Technology Transfer and the F-2 Fighter: How the Japanese Defense Industry Defied the Odds

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Abstract:

Japan's defense industry, despite being relatively smaller than other developed nations, has prospered technologically. The technology transfers pivotal in bringing Japan to this point would not have been so successful without the catalysts of the United States (US) alliance, clusters and civil-military company structures to create dual-use technologies. In producing the F-2, Japanese industries did more than lightly modify the F-16 or duplicate processes acquired from older licensed production runs—they produced groundbreaking innovations and developed new ways of doing things. Today, as the US moves away from the expensive model of bilateral partnership to the more profitable international arms collaboration, Japan too should revise its internal policies—in particular, the legislature on arms exports and offensive weapons—to prevent being technologically isolated and shut out of a lucrative market.

Keