throughout the industry when it announced the "Superfan" V2500 derivative, committed to an ambitious development schedule, and then cancelled the project within four months, stating that the Superfan had never been a definite product. The airline eventually cancelled its V2500 orders altogether, and another followed suit. IAE is resolving slowly the technical problems, but costly delays, combined with tough competition and the organizational awkwardness of a five-nation consortium with two leaders, have made future profits improbable and the future of IAE itself problematic. At best, the V2500 will be runner-up in a market segment led by the GE/SNECMA consortium and is unlikely to recover development costs. At worst, the leaders will tire of IAE's problems and pursue alternate strategies to maintain their status as full-line producers, a real if apparently diminishing possibility. In any case, the Japanese participants long ago delivered their relatively low technology subsystems, and with major events beyond their control, are learning what they can about international sales and support.[7] They are also learning the hard way about the vulnerabilities associated with junior partnerships in international consortia.

Between the troubles at IAE and the demise of the 7J7, the collaborative strategy once intended to drive commercial aerospace into the next century is beginning to appear little more satisfactory than the autonomous approach of the YS-11 era. Once again, and despite persistence and flexibility, Japanese policy makers and industrialists have proved unable to replicate in commercial aviation their success in other industries. Is this failure inevitable, overdetermined by a long list of adverse market conditions that MITI cannot surmount, and that MITI's policies often exacerbate? Such conditions discussed in the literature include a small and possibly misshapen home market, a lack of domestic competition, the strong position of Western technology suppliers, overdependence on low-growth military co-production, a ban on weapons exports, a lack of experience with design, systems integration, and international sales and support, and other factors.[8] The pernicious effects of many of these problems can be seen in the examples above.

We agree that Japan's aerospace industry faces fundamental problems. But we also believe that these problems -- and their solutions -- are less determined by market forces *per se* than by political forces flowing from Japanese attitudes about how and how much to best provide for national security. Traditional reluctance to invest in the defense industry and a ban on military exports surely have stunted the development of Japanese aerospace. Most analyses acknowledge this and stop there, suggesting that these political limitations place a "natural cap" on the industry; Mowery and Rosenberg, for example, argue that "any growth in the aircraft market must perforce come from an expansion of the commercial aircraft market."[9] To the contrary, we believe that the Japanese perceive the benefits of this business to be so compelling, and that these perceptions are converging so

rapidly with other strategic and technological developments, that a significant recalculation of Japanese defense industrial policy is not only far more probable than permanent weakness in aerospace, but indeed, it is already underway.

III. A NEW STRATEGY FOR JAPANESE AEROSPACE

The weakness of Japanese aerospace is best understood as the obverse of the general economic benefits conferred by postwar demilitarization. By the end of the Pacific War, the military had come to play a major role in Japan's heavy industrial development, consuming a large fraction of domestic output and presiding over a large and technically advanced aircraft sector.[10] Under Occupation orders, the military and its budget vanished and the aircraft industry disappeared for seven crucial years while the West entered the jet age. Despite nominal rearmament starting in 1954, the military has played a trivial role in the postwar Japanese economy. Demilitarization, imposed by the Occupation and later enabled by US security guarantees, became the centerpiece of postwar security policy. A popular anti-militarist political consensus, enshrined in the ambiguous Article Nine of the Constitution, combined with exceptional opportunities in world markets for commercial goods, made possible a temporary limit on spending for "self-defense" forces of one percent of GNP (1976-1987). Military procurement has been carefully supervised by MITI, and the industry that equips them is formally forbidden to export.[11] These restrictions undoubtedly contributed to commercial competitiveness overall, but undermined Japan's efforts to compete in aerospace. This trade-off was quite a happy one for most of the postwar period; the formal budget limit in effect between 1976 and 1987 had been a reality since the mid 1960's, and the export ban went unchallenged while heavy industry prospered in commercial markets.

In the 1980's, however, a realignment of political and economic forces has brought a recalculation of defense policy, which in turn has stimulated a fundamental change in Japan's overall approach to aerospace industrial development and in the scale and scope of the industry itself. The defense budget and the fraction spent on aerospace have grown steadily over the past decade, a period of austerity for other government agencies. The ban on weapons transfers, always open to interpretation, is eroding as an obstacle to the export of "dual use" aircraft and aerospace technology. Military aerospace, including expanded production at the major electronics firms, is fast becoming the primary beneficiary of an evolving Japanese national security regime. In turn, this regime benefits from a gold mine of domestic high technology, originally developed for civilian purposes but now available to supplement and gradually supplant the imported results of American military R&D.

Aerospace industry sales measured in yen have more than doubled and become increasingly important to the diversified companies that participate and increasingly attractive to those that do not. At industry-leader

Mitsubishi Heavy Industries (MHI), aerospace sales grew by 50% between 1983 and 1985 alone, catapulting the business from last to second among seven divisions.[12] Aerospace and defence production have undergone similarly vertiginous growth at other heavy industrial firms, such as Ishikawajima-Harima Heavy Industries and Kawasaki Heavy Industries. Technological competence, managerial experience, and facilities for research, development and manufacturing have all improved substantially. A minor portion of the growth in sales and capability has been funded by commercial projects and somewhat more by the ambitious Japanese space program, but the lion's share has come from a defense buildup that has already spanned several administrations and that will continue at least into the 1990s. The one percent of GNP limit ended with the fiscal 1988 budget, but its demise was preordained by programs begun in the late 1970's and its importance had diminished regardless. Japan's emergence as an economic giant means that 1% of GNP now supports a defense budget comparable to that of West Germany or France, each spending three times as much when expressed as a percentage of GNP. Japan now ranks second in military spending among non-nuclear powers.

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. Necessary preconditions were established in the 1970s, when expensive oil, slow growth, and increased competition from newly industrializing countries sparked wide-spread agreement within the industrial and economic policy bureaucracies and the private sector that a strong presence in high-technology industries was essential to Japan's future economic success. Government and industry launched major efforts in computers, materials science, semiconductors, mechatronics, and other high value-added fields, many of which would later contribute to "spun-on" competitiveness in aerospace even when more direct strategies proved disappointing. At the same time, the US retreat from Southeast Asia, the growth of Soviet power throughout the region, Japan's emerging economic strength and, most of all, US exhortations, converged to create compelling reasons for a Japanese military buildup. Economic pressure from the NIC's, political pressure from the US, and military pressure from the Soviet Union have only intensified in the years since.

It must be noted that whatever the extent of external pressures, legitimate defense needs or available technology, considerable antipathy towards the military remains firmly embedded in Japanese society. The pacifist legacy of the Pacific War has led to a curious situation for defense planners. Former Prime Minister Nakasone's previous service as Director-General of the Defense Agency notwithstanding, there is no evidence that the military have regained either sufficient political influence to bring about such a change in policy, or sufficient political respectability to be given a larger share of scarce public funds, financed with deficits, to spend as they see fit. Although the situation has begun to change as career officials assume key JDA posts, many are still held by officials seconded from other ministries, especially MITI.[13] In a sense, though, this change is irrelevant, for one of the most interesting and unusual aspects of

the buildup is that it could not have been started or sustained without MITI's firm support.

MITI officials have always been aware of the link between military and commercial aerospace, and the depth of their previous commitment to an exclusively civilian strategy can be overstated; as the name of the Aircraft and Ordnance Bureau implies, they oversee the military production that dominates the industry. As a result of such longstanding involvement and the bleak near-term outlook for commercial projects in the late 1970's, MITI endorsed stepped-up military production as a more timely, controllable and realistic means of aerospace industrial development, as well as a fruitful way to help the electronics industry move from consumer to capital goods.[14] MITI officials have steadily supported the defense buildup and worked closely with the Japan Defense Agency and the private firms to insure that the defense budget is advancing strategic industrial goals as well as strategic military ones. We expect, moreover, that the latest disarray in commercial strategy stemming from the demise of the 7J7 and the problems at IAE will renew the relative importance of military efforts in MITI's policy portfolio.

MITI's involvement in the growth of the military aerospace industry has created a novel situation, for it has been standard historical practice for nations to foster civilian industrial development in pursuit of military advantage, not the other way around. We do not argue that the defense buildup is somehow a Trojan horse for commercial strategy, although it is clear that some civilian leaders support it for this reason. Nor do we believe that Japanese planners have replaced their goal of building a competitive commercial aerospace industry with that of creating a military industrial complex; as noted above, plans are already being made for a new Japanese-led transport consortium to fill the void left by the 7J7, a next-generation transport engine is under development, and commercial aspirations remain very much alive.[15] Finally, we do not believe that Japanese planners are expecting military R&D to spin-off commercial technology as it did in the US thirty years ago; they are convinced that far more technology will be spun-on than off.[16] We do expect, however, that with increased defense procurement, and ultimately with overseas sales, Japan will fund the military-industrial infrastructure that has been an historical precondition for success in commercial aerospace, an infrastructure that today is built upon dual-use technologies, already a Japanese strength. For the first time, Japan is preparing to pursue "spin-off" and "spin-on" simultaneously.

This first was suggested openly in an influential report to the Minister for International Trade and Industry in mid-1988. After establishing that Japan is a peaceful country that will continue to adhere strictly to its three principles on weapons exports, this report clearly addresses the rationale for participation in dual-use technology transfer and joint weapons development with the US:

> "...although patterns of technology diffusion related to dual-use technologies are changing, one can see that there are not a few cases of the effective diffusion of

> "key technologies" from military to civilian sectors. In order not to lag behind the West in international competitiveness in the future, it is undoubtedly necessary to participate as appropriate in the military sector through close contact with top rank Western firms. Most advanced technologies are already dual-use..."[17]

The report then continues by noting how sensitive a matter such an advance into the defense industry is for Japan.

However sensitive, increased defense production is proving to be a versatile and effective strategy for both industrial development and national security. It satisfies multiple needs and interests, and has become the basis for a new and active domestic political coalition, a coalition that joins influential subgroups in the industrial, foreign, and economic policy bureaucracies and the defense establishment with an increasing number of important private firms. After identifying the industrial base of this coalition, in the next section, we will explore its actions in the specific case of Japan's single largest procurement program of the 1990's, the FS-X next generation fighter plane.

IV. THE AEROSPACE INDUSTRIAL BASE

The four heavy industrial companies that dominate the Japanese aerospace industry have been strong proponents of increased defense production. Mitsubishi Heavy Industries (MHI), Kawasaki Heavy Industries (KHI), Fuji Heavy Industries (FHI), and Ishikawajima-Harima Heavy Industries (IHI) were all central participants in the first stages of economic recovery, manufacturing ships, cars, electrical equipment, and other capital goods that led Japan's industrialization through the 1960's. They were then big losers from the first oil shock and the end of high growth. Along with textile and steel firms, they were also among the first to be threatened by producers in the NIC's. By the mid 1970s they clearly needed new business, and for historical and economic reasons they looked quite naturally to aerospace. At the time, however, commercial opportunities were actually contracting as YS-11 production wound down without a follow-on. The firms and their many stakeholders developed a strong interest in increased defense production, and raised their collective voices in support. The influential Federation of Economic Organizations, *Keidanren*, began insisting through its Defense Industries Production Committee that the JDA do more for the domestic defense industry.[18]

The military aircraft business is by no means new to these four firms. They have engaged in different parts of the business together and separately since its national introduction in the early part of the century. In the prewar period all airplane manufacturing was done by single firms, there was little or no standardization of parts or specifications, and productivity

was low. A wartime consolidation ordered by the military was incomplete, handicapped by opposition from the firms. As late as 1944 there were twelve independent airframe producers and seven engine manufacturers. The US Occupation then banned all aircraft manufacturing and broke up the major manufacturers into smaller, more benign enterprises.[19] The result was a dispersion of engineering talent and the refocusing of manufacturing activities. When the ban was lifted in 1952, the rest of the world was already in the jet age, while the thinning ranks of Japanese aircraft engineers had been designing bicycles and fire extinguishers.

The industry was revived first by repair and maintenance, then by off-shore procurement, and later by co-production agreements with the American military, and has never overcome its financial dependence on military production.[20] The handful of commercial projects, including the YS-11 and components for Boeing, have been produced alongside warplanes and military engines in plants surviving from the prewar era, often with machine tools and other equipment paid for by the Japan Defense Agency.[21] The technological spillovers from military licensing also have been considerable.[22] According to Hall and Johnson:

> "...In a very short period - largely as a result of skillful importation of technology - the Japanese acquired a small but capable and profitable aerospace industry. A key element in this accomplishment was the Japanese government's sponsorship of military aircraft co-production programs."[23]

Aircraft production is organized as divisions of the heavy industrial companies and until recently provided only a small portion of their total revenue. Despite Hall and Johnson's optimistic assessment, in the 1950's and 1960's these divisions were less profitable than Japanese firms overall, than other manufacturing firms, and than other divisions within the firms, and were viewed internally as "poor cousins." In the 1970's, the business collapsed. In the 1980's, however, it has been revived once again by military production, and the prospect of sustained higher defense spending and increased emphasis on domestic technology have turned the business into an important and prestigious growth sector, offsetting precipitous declines in such areas as shipbuilding and petrochemical plant construction. Defense production has provided an almost "natural" path for the migration of human and capital resources; the transition from sophisticated heavy machinery to military aircraft is not seamless, but it is quite straightforward compared with the steel firms' moves into silicon wafers and theme parks.[24]

The heavy industrial firms making airframes and engines are the biggest but not the only players in the Japanese aerospace industry, nor are they the only beneficiaries of the buildup. Mitsubishi Electric, Toshiba, NEC and Hitachi produce avionics, missiles and military communication systems, all prime areas for "spin-on" and all of which have boomed. There are also many smaller component firms, and although most of their increasing output goes to the JDA as well, they have enjoyed brisk growth in overseas commercial sales since the mid-1980's. Overall, the industry is comprised

of nearly two hundred firms, three-quarters of which are members of the Society of Japanese Aerospace Industries (SJAC), the major industry association.[25]

V. MAKING MILITARY AIRCRAFT

V.1. Product and Process

Modern jet fighters are remarkably complex, high performance machines. The largest weigh up to 20 tons empty and the most powerful carry more than their own weight in fuel and armament. They travel at altitudes ranging from 100 feet to 10 miles at speeds exceeding 1500 miles per hour, and execute maneuvers that will black out the pilot before reaching the limits of the airframe. Their avionics meld together a bewildering array of electronic, electro-mechanical and opto-electronic equipment that must function in an environment of extreme temperature, shock, vibration, g-forces, and in the worst-case, electromagnetic pulse.[26] Although many nations now produce low performance tactical aircraft, those with the technological, managerial and financial wherewithal to design and deploy top-of-the-line fighters form an exclusive club, and they pay dearly for membership. Until the shift in exchange rates in the mid-1980's, the amount typically spent by the US simply for fighter-related R&D exceeded the sales of the entire Japanese aerospace industry.

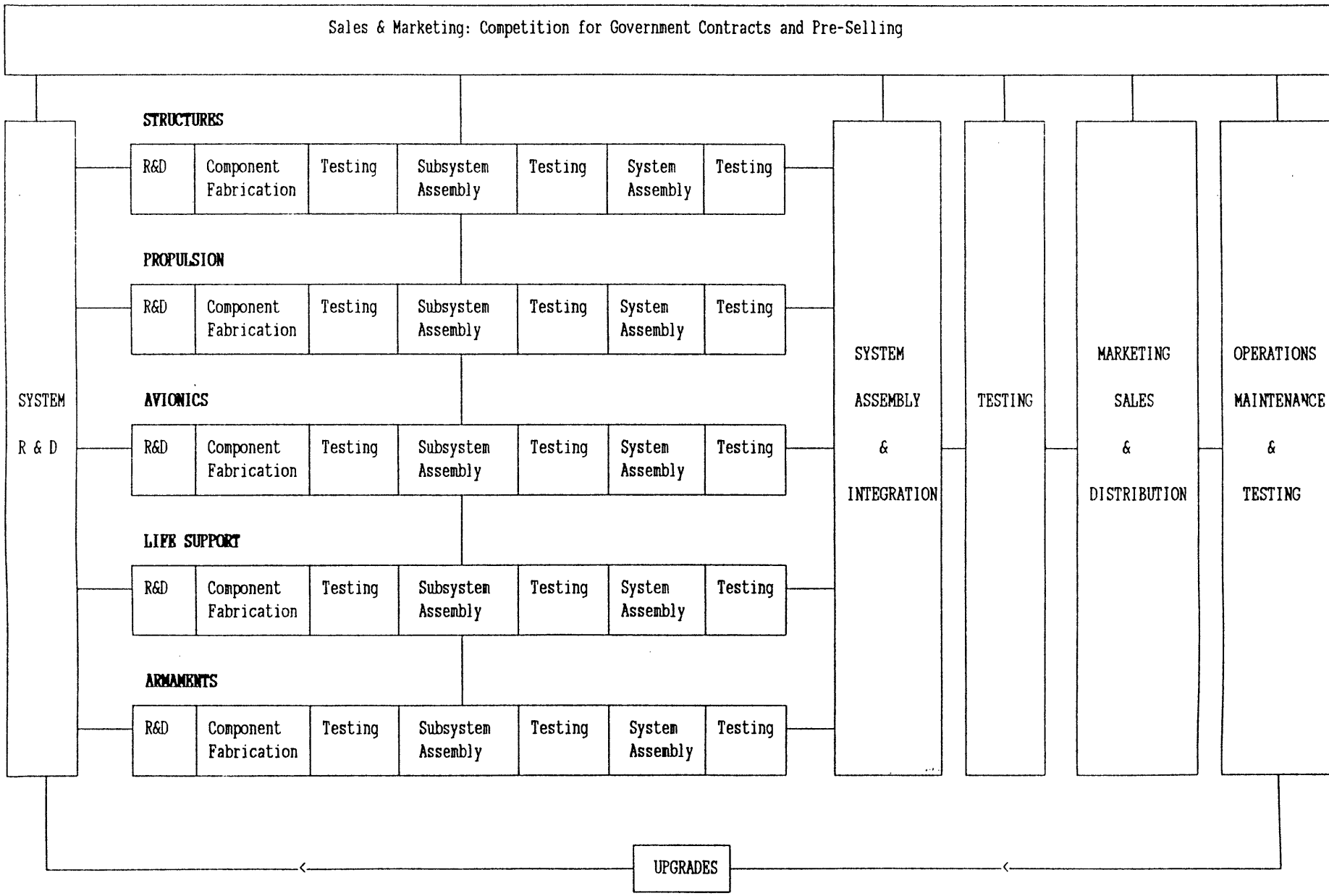
The design and manufacturing processes for these sophisticated machines are equally complex and demanding. Like all aerospace final products, fighters require long lead times and high R&D expenditures, both absolute and relative to manufacturing costs. Each is an intricate assembly of subsystems -- structure, propulsion, avionics, and armaments -- and each subsystem in turn is an intricate assembly of components, many of which push the limits of whatever technologies are involved. The low-rate manufacturing process is both capital and labor intensive, and depends on elaborate facilities, highly skilled artisans and slow learning curves. Figure 1 illustrates the value-added chain, in which millions of parts are designed, manufactured and built up into final products. The multi-year multi-billion dollar process is essentially the same for all aerospace vehicles, although some lack life-support and/or armaments.

Figure One about here: Aerospace Value-Added Chain

Aerospace systems integration deserves special mention. Systems integration is not only, as pictured, one of the last links in the value chain where all subsystems and components must be made to fit and work together, but is also a metaphor for the management process in its entirety. One cannot easily integrate subsystems at the tail end if the interface was not properly specified up front or if inevitable in-process design changes have not been properly managed. Integration problems are magnified by concurrent development and production, multiple organizational boundaries,

Figure 1

The Value-Added Chain in Aerospace



sheer complexity, and the need to insulate the overall program from delays and difficulties at the subsystem level. With its blend of stiff technical and managerial requirements, systems integration is the most challenging aspect of aerospace production, and given the infrequency of full scale production programs, also the hardest set of skills to develop. A stable set of partners is a critical requirement.

V.2. Industrial Organization

The intricate value-added chain is reflected in an industrial division of labor that varies from country to country. In the US, the traditional structure has been a distinct pyramid with a dozen or so large "prime contracting" firms competing at the top, mostly corporate combinations of the original aircraft makers. With few exceptions, these firms specialize in aerospace production and their fortunes rise and fall accordingly. In a typical program, the winning prime contractor will do system R&D, manufacture most of the main structures, and perform final assembly, integration, and testing; the remaining 40%-70% by value is subcontracted directly or as "government furnished equipment." Contracts for the major subsystems are shared among other primes and a larger number of subsystem manufacturers, which in turn let out work to thousands of small component fabricators and machine shops. The general structure of European aerospace is quite similar, although intra-European consortia generally assume the role of American prime contractors, national firms serve as the main subcontractors, and a large but diminishing number of designs and components come from the US. Both industries (and their government customers) rely heavily on exports to lower unit costs.[27]

The industrial structure of Japanese aerospace production is very different. As noted earlier, the industry is organized as divisions of diversified companies, which in turn are affiliated with important *keiretsu*, the finance-centered business groups decended from the prewar *zaibatsu* trusts. As a result, aerospace is more closely linked to other industrial sectors, both within the firms and within the *keiretsu*. Presumably, this closer linkage promotes both the identification of multiple use technologies and their intersectoral transfer, by reducing the organizational boundaries over which opportunities must be perceived and through which technologies must pass.[28]

The industry is far more concentrated than in the U.S, with three firms controlling over 90% of the prime contract market. Mitsubishi alone has almost half, Kawasaki and IHI about one quarter each. Fuji Heavy Industries accounts for much of the rest, giving the "big four" essentially complete responsibility for Japanese aircraft production. Extensive vertical integration within these companies and other historic ties lead to a different pattern of subcontracting than is common in the West; often other *keiretsu* members are major beneficiaries. Mitsubishi Electric (MELCO), for example, is the leading supplier of avionics, while Mitsubishi Precision,

created in 1962 by MHI, MELCO, Mitsubishi Trading, the Mitsubishi Bank and US General Precision, is a leading supplier of instrumentation.[29]

Relatedly, the industry is also far more openly collusive than in the US. The Japanese describe it as a sort of "friendship club" (*nakayoshi kurabu*) built within a "village society" (*mura shakai*), and based upon "mutual knowledge" (*tsūka*).[30] The central purpose of the First Aircraft Industry Promotion Law of 1954 was to cartelize the industry with inducements to interfirm cooperation, and the law and its successors have been very successful in this regard.[31] From the Japan Jet Engine Consortium established in July 1953 to the "Orient Express" hypersonic plane project now on the drawing boards, every MITI, STA, and JDA program has been divided up such that the big four participate significantly in each one, regardless of which among them has been designated military prime contractor or commercial consortium leader.

Collaboration often begins with research and development upstream and nearly every project combines several firms that would otherwise (and elsewhere) likely be competitors. Participating firms often protect proprietary information, yet the extent of their collaboration and the stability of the partnerships are extraordinary by American standards. Several prominent examples include collaboration in new materials that is conducted under the aegis of MITI's Agency for Industrial Science and Technology Program for "Research for Basic Technologies for the Future Industries." This program supports the R&D Institute of Metals and Composites for Future Industries, which consigns a significant portion of its research support to aerospace firms for work on metal and polymer matrices, and carbon fibers. Additionally, SJAC (with MITI support) has successfully diffused metal bending and processing technologies to its members.[32] The big four (in collaboration with thirty-three other firms) are jointly developing a quiet, fuel efficient, low pollution, all-Japanese "Advanced Turboprop" engine with funding from the government's Key Technology Center. Here, too, they are collaboratively focused upon new materials, process technologies, design, and optics problems.[33] The same players are simultaneously engaged in the Japan Aero Engines joint venture with the IAE to build a turboprop for large commercial aircraft. These firms again join to form the Japanese consortium participating with Boeing in its 767 and 7J7 aircraft, in military projects such as the T-2 and XT-4 trainers, the FS-X, and, of course, the ill-fated YS-11. In short, the division of labor has been remarkably stable; after 30 years of carefully orchestrated work-sharing, coordinated investment strategies, and managed competition between the leading firms, all backed by extensive state support, are prominent features of the industry.

Finally, the Japanese industry has historically lacked independent capability in key segments of the value chain, notably systems-level R&D and design, systems integration in both senses, and international sales and support. The industry's mainstay has been licensed co-production of US warplanes, for which R&D has been long since completed, for which all systems integration problems have already been solved, and for which export sales are out of the question. Co-production, even with steadily increasing

local content, is equivalent to following a script; Japanese officials often deplore co-production as a transfer of "know-how" but not "know-why." As we will see, however, Japan has made considerable progress in remedying these deficiencies during the 1980s, and is poised to take advantage of and to continue this progress. One senior industry leader described how Japanese firms now approach licensed co-production by using the metaphor of a hand-me-down garment: "First you put it on, then you grow out of it."[34]

V.3. The Next Generation

The transformation of aerospace from metal-bending to integrating multiple advanced technologies continues to recast the production of military aircraft. The industrial requirements of the fighter business have changed radically in the last decade due to a revolution in design made possible by cumulative advance in materials and electronics, and made urgent by the proliferation of precision-guided anti-aircraft munitions. The old school of design, stressing size and speed, reached its peak in the early 1970s with the F-15, a very large and very fast all-metal airplane with mechanical controls and instruments, and with radar and radios essentially bolted in.[35] The F-16 and F-18, dating from the mid 1970's, blend old and new technology and are best considered transitional aircraft. The next generation, still in the R&D stage, makes extensive use of a broad range of new technologies: composite structural materials for lighter weight, lower observability and more streamlined shapes; "fly-by-wire," in which mechanical controls are replaced by computer-controlled actuators, and software algorithms actually fly the plane; miniaturized, more sophisticated and more tightly coupled sensors, displays and avionics, now tied directly into the computerized flight control system; and the odd-looking control surfaces, unstable aerodynamics, and extreme agility made possible by fly-by-wire, known as "control configured vehicles," or CCV.[36] The confluence of these new technologies will bring higher performance and "survivability" to the next generation of fighters.

The changing technology has already brought new skill requirements and much higher costs and complexity to the aircraft development process, and structural change to the industry. European firms and governments are struggling to form a follow-on consortia to the Panavia organization of the F-15 era, and US prime contractors have been forced into unprecedented teaming arrangements to spread costs and risks that DoD is no longer willing to absorb. To accommodate the next generation within the declining defense budgets of the late Reagan administration, DOD began insisting that former arch rivals collaborate on the dwindling number of new major projects, and assume much of the cost of competitive development without the guarantee of a future monopoly. Both next generation fighter projects, the Navy's ATA and the Air Force's ATF, are being developed in this manner. At least one and perhaps two or three US producers are likely to exit the tactical aircraft business, and others may disappear through merger and divestiture.[37] Those that remain will participate in either teamed

production of new aircraft or in the growing market for more affordable programs to retrofit new technologies into existing aircraft.

How might these disruptive changes affect Japanese ambitions? It is tempting to argue that they can only increase the competitive advantage of experienced US firms serving the enormous American market, thus raising the threshold and rendering any Japanese fighter project somewhat quixotic. We believe, however, that they will have precisely the opposite effect: the specific requirements of the next generation make virtues of the distinctive technological, organizational and managerial characteristics of Japanese industry. Technologically, Japan is on the leading edge in advanced materials, microelectronics, and other relevant areas, a potential advantage that the "spin-on" strategy deliberately exploits. 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. Finally, it should be noted that Japan will move towards the next generation via an upgrade program, albeit an extensive one, that combines the benefits of new technology with the economic advantage of starting from an existing aircraft. The transitional and widely acclaimed F-16 which they have chosen for the FS-X project is an ideal platform.

VI. THE CASE OF THE FS-X

VI.1. The Requirement

Under the "roles and missions" philosophy that guides defense cooperation between the US and Japan in the 1980s, Tokyo has agreed to assume primary responsibility for protecting her territory, airspace, coastal waters, and sea lanes out to 1,000 miles.[38] Expanded airpower is necessary to meet these objectives, as illustrated by former Prime Minister Nakasone's vow to make Japan an "unsinkable aircraft carrier." The current structure of Japanese airpower shows the legacy of dependence on American aerospace: of thirty-six types of aircraft deployed by the three Japanese services, nine are imported, sixteen coproduced, and among the remaining eleven are several direct copies of low technology US aircraft. The Japan Air Self Defense Force (JASDF) currently flies three different fighters, and two of them -- the F-4J and F-15J -- were designed by McDonnell Douglas and coproduced by consortia led by MHI. The F-1 close support aircraft, the first and thus far only postwar Japanese fighter, was designed and built by the MHI consortium without formal Western assistance, but like the other two and the upcoming SX-3, it is powered by engines produced under license by IHI.

The F-1, which first flew in 1977, is much smaller, slower and less capable than the F-4 and F-15, designed in the late 1950s and 1960s respectively.[39] The production run of 80 or so ended in 1983, by which time

JASDF was already concerned about technical obsolescence in the avionics, metal fatigue in the airframe, and the stiffer requirements posed by new "roles and missions" responsibilities and the buildup of Soviet power in the region. The JDA decided to accelerate replacing the F-1 and thus was born the formal requirement for the FS-X (or Fighter-Support/Experimental). Some of the F-4Js would also need replacement later in the decade, and although this issue was not explicitly linked to the FS-X procurement, the two could not be disentangled.

The need for new aircraft was uncontroversial, but settling the specifics immediately gave rise to a domestic debate, a debate best understood in the institutional, international and historical context of Japanese defense procurement. Defense production in the US is settled by the Department of Defense and Congress, with muted complaints from the Office of Management and Budget, occasional intervention by the President, and constant lobbying by industry. In Japan, proposals originate within JDA, are passed on for MITI's modifications and approval, and attract considerable attention from the ministries of finance and foreign affairs. The JDA has been traditionally unconcerned with the commercial implications of its procurement plans, but naturally prefers domestic production to simplify maintenance and repair. MITI's participation, however, injects a clearly articulated industrial policy component that favors domestic content and industrial development for reasons only partially related to defense. MITI's position is strongly supported, of course, by the heavy industrial companies. The powerful Finance Ministry predictably favors least-cost solutions, while the Ministry of Foreign Affairs (MOFA) serves to remind all that the US (and Japan's neighbors) are keenly interested in Japanese defense procurement.

VI.2. The Domestic Debate: Initial Positions

There were few surprises at the outset of the FS-X debate in the early 1980's, although both MITI and the JDA were internally divided. Private industry, the JDA's Technical Research and Development Institute (TRDI) and Air Staff Office, and MITI's Aircraft and Ordnance Office, were the most active proponents of domestic development, while MITI's Trade Bureau and JDA budget officials were opposed. Finance and Foreign Ministry officials concerned with budgets and US-Japanese relations were reported to be cautious or opposed. The other ministries were united in opposition and were joined by Japan's perennial opposition parties.[40]

Early arguments that the time had come for Japan to design an advanced aircraft were strengthened by clear indications that the US was adopting a tougher stance on technology transfer. Regarding the F-1, Japan had originally sought to co-produce an American plane but was turned down because DOD felt that they could make a sale; when JDA then sought to license avionics technology for their domestic program, DOD turned them down again.[41] The contrast between F-4J co-production in the 1970's and the

F-15J program just getting underway was also instructive. In the F-4 program, as in the F-104 program of the 1960's, the US had adopted a very liberal attitude towards technology transfer and work-sharing, and Japanese content and aerospace "know-how" rose accordingly. Many more restrictions were applied to the F-15 program. The most advanced 40% of the aircraft was to be perpetually imported "black boxes," and DOD refused to release a sensitive electronics warfare system in any form; meanwhile the US Congress was complaining that the program was overly generous.

Proponents also argued that with Western aerospace industries about to incorporate major technological advances in a new generation of fighters, and with the FS-X slated to be the only major new procurement program for a decade, Japan would fall hopelessly behind if it settled for restricted co-production of an existing aircraft. TRDI issued a report concluding that domestic development was within the technical grasp of Japanese industry, while MHI invoked the experimental TRDI/Mitsubishi T-2 Control Configured Vehicle as additional evidence that Japanese industry could go it alone. The solemn remarks of MHI president Suenaga Soichiro were typical:

> "If a foreign type is applied, there will remain no opportunity for new development in this century, and our development capability will be far behind international levels. A national design is necessary by all means."[42]

In the early 1980s, however, this position was a minority viewpoint even within JDA and MITI. There were few reasons to believe that Japan had the technological or budgetary resources to design and build a competitive fighter. There were many reasons to believe that she did not, including the unsatisfactory F-1, the new generation getting underway in the West, technical problems and delays in the T2 CCV project, and the fiscal austerity then crimping all budgets save defense. The high cost of such a project generated particular opposition, and although the Japanese government has always been willing to pay a co-production premium for jobs and technology transfer, the proposed FS-X project entailed a different magnitude of expense.[43] Given the uncertain success and high cost of a fighter development program spread over the short production run of a plane needed in limited quantities and unavailable for export, budget officials in JDA, MITI, and especially the Ministry of Finance viewed domestic development as a good way to pay more and buy less. These officials were already quarreling over the cost of the military build-up, and the domestic option received little initial support and generated much opposition.

Officials at the MOFA and MITI expressed additional concern at the predictably negative reaction of the US, still the ultimate guarantor of Japan's defense and its largest trading partner. Aerospace was one of the few industries where the US ran a consistent surplus, and it had become a traditional means of alleviating trade tension. When US policymakers expressed alarm over the widening deficit in the late 1970's, MITI and the Economic Planning Agency acted to defuse the situation by subsidizing the purchase of $1 billion worth of unneeded American transports for lease in the world market.[44] In 1978, acting under pressure from the MOFA, the JDA

agreed to reduce further the Japanese content in the upcoming F-15J program.[45] With the trade surplus expanding rapidly in the early 1980's, officials concerned with US relations were reviving the transport leasing program, and viewed the prcposal for a domestic fighter as a step in the wrong direction.

Given the breadth and depth of opposition, it was apparent that a foreign design would be selected if the FS-X decision was made on schedule in 1984; indeed, JDA procurement officials earmarked funds in the 1981-1986 five year plan to buy 24 aircraft and solicited bids from the West.[46] Moreover, the FS-X timetable rested on an assumption of co-production or outright purchase, and did not allow enough time for indigenous development even if the decision was favorable: the F-1s were to be replaced late in the 1980's, but a domestic aircraft could not be available before the end of the decade at the earliest. From the FS-X advocates' perspective, delay was imperative.

VI.3. Strategic Delay

Technical and structural obsolescence were driving the need for near-term replacement of the fighters. JASDF, TRDI and MHI came up with an inexpensive solution known as the "Service Life Extension Program" (SLEP). Ironically, both the idea and the technology were imported from the US, where SLEPs are common practice. The JDA had begun investigating them in the mid 1970's with an eye to the future of their F-4 fleet. In 1981, a team of engineers from TRDI and MHI was dispatched to the States to study US methods for reinforcing high stress areas on airframes. In 1982, MHI was awarded a contract to reinforce and refit a single F-4J with advanced avionics and armaments, extending its useful life well into the 1990's. In 1984, the five Western firms that had submitted FS-X proposals were told that consideration of foreign aircraft had been dropped for the time being in favor of an F-1 SLEP, and that the modified F-1 would last another five years. In early 1986, MHI was awarded a $400 million contract to update 100 F-4Js.[47]

But the SLEP strategy was much more than a technological "quick fix." By extending the service life of the F-1 by four years, the Japanese were giving domestic producers breathing space to get their own FS-X program up and running:

> "Time for producing a domestic FS-X was thereby ensured...These four years provide a golden opportunity for domestic development because the powerful rivals of a domestic FS-X will have become obsolete by the mid-1990's."[48]

> "The JDA, mindful of the need to nurture a domestic aircraft industry, had been set all along on using the FS-X procurement as an opportunity for the development of a new fighter plane...A domestic plane would put

> Japanese manufacturers in the driver's seat, help nurture their capabilities, and ultimately assist our future needs...Postponement will tilt the scale in favor of domestic development."[49]

The SLEP strategy was a resounding success because it offered something to all parties. Budget officials at JDA and the Finance Ministry were delighted because it delayed funding new aircraft years into the future. The US and MOFA were mollified temporarily, for much of the F-4J contract was slated for American avionics, and because in a separate decision, the length of the F-15J production run was extended. MHI got a substantial contract and experience with integrating digital avionics, while JASDF got uninterrupted deployment. More importantly, the SLEP contracts gave Japanese industry additional time to prepare, and perhaps most important, deployment rescheduled into the 1990's winnowed the field of potential competitors. Western planes designed in the 1970s would be technically obsolete.

Despite the window of opportunity opened by SLEP, however, convincing the critics that a Japanese FS-X was viable remained a challenging task; if the aerospace coalition was to prevail when the decision reappeared on the agenda, they had to overcome wide-spread and well-founded skepticism about the level of domestic technology and the lack of aerospace experience.

VI.4. Technology Development

JDA began funding next-generation fighter studies in the late 1970s, primarily to identify requisite technologies. On the basis of their findings, TRDI focussed attention, efforts and funding on advanced metallurgy, composite materials, stealth technology, advanced avionics and CCV. One aspect of these efforts was a traditional quest for American technology, despite increasing US reticence. In the case of the F-15, the JDA was able to overcome or at least reduce this reluctance by bargaining and persistence:

> "Among the items initially withheld were some that were open to reconsideration as passage of time made them less sensitive. The JDA pursued DOD on this list every year for the first 5-6 years of the program and eventually got everything short of what was firmly "non-negotiable."[50]

In an important break from past practice, however, TRDI placed main emphasis on creating indigenous expertise in the key technologies, and took advantage of the higher defense budgets to step up funding in its own labs and at the major aerospace and electronics firms. A noteworthy feature of the ensuing domestic development program was the manner in which contracts were conceived and organized in close correspondence with the value-added chain (Figure 2). Numerous small contracts were let for component development in each of the six aerospace subsectors. A smaller number of

subsystem contracts, even fewer system contracts, and only one full scale development and production program were awarded. Each contract, whatever its type or magnitude, was focused on some aspect of the larger issue of technological and industrial capability, and all were scheduled to show results by 1986.[51]

Figure Two about here: Table of Contracts

VI.5. Strategic Systems Integration

While the proliferation of smaller contracts were targeted at improving indigenous capabilities in specific segments of the value chain, the fewer but larger contracts aimed along the full length of the chain -- at systems integration -- deserve special mention. Two of the contract types, upgrade programs and prototypes, replicate in miniature important aspects of the systems integration experience provided by a full scale program but with lower costs and in less time. The F-4J SLEP, in which MHI rebuilt the planes from scratch and installed and integrated a completely new (though mostly American) avionics suite, thus provided benefits extending beyond deferred replacement. TRDI followed up the SLEP with the XSH-60J program, in which two American helicopters were bought "green" and fitted with mostly Japanese avionics. Eleven advanced systems were joined together in the aircraft, which JDA called "a platform for national capability development," and which domestic firms and TRDI planned and executed, though with substantial Western assistance.[52] In a program that combined the development of key technologies with systems integration experience, MHI was awarded the contract to convert a jet trainer into a prototype CCV.

While work on advanced components, upgrades and prototypes narrowed the gap in technology and experience, it did not address the criticism that Japanese industry completely lacked experience managing the development and production of a completely new aircraft: even the three major postwar "domestic" designs relied on imported or coproduced engines, avionics and other major subsystems.[53] The FS-X advocates were proposing to undertake a multi-year project involving billions of dollars, multiple organizations, thousands of highly skilled people and countless risks. Cost overruns, schedule slippage and technical problems are endemic, and the demands on management are high. Systems integration skills in the narrower sense are necessary but not sufficient; there is no substitute for experience managing the full process.

The JDA responded to these concerns with design and production of the supersonic XT-4 jet trainer. Trainers are smaller, simpler and much less expensive than fighters, so the decision to pursue national development was relatively uncontroversial; the program first appeared in the budget as an $8 million item, and received only token resistance from MOFA bureaucrats, who suggested foreign engines to appease trading partners. But, overseas firms were formally excluded in 1980. The consortium awarded this project was by now familiar: KHI would take the lead as prime contractor responsible for 40% of the airframe. MHI and FHI were each allotted 30%,

Figure 2: Japanese Military Aircraft Programs in the 1980's

Aerospace Materials	Avionics	Complete Systems
Advanced Metallurgy	ALQ-7 Airborne Jamming System	Prototypes
Composite Fabrication Techniques	ALQ-8 Electronic Warfare System	C1-ECM
Heavy Aluminum Plates	Attitude/Heading Reference System	Q-STOL*
Metal / Polymer Matrices	Automatic Flight Management System	T2-CCV
Radar Absorbing Materials	Cockpit Systems & Displays	
	Digital Engine Control System	Upgrades
Generic Technologies	Fiber Optic Aircraft Data Bus	F-1 SLEP
	Fire Control System	F-4 SLEP
Aerodynamic Research	Flight Computer	XSH-60J
CAD / CAM	Fly-by-Wire Control System	
Next-Generation Fighter Studies	Phased Array Radar	Coproduction
Test Facilities	Radar Warning System	AH-1S
	Search Radar	CH-47J
		F-15J
Aircraft Propulsion	Aircraft Armament	P-3C
		SH-3BJ
FJR-710*	ASM-1 Missile	UH-1H
XF-3	ASM-2 Missile	
	AAM-3 Missile	Production
* National Aerospace Laboratory	Radar guided missile	XT-4

and IHI would provide its XF3 engine. In all, 43 firms are participating in the project and will build two hundred aircraft. This is the first Japanese aircraft to use carbon fiber on a large scale and to use all Japanese aluminum plates, and the first to employ large scale use of computer-aided design and manufacturing. It is also the first aircraft project in which the engine and the body development proceeded in parallel. No plane of the postwar period has been comprised so exclusively of Japanese technology and components.[54]

The challenge of XT-4 development was more managerial than technical, as it replicated in miniature all aspects of an FS-X program, but with less demanding technology. A tight schedule, small budget, and almost equal participation by the three major firms intensified the demand for skillful management at every link in the value-added chain. Despite their inexperience, Japanese managers proved their ability to meet these demands when the first plane rolled out a month early and on budget, an exceedingly rare event in aerospace. Equally unusual, the XT-4 reportedly met all specifications during flight testing and entered production on schedule in 1986.[55] The complete success of the project contributed greatly to the increasing self-confidence and domestic credibility of the Japanese aerospace community, leading one US official at the time to note "peacock-like tails over Mitsubishi and the others."[56]

VI.6. The FS-X Decision: Trade and Technology

Although the FS-X ultimately became a trade issue, it was first and foremost a controversial domestic decision with an uncertain outcome. Japanese FS-X advocates were poorly received in the domestic arena when they first presented their case in the early 1980's. If they had not been able to delay the decision for several years, their defeat would have been certain. When the decision reappeared on the agenda later in the decade, however, they achieved many of their goals despite intense US pressure to "buy American." Ironically, this same US pressure rallied support for domestic production as an assertion of national sovereignty.

Five developments in the interim tipped the balance. First and foremost, an industrial strategy carefully crafted to develop and demonstrate the requisite technical and managerial skills came to fruition; the Japanese aerospace industry circa 1988 can cite specific accomplishments and argue credibly that it is now prepared for the FS-X, something it simply could not do earlier in the decade. Second, the delay allowed the coalition to redefine the FS-X as a possible replacement for two or perhaps even three different aircraft types instead of the original one, paving the way for an economically feasible development program. Third, by rescheduling deployment from 1986 to 1997, the coalition could argue persuasively that unmodified American aircraft designed in the early 1970s would be obsolete when deployed. Fourth, a consensus emerged within industry and government that dual use technology ought to be recognized and nurtured as such. Finally, external events also played a role: renewed difficulties in shipbuilding and the collapse of the Middle Eastern construction business

intensified the heavy industrial companies' need to diversify and the government's desire to help them do so. Simultaneously, growing frustration with the 7J7 and IAE junior partnerships undoubtedly was undermining the perceived wisdom of international collaboration in commercial programs, at least as a junior partner, and was helping the "hard-liners" make their case for domestic development. When the FS-X decision was finally made, domestic opposition to domestic development had largely withered away, and only US pressure, amplified by the Toshiba incident, remained a significant obstacle.

In October 1987, Director-General Kurihara Yuko of the Japan Defense Agency announced that Japan would forego domestic development of the FS-X and instead spend $6 billion procuring a "lightly modified" American aircraft. The decision was widely interpreted as a conciliatory gesture by the departing Nakasone administration, as an unambiguous victory for the United States, and as vindication of the intense pressure applied by US congressmen and negotiators. American officials praised the Prime Minister and Mr. Kurihara for realizing that given US strength in aerospace, the $60 billion trade deficit and concern about the "interoperability" of Japanese and American military forces, a "buy American" policy was appropriate. Senator John Danforth of Missouri, who had focused congressional attention on the issue and who earlier warned Japan not to throw "large amounts of gasoline on the already raging fires of protectionism," accepted the announcement as a sign that Japan was "serious about improving trade relations."[57]

Kurihara's announcement came as a surprise to many who had been following the dispute, because the decision overrode strong opposition from a coalition of officials within the Japanese defense establishment, MITI, the heavy industrial companies, the *Keidanren* and the Diet. Since the late 1970s, this coalition had been laying the groundwork for an all-Japanese FS-X, and they had become increasingly confident that their views would prevail. Given their careful preparations and growing influence, it had appeared unlikely that the US could exert sufficient pressure to win such a victory, especially since excessive pressure ran the risk of being counterproductive rather than countervailing. As it became apparent that some sort of compromise was likely, the leading Japanese business daily editorialized that the lame duck Nakasone administration was too weak to resist US pressures and that the emerging "government, LDP and industry stance" was that the decision should be left to its successor.[58]

As the general framework for FS-X co-development was subsequently worked out, the project was portrayed as less and less of a US victory in the American press, yet as more and more of one in the Japanese press.[59] Neither portrayal is correct, and both fail to capture the essential significance of the Memorandum of Understanding (MOU) approved eight months after the announcement. The SX-3, as the plane is now called, will be an extensively modified F-16 with a high level of Japanese content and technology. The fuselage and the engine will remain generally unchanged, but the wing, the avionics and the armaments will be largely Japanese. Japan will lead the project, with a roughly 60-40 split of the development

and production work. Given its strong resemblance to original proposals for an "all domestic" aircraft, which itself rested on a base of borrowed American technology, the SX-3 is clearly not an unambiguous US victory.[60] Nor is it an unambiguous defeat. The 60-40 split is a genuine compromise negotiated under intense and conflicting pressures on both sides.

At the heart of this compromise is a set of rules for technology transfer that acknowledge Japan's rise as a technological power of the first rank, and that are likely to become a model for future agreements.[61] In exchange for access to some of the American aerospace industry's most sophisticated technology, the Japanese have agreed to return any improvements they make at no charge and without being asked, and to make available any original Japanese technology used in the program if it is specifically requested and paid for. They have also agreed, in a separate but closely linked issue, to make an exception to Japanese patent law and permit US firms to have military patents held confidentially at JDA instead of openly at MITI.[62] In effect, the US is betting that Japanese firms can improve US military aerospace technology by spinning-on commercial manufacturing and electronics expertise, that US firms will learn and exploit these improvements, and that the interests of both countries will be served by such an arrangement.

Rather than a victory or defeat for either country, the FS-X agreement is simply a reflection of the shifting terms of trade in advanced technology, a shift noted by General Yamamoto Masashi, Director General of JDA's Equipment Bureau and one-time Deputy Director General of MITI's Machinery and Information Industries Bureau:

> "...I want you to regard it as a 'fusion of high technologies.' At the final stage, the US side was extremely co-operative, and Japan was able to negotiate on an equal footing, for the first time, in regard to defense technology ... It is true that the gaps in the field of aircraft are big, but as a result of Japan's having shown to what extent it will be able to do things through the use of elemental technology, such as onboard equipment, and partial systems, we have been able to elicit the positive co-operation of US manufacturers concerned. I think that this is epoch-making."[63]

A US DOD official who participated in these negotiations agreed, pointing out that

> "The Japanese made it very clear that the American side needed to recognize the world had changed considerably... When we proposed yet another co-production project, the Japanese calmly urged us not to be so 'nostalgic.' They insisted that the era of co-development is upon us."[64]

The $6 billion SX-3 co-development project will develop and test Japan's ability to lead the redesign, manufacture, and systems integration of a world-class jet fighter, one of the most technologically sophisticated products ever devised, and one considerably more demanding in many respects than a commercial transport. Although not the total victory sought by advocates of domestic development, SX-3 co-development will give the Japanese aerospace industry a powerful technological and financial boost. It provides a formal structure for access to American expertise in areas where Japan lags. It will give a generation of Japanese aerospace engineers design experience with high performance aircraft. And it will provide a massive capital inflow to underwrite continued expansion of the aerospace industrial infrastructure, including the base of dual-use technology, production equipment, and skilled employment in the plants where military and commercial production take place in tandem. It is very different from the co-production model that it replaces, and it will unquestionably advance Japan's long range plans to compete effectively in world aerospace markets.

VII. CONCLUSION

We do not suggest that revitalization and growth of the defense industry is a unanimous goal of Japanese leaders, uncontested in domestic bureaucratic or democratic politics, or that it is uninfluenced by external events, particularly conflicting pressures from the United States. To the contrary, we have shown how the subject is highly controversial both domestically and in the larger context of US-Japanese relations. Our analysis of the different organizations involved in the case of the FS-X reveals many different interests and agendas. No "consensus" for rearmament is apt suddenly to emerge. Most important, we certainly do not suggest an impending resurgence of Japanese militarism, a different matter altogether.

We do argue, however, that increased defense production has emerged in the 1980's as a new strategy for aerospace industrial development, that it has emerged because it is a versatile and effective strategy that satisfies the needs and interests of numerous influential groups, and that it has become the basis for a sturdy political coalition. Convinced that aerospace can help revitalize the troubled heavy industrial sector and spread high-technology benefits throughout the economy, frustrated in attempts to develop commercial aircraft, anxious to capitalize on new opportunities to exploit domestic technology, and continually pressured by the United States to rearm more vigorously, Japanese policymakers in the 1980s have turned to military spending as a mechanism for industrial development.

The Japan Committee for Economic Development (*Keizai Dōyūkai*) made the case for this strategy a decade ago, when it recognized that single domestic markets are never large enough to sustain national production. Their report argues that even then Japanese fighter aircraft were technologically, but not economically competitive because of export constraints. Low cost "efficient mass production" was possible only through government

procurement. The link between civilian and military production was stated explicitly:

> "Generally, the dependence upon military aircraft production is high in developing countries and is low in countries with a well developed aerospace industry. In this sense, Japan is clearly a latecomer, as our aircraft industry is nurtured by the high capital costs and technological requirements of military demand that, in turn, establish the base for an advance into civilian areas."[65]

Naito Ichiro, the former head of the JDA's Technical Research and Development Institute, echoed this by pointing out:

> "Once demand for fighter aircraft exceeds 300 units it will be possible to establish a mass production system (that eventually) will enable us to gain sight of the civil aircraft market..."[66]

Morikawa Hiroshi, the Executive Director of the Keidanren Defense Production Committee, has linked the specific case of the FS-X to the current problems in commercial aircraft development:

> "We have no alternative but to pin our hopes on the FS-X, given the current lack of progress in plans to jointly develop civilian aircraft."[67]

Industrial development is the key variable because competitiveness is central to Japan's definition of national security. In large measure due to American security guarantees, postwar Japan has measured national security far more by industrial strength than by military power. While quietly questioning the capabilities and commitment of the declining American hegemon, Japanese planners continue to build their future upon the foundation of high value-added industrial technologies. Aerospace, with the added attraction of military application, is considered vitally important. This importance remains undiminished by past setbacks and continuing difficulties in efforts to develop a competitive presence.

The report of a MITI advisory commission in 1986, when the 7J7 still appeared promising, indicates that MITI was well-aware of the obstacles but undeterred. The report introduced its recommendations for increased public support of aerospace by highlighting derivative technological benefits, and went on to discuss the problem:

> "Every nation is avidly promoting its aerospace sector in order to strengthen their technology base...The strengthening of the Western European and the US aerospace oligopoly in large and medium sized planes, combined with the emergence of a light aircraft industry

> in the developing countries, means that if a Japanese aircraft industry is to survive, it will have to escape through a very narrow gate."[68]

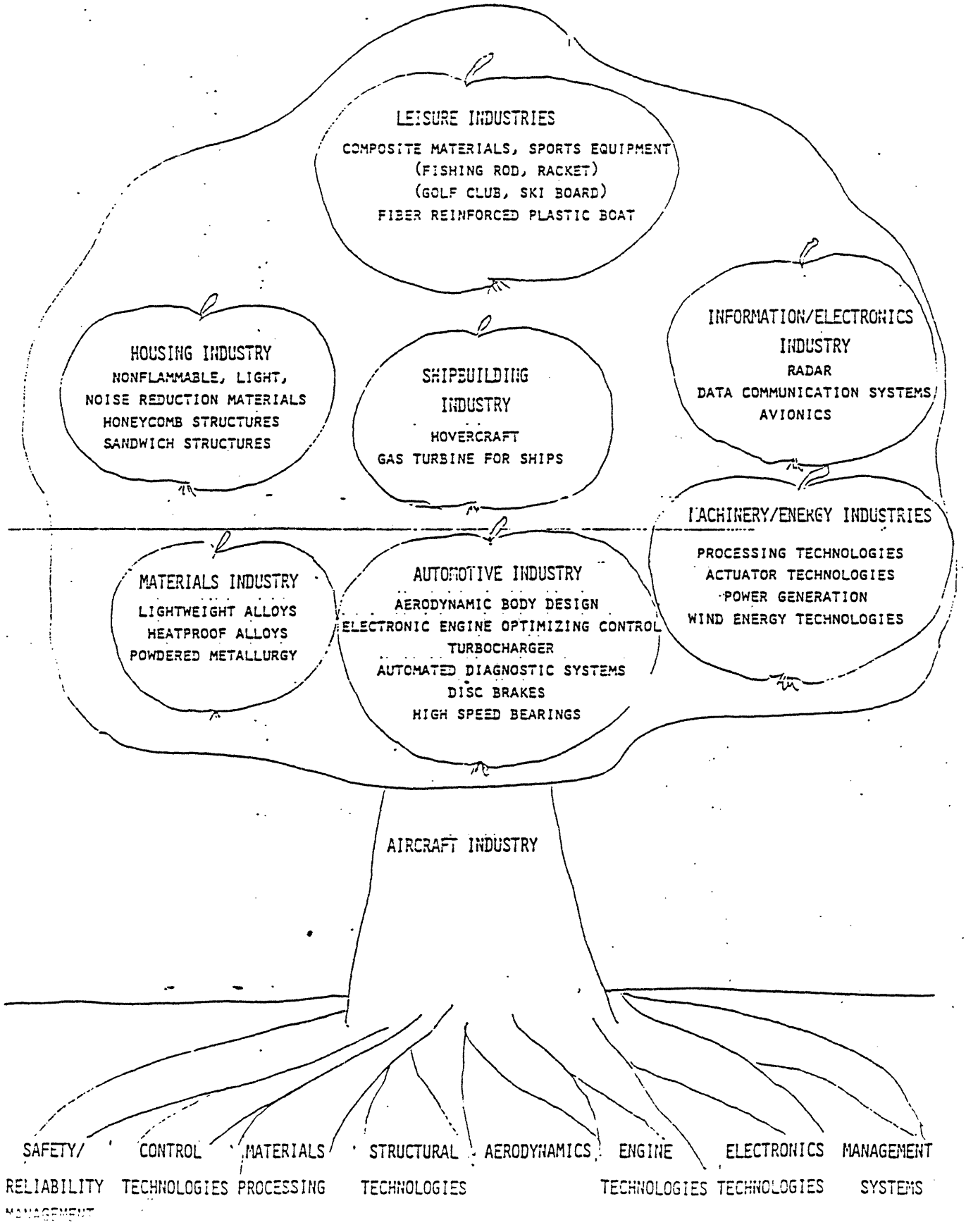
This MITI report, the first proposing the International Aircraft Development Fund, stressed two fundamental benefits of a healthy aerospace sector: 1) economic expansion and 2) enhanced national security through technological independence and sophistication. Japan's goal was clearly to make its aircraft industry equal to the rest of the world by the early part of the next century, and in so doing, contribute to the economy in every related area. These relationships are commonly embodied in the metaphor of a tree that provides the technologies and the products (from roots to fruits) that will sustain Japan into the twenty-first century (Figure 3).

Figure Three here: MITI Tree

Beneath the hyperbole and simplicity, this metaphor reveals a way of thinking about how success or failure in aerospace has profound implications for the future of Japanese industry. The perceived benefits extend well beyond creating new business for the heavy industrial companies. They extend past the explicit linkages between avionics and electronics, systems design and computer science, "space-age plastics" and ceramics and alloys that will never leave the ground. They extend past the multitude of other opportunities for spinning technologies off and on among military and commercial aerospace and the rest of the industrial economy. In this vision, machinery, housing, automotive, leisure, and service industries are each linked systematically to a healthy and active aerospace sector. The benefits are commercial and technological.[69] But they cannot be divorced from their implications for Japanese national security. Nor, we insist, will they be derived entirely from commercial projects. We expect a vibrant military aerospace program, revolving on an axis of indigenous dual use technology, to help push the Japanese commercial aircraft industry through the "narrow gate," to what policy planners and industrialists believe will be greener and safer pastures.

FIGURE 3

TECHNOLOGY DIFFUSION TO OTHER INDUSTRIES FROM AEROSPACE TECHNOLOGIES



NOTES

1. These refer only to *hojokin* loans. Data are from Table 12-3 in Wakasugi, Ryohei. *Gijutsu Kakushin to Kenkyū Kaihatsu no Keizai Bunseki* Tokyo: Tōyō Keizai, 1986.

2. For a typical press account, see Aerospace America (March 1987), which claimed (with some alarm) that in each major case of aerospace technology licensing from US to Japanese firms, licensing was phased out in favor of independent projects as the Japanese firms developed their own design and integration skills.

For an optimistic analysis see Orit Frenkel, "Flying High: A Case Study of Japanese Industrial Policy," Journal of Policy Analysis and Management, Vol. 3, No. 3 (1984).

For scholarly pessimism, see David Mowery. Alliance Politics and Economics Cambridge., MA: Ballinger, 1987. and Thomas Roehl, "Emerging Sources of Foreign Competition in the Commercial Aircraft Manufacturing Industry: The Japanese Aircraft Industry" Report to the United States Department of Transportation. (June 1985); and Thomas Roehl and J. Frederick Truitt, "Japanese Industrial Policy in Aircraft Manufacturing," International Marketing Review (Summer 1987).

3. To put the Western jetliner business into market perspective, consider that as of 1984, $180 billion in total postwar sales had yielded an estimated net loss of $40 billion, without counting the costs of essential research, development and manufacturing facilities spun off from military programs. Three out of the total 29 jet transports designed and built have passed break-even; the Boeing Corporation that makes all three is just now beginning to reap positive returns from thirty years of activity, after being launched into the business by military production and sustained through many bad years by government contracts. The Airbus consortium among European military aircraft firms is quite unlikely ever to recover its sponsors' full investments, even disregarding the time value of money. For an excellent summary, see Wolfgang and Christopher Demisch, "The Jetliner Business," First Boston Research Special Report, AE1991, October 5, 1984.

4. For more details on this form of industrial organization, see Chalmers Johnson, Japan's Public Policy Companies Washington, DC: American Enterprise Institute, 1978 and Richard J. Samuels The Business of the Japanese State: Energy Markets in Comparative and Historical Perspective. Ithaca, NY: Cornell University Press, 1987.

5. In order to facilitate this shift, the Aircraft Industry Promotion Act was revised in April 1986. The legal objective was changed from "promotion of domestic production" to "promotion of joint international development" of aircraft. Symbolically, this revision also abolished the long moribund Nippon Aircraft Manufacturing Company, maker of the YS-11. See *Tsūsan Kōhō*,

February 1986. A new public corporation was also established. This "International Aircraft Development Fund" was designed to make funds available to Japanese manufacturers despite severe budgetary constraints imposed by the Ministry of Finance and despite foreign pressures to eliminate "targeting." The result was a creative financing package that supports only joint international ventures through off-budget financing and that establishes a permanent "kitty" for the aircraft makers.

6. Wall Street Journal, 17 February 1988.

7. The Japanese press continued to run positive "puff pieces" on the progress of the IAE long after IAE's ongoing problems have been chronicled in the western press. Compare, for example, the *Asahi Simbun* 26 June 1988 and Aviation Week, 3 June 1985; 7 July 1986; 16 February 1987; 16 March 1987; 13 April 1987, 25 May 1987; 9 November 1987.

8. There are several studies in English that identify and discuss these problems. See, for example: Mowrey, David C. Alliance Politics and Economics: Multinational Joint Ventures in Commercial Aircraft. Cambridge, MA: Ballinger, 1987. Roehl, Thomas and J. Frederick Truitt, "Japanese Industrial Policy in Aircraft Manufacturing, " International Marketing Review, Summer 1987, pp. 21-32; Mowrey, David C. and Nathan Rosenberg. "The Japanese Commercial Aircraft Industry Since 1945: Government Policy, Technical Development, and Industrial Structure," Occasional Paper of the Northeast Asia-United States Forum on International Policy, 1985; Frenkel, Orit. "Flying High: A Case study of Japanese Industrial Policy," Journal of Policy Analysis and Management. Volume 3 Number 3. pp.406-420, 1984. For an optimistic view by a leading Japanese bank, see Long Term Credit Bank of Japan, ed., "The Japanese Aircraft Industry: Entering a Period of Progress Spurred by International Joint Development," (May 1986). For MITI's view, see Kōkūki Kōgyō Shingikai Kōkūki Kōgyō Bukai, ed. *Kōkūki Kōgyō no Tōmen suru Kihon Mondai to Seifu Hojo no Arikata ni Tsuite (Chūkan Hōkoku)* (The Current State of Government Assistance and Basic Problems in the Aircraft Industry- A Midterm Report).

9. David Mowery and Nathan Rosenberg, "Commercial Aircraft: Cooperation and Competition Between the US and Japan," California Management Review, Vol. XXVII No. 4 (Summer 1985), p.77.

10. Japanese aircraft technology was considerable in this period. A Japanese plane, the *Kamikaze-go* set a world flight distance record in 1938, and Japanese firms were building experimental jet engines and aircraft by the end of the war. For a study of the wartime aircraft industry structure, see Asajima, Shoichi "*Senji Taiseiki no Nakajima Hikōki,*" (The Nakajima Aircraft Company during the Wartime Period) Keieishi Gaku Volume 20, Number 3, 1985.

11. This "ban" was actually a 1967 reinforcement of a 1949 Export Trade Control Order prohibiting foreign sales of arms. Fearing a domestic backlash against its cooperation with the US military in Vietnam, Prime Minister Sato Eisaku's Cabinet put forth the "Three Principles," proscribing sales to Communist countries, countries at war, and those apt to engage in international disputes. In 1976, Prime Minister Miki extended this to weapons technology as well. In 1981 the United States requested a revision allowing it to import Japanese military technology, and in 1983 Prime Minister Nakasone granted their wish. See Reinhard Drifte. Arms Production in Japan: The Military Applications of Civilian Technologies, Boulder, CO: Westview Press, 1986.

12. Mitsubishi Handbook, 1986. 1985 sales of the Aircraft and Special Vehicles Division surpassed 314 billion yen, second only to Power Systems. This does not include automobiles, which were spun off into the Mitsubishi Motor Corporation in 1970.

Other signals of Japan's shifting calculus on the defense-industrial linkage include the 1983 technology transfer agreement and participation by Japanese firms in the American Strategic Defense Initiative. (For details on the negotiations concerning Japanese industrial participation in SDI, see Michael W. Chinworth, JEI Report, 8 May 1987.) There is also public debate underway concerning the production of "light carriers" that would simultaneously revive ship production and help Japan fulfill its commitment to defend the 1,000 mile sea lanes. Internally, there is the transformation of corporate charters, such as Komatsu's entry into the missile business in 1987, and Ishikawajima-Harima Heavy Industries' new division in 1988 devoted entirely to weapons systems. (See the Japan Economic Journal, 19 December 1987 and Aviation Week 14 March 1988).

13. In 1988, for the first time, the top career position in the JDA was given to Nishihiro Seishi, and the top post within the JDA's Technical Research and Deveopment Institute was given to Tsutsui Ryozo, both career JDA officials. The position of JDA Equipment Bureau Chief has been a virtual MITI monopoly.

14. In the mid 1970s, the full dimensions and costs of YS-11 failure were readily apparent to officials of MITI's Aircraft and Ordnance Bureau and their superiors. The commercial aircraft strategy was in disarray, as was the Japanese budget. The Ministry of Finance made it quite clear that the government could not afford to sponsor a follow-on program similar in scale and scope to the YS-11, and MITI planners knew that no such program would emerge without their sponsorship. Officials articulated the new strategy of international collaboration and arranged two new consortia (one for airframes and one for engines), but most of the decade passed without a clear definition of their purpose: negotiations with Boeing began in 1973 but did not yield the 767 agreement until 1978, and the engine consortium idled along from 1971 until it joined with Rolls Royce in 1979. Between 1972 and 1977, hours worked in the aerospace industry declined by two

thirds. See Aviation Week 21 March 1977.

15. The Japanese press continues to report on possibilities for civilian aircraft projects. Some, such as the "follow-on" to the YS-11 has been championed by the Transportation Ministry and by MITI, which is now subsidizing feasibility studies. The reported goal is to eliminate dependence upon foreign manufacturers in the long run. Other projects mentioned are helicopter engine cooperation with MBB of West Germany, commuter planes with China, and hypersonic transports with the United States. See the *Nihon Keizai Shimbun*, 14 April 1988, 9 May 1988, and 7 May 1988.

16. The more general point about the declining importance of "spillover" from military to commercial aircraft is made by Mowery, David. Alliance Politics and Economics: Multinational Joint Ventures in Commercial Aircraft, Cambridge, MA: Ballinger, 1987, p.48-9.

17. Tsushōsangyōshō Daijin Kanbō, ed. *Nippon no Sentaku* (Japan's Choices) Tokyo: June 1988, p. 116.

18. More recently this has included demands that the JDA expand its procurement program and broaden its definition of defense items to include so-called "rear support expenses" such as communications, fuel, and other items. See *Asahi Shimbun* 12 April 1985. Also see Reinhard Drifte, op. cit.

19. The aircraft division of Mitsubishi Heavy Industry which had built 17,000 aircraft and 54,000 engines, for example, was broken up into three firms that focused upon auto bodies, internal combustion engines, scooters, and agricultural equipment. Nakajima Hikoki, which ultimately became Fuji Heavy Industries, was divided by SCAP into twelve firms. Kawasaki became a manufacturer of fire extinguishers, textile machinery, and bus bodies. See Kuno and Rubin (1984-6) and in the original, see Kuno, Masao. *Nihon no Kōkūki Uchū Sangyō*. (The Japanese Aerospace Industry) Tokyo: Daiyamondo, 1984. Also see the postwar history produced by the Society of Japanese Aerospace Companies, *Nihon no Kōkū Uchū Kōgyō Sengoshi*. Note that in 1952, as soon as restrictions were removed with the end of the Occupation, the MHI firms, the KHI firms, and the FHI firms were all reconsolidated. Note also that the key players in the prewar aircraft industry returned as the presidents and senior managing directors of these companies. Also see the detailed company histories, such as *Fuji Jūkō, ed. Fuji Jūkōgyō Sanjū Nen Shi (The Thirty Year History of Fuji Heavy Industries)* published in July 1984.

20. In all, nineteen different US military aircraft have been produced under license by Japanese firms. Japan's first postwar aircraft export was Toyo Koku's licensed version of the US Fletcher FD-26 trainer/attack plane sold to Cambodia and Vietnam in the late 1950's; Japan's first export of aircraft technology was a license for "wave suppressing sonar" sold to Grumman in the 1970's. In the entire postwar period, the value of commercial production

surpassed military only at the height of the YS-11 program and quickly returned to its traditional level of about 20% of output.

21. Interview with Civilian Aircraft Corporation official, Tokyo, 20 June 1988.

22. For example, FHI manufactures the main wing spars and horizontal stabilizers of the P-3, the landing gear of the F-15, the entire UH1B helicopter and the main wing cowling of the B-767 in the same plant. Interview, official of the Society of Japanese Aerospace Companies, Tokyo, 10 June 1987 and with a DoD official, Tokyo, 11 June 1987.

Another example is the landing gear for the commercial YS-11 that was adopted directly from the co-produced KHI/Lockheed P2V-7 aircraft. This example is drawn from Frenkel, op. cit.

23. Hall, G.R. and R.E. Johnson, "Transfers of United States Aerospace Technology to Japan," pp. 305-363 in R. Vernon (ed.) The Technology Factor in International Trade. New York: National Bureau of Economic Research, 1970, p.315. Mowrey, op.cit., p. 56 and Roehl and Truitt, op.cit., p. 26 disagree, arguing that licensing and co-production has not provided Japanese or any other firms the design experience necessary for an independent aircraft industrial base. Hall and Johnson go on to argue, however, that "co-production increased the rate, amount, and kinds of technological information provided the Japanese by several orders of magnitude," including even manufacturing "art" embodied in translated "blackbooks" of shop foremen. (pp. 316-317).

24. For a (now slightly dated) introduction to the Japanese defense industry, see Tomiyama, Kazuo. *Nihon no Bōei Sangyō* (Japan's Defense Industries) Tokyo: Tōyō Keizai, 1979. Also see *Asahi Shimbun Shakaibu, ed., Heiki Sangyō* (The Weapons Industry) Tokyo: Asahi Shimbunsha, 1986. News reports are often revealing as well. Consider the following pair of stories in the same newspaper on the same day: The first article describes how KHI has begun a "large scale" transfer of personnel from shipbuilding to aircraft due to the recession in the dockyards. The second story reports that KHI has announced the use of industrial robots for its aircraft manufacturing operations. See the *Nikkei Sangyō Shimbun* 18 June 1986.

25. For a useful overview of the industry, see Masao Kuno and Paul Rubin "Japanese Aerospace- Aiming for the Twenty-first Century," Aerospace Japan July 1984 - February 1986. The Society of Japanese Aerospace Companies now publishes annually a detailed membership list and statistical abstract in English called "The Aerospace Industry in Japan." Additionally, the *Nikkei Sangyō Shimbun* and the *Nikkan Kōgyō Shimbun* provide detailed coverage of these businesses.

26. Electromagnetic pulse (EMP), the intense burst of energy released by the atmospheric detonation of nuclear weapons, is a major concern for designers of military electronic systems.

27. See Jacques S. Gansler, The Defense Industry, Cambridge, MA: MIT Press, 1980 for a discussion of US defense industrial structure.

28. It must be noted, however, that *keiretsu* affiliation is not a reliable predictor of technological linkage in Japan. Firms increasingly are seeking R&D partners from outside their own *keiretsu* group. See R.J. Samuels "Research Collaboration in Japan," MIT-Japan Science and Technology Program Working Paper 87-02, 1987 for a more systematic analysis.

29. Kazuo Tomiyama, "Revival and Growth of Japan's Defense Industry," Japanese Economic Studies Volume 9, Number 4, Summer 1981

30. These descriptions were provided in a series of interviews with senior officials of the Society of Japanese Aerospace Companies, industry leaders, and government officials, June 1988.

31. MITI long has favored this strategy for most industrial sectors but has been generally unable to enforce it. One famous case is MITI's attempt to keep Honda out of automobile production. See R.J. Samuels, The Business of the Japanese State, 1987, op.cit., for a fuller explanation of the relationship between the politics of oligopoly and industrial policy in Japan. In any case, MITI encountered little opposition in aerospace, most likely because the government procures four-fifths or more of industry output.

32. For a full list of SJAC-sponsored projects (many of which also attract MITI support) see the SJAC yearbook: *Kōkū Uchū Kōgyō Nenkan*. See also Nikkei Aerospace 29 September 1986.

33. The firms participating in this consortium justify their cooperation by reference to the need to "confront Western manufacturers," (MHI), to "expand the Japanese share" of world markets (IHI), or to "compete with Western firms." (FHI). Each clearly links this project to its broader technology strategy.

34. Interview 22 June 1988, Tokyo.

35. The F-15, like all fighters, has been upgraded continuously since its introduction. More recent models incorporate some composite materials and are fitted with advanced avionics.

36. The flight characteristics of a control-configured aircraft are closer to those of a flying saucer than of a traditional airplane. With computerized manipulation of canards, winglets and other novel control surfaces, a CCV can change altitude and flight path without changing "attitude," the direction the vehicle is pointing. The advantages for aerial combat and defensive maneuvering are significant.

37. This is certainly the prevailing view among Wall Street aerospace analysts. See for example, Aviation Week 22 February 1987; Wall Street Journal 31 October 1986.

38. These new responsibilities were formally recognized in a 1981 joint communique signed after talks between then Prime Minister Suzuki and President Reagan. For discussion of the US-Japan defense relationship, see Gregg A. Rubinstein, "US-Japan Security Relations: A Maturing Partnership," 26 October 1987, and Michael W. Chinworth, "The Trade-Defense Linkage," Japan Economic Institute Report, No. 35A, 18 September 1987.

39. The F-1 is actually a reworked version of MHI's T-2 trainer, which in turn is closely though informally modeled on the Anglo-French Jaguar, with which it shares the French Aldour engine.

40. *Asahi Shimbun* 16 April 1985; Aviation Week 12 March 1984, 18 March 1985, 30 September 1985.

41. The plane in question was Northrop's F-5E. The story of the DOD's refusal to release it is from personal correspondence from a former DOD official 18 May 1988.

42. Aviation Week 18 March 1985.

43. The coproduction premium for the F15 is about $2 billion. However, Hall and Johnson, op. cit., argue that Japan coproduced the F104 in the 1960's for 10% less than the cost of outright purchase, with the savings accounted for by lower labor costs.

44. Aviation Week 16 January 1978.

45. Aviation Week 23 November 1981.

46. Initial candidates for the FS-X discussed in the Japanese press included the General Dynamics F-16, the Panavia Tornado, the Harrier of British Aerospace, and the McDonnell Douglas F-4. Much later, the McDonnell Douglas F-18 was actively discussed, but was denigrated in the press as inferior.

47. The Japanese press tied the delay to the mid-term elections in the United States. There was apparently some hope that a more congenial Congress would reduce the pressure on Japan for co-production or outright purchase. See *Nikkei Aerospace* 29 September 1986; Aviation Week 3 March 1980, 1 January 1981, 18 March 1985, 10 March 1986.

48. Airworld December 1985. See also the *Asahi Shimbun* April 16, 1985, which suggested that the JDA and MHI were moving secretly in this direction and were making every effort to shield the SLEP strategy from public debate, and from the Japanese Diet in particular.

49. *Nikkei Aerospace* 29 September 1986.

50. Personal correspondence from a former DOD official 18 May 1988. See also: "US Military Coproduction Agreements Assist Japan in Developing Its Civilian Aircraft Industry," General Accounting Office, 1980.

51. Aviation Week 9 March 1981, 10 March 1986.

52. Aviation Week 18 March 1985.

53. These were the C-1 of KHI, the F-1 of MHI, and the YS-11.

54. For a brief, but detailed overview, see *Nikkei Aerospace*, 13 May 1985, pp. 1-6. The development of this aluminum plate capability is another example of public/private cooperation to meet industrial goals. Alcoa Aluminum had been the sole source to MHI/KHI of polished aluminum sheets for the B-767, but could not deliver on time for the T-4. MHI/KHI encouraged MITI and SJAC to establish the "Advanced Aerospace Technology Development Center." Kobe Steel and Furukawa Aluminum acquired the technology, invested in special equipment for processing it, and began deliveries in 1984. See Kuno and Rubin, op.cit.

55. The USAF/Fairchild T-46 jet trainer, the American counterpart of the XT-4, ran into such cost, schedule and quality problems that the USAF cancelled it.

56. Wall Street Journal, 23 April 1986. As noted above, KHI was the prime contractor on this project.

57. Danforth quoted in the Wall Street Journal 16 March 1987, and 12 October 1987. The corporate headquarters of the two US firms that competed to supply the FSX are in St Louis. McDonnell Douglas is one of Missouri's largest employers, while General Dynamics' production facilities are located in Fort Worth, Texas. McDonnell Douglas was heavily favored to win the competition: the Japanese had always insisted that the FS-X, which will spend much of its time over water, have two engines, and both of MD's candidates (the F-15 and F-18) do. GD's F-16 does not, and GD discouraged a such a major modification.

A team of engineers visited the US shortly before the decision and returned to Japan endorsing the F-15, but their advice was ignored; the F-16 was selected in a last minute reversal. The official reason given was cost, but the F-15 was already in production at MHI, the strong yen made all US fighters a relative bargain, and cost has never been a primary consideration in Japanese procurement strategy. One reason may be that the fly-by-wire F-16 offered more opportunities to learn than the F-15 and was more amenable to extensive modification; by these criteria, however, the fly-by-wire F-18 was the natural choice. A modification of this argument would be that Japanese planners, having worked with MD on coproduction of the F-4 and F-15, felt that they could learn more by switching partners. There has even been speculation that the JDA's surprise move was influenced by a desire to punish Danforth, sometimes known as "the senator from McDonnell Douglas," for the heavy-handed pressure and outright threats he made prior to the decision.

58. "Nakasone cannot fight US on FSX development," *Nihon Keizai Shimbum*, reprinted in Japan Economic Journal, 25 July 1987.

59. Vociferous criticism of the arrangement in the Japanese press indicates that the FS-X coalition may have used the "humiliation factor" to rally support for a tough stance in negotiations over program leadership. For example, Keidanren Defense Production Committee Executive Director Morikawa Hiroshi said at the time of the October agreement that "Now that our original FS-X development plan has been completely abandoned, our concern is how Japan can take the initiative in the joint project." Similarly, the *Nihon Keizai Shimbun* editorialized that the US had "jeopardized Japanese national sovereignty" and that "We hope that the Defense Agency will spare no words in securing a leadership role to ensure that the program is as fruitful for Japan as possible." (Both citations are from the Japan Economic Journal 17 October 1987, p.27.) The *Asahi Jaanaru* (1 July 1988) went even further in its story on the "US-Japan High Tech Air War," asking if "Japanese industries, that have finally achieved their independence, can escape from the evil influence of technonationalism that was born in Nazi Germany and nurtured in the United States."

60. Although the SX-3 is clearly not the all-new, all-domestic aircraft sought by the FS-X coalition, the comparison is potentially misleading. In discussing the agreement's benefits for Japanese industry, JDA defense policy bureau chief Nishihiro Seishi remarked:

> "Japanese fighter contractors wouldn't have any real future as long as they merely dreamed of developing their own FSX. Their blueprint for domestic development was essentially not better than a copy of an American fighter plane."

Quoted in Japan Economic Journal, 17 October 1987, p.3.

61. Neither the "flowback" provision nor access upon request to original Japanese technology is unique to the SX-3 deal or new in US-Japan defense technology agreements. Flowback has been negotiated in previous deals, but never on the scale of the SX-3. Access on request to Japanese military technology, as defined by Japanese companies, was agreed to in 1983, but there have been few transfers under its terms. The SX-3 is the first major test of the 1983 agreement. There will be little room for ambiguity as to which technologies are covered, although much debate is likely as to which category they belong in.

DOD interest in acquiring Japanese technology has been growing since the 1970's. In 1980 the DOD and the JDA established a Systems and Technology Forum to discuss the coordination of defense technology transfers, and in 1981 the US proposed a looser interpretation of the "Three Principles" governing military exports. This met with firm opposition from MITI, other government agencies, and the opposition parties. Prime Minister Suzuki avoided the issue, but in early 1983, Prime Minister Nakasone agreed to take the political heat and approved the transfer of military technology to the United States. An Exchange of Notes in November established an intergovernmental channel for reviewing requests and assisting the transfer.

For a complete account of these discussions, see Gregg Rubinstein, "Emerging Bonds of US-Japanese Defense Technology Cooperation." Strategic Review Winter 1987. For the Defense Science Board's evaluation of Japanese dual-use technologies, see the Report of the Defense Science Board Task Force on Industry-to-Industry International Armaments Cooperation-- Phase Two-- Japan. Washington, D.C.: US Government Printing Office, June 1984.

In a more recent, but predictable development, Japanese firms are beginning to test the limits (and the reach) of MITI policy by acquiring defense production capabilities abroad. The first such case involved Minebea, a bearing manufacturer, and was reported in the *Nihon Keizai Shimbun* 12 July 1988.

62. The 1951 Patent Secrecy Law discourages US companies holding patents with Pentagon classification from registering them in countries that will not keep them secret. A number of countries, including Australia, France, Norway, Turkey, and the UK, have since signed separate agreements to establish procedures for processing secrecy order patent applications. The Japanese Diet ratified such a treaty in 1956, but the Japanese government failed to take measures to implement the agreement. Thirty-two years later the changes were made in order to accomodate the formally unrelated FS-X and the SDI cooperative projects. Wall Street Journal, 24 February 1988. The influential weekly, *Asahi Jaanaru* (1 July 1988) has argued this is part of an American "Nazi-style patent strategy."

63. Interviewed by The *Nihon Keizai Shimbun*, 25 October 1987.

64. Interview, US DOD official, Tokyo, 26 June 1988.

65. Keizai Dōyūkai, ed., *21 seki e no Sangyō Kōzō Bijiyon o Mitomete* (Demanding a Vision for the 21st Century) Tokyo June 1979 p.71.

66. Interview in the *Shukan Posuto*, 9 October 1987.

67. Quoted in *Asahi Jaanaru* 1 July 1988.

68. *Kōkūki Kōgyō Shingikai, Kōkūki Kōgyō Bukai, ed. "Kōkūki Kōgyō no Tōmen suru Kihon Mondai to Seifu Hojo no Arikata ni Tsuite (Chūkan Hōkoku)* (The Current State of Government Assistance and Basic Problems in the Aircraft Industry- A Midterm Report). p.1-2.

69. This way of thinking about technology linkages is also articulated in *Keizai Dōyūkai* ed., 1979, p. 69, 85-89.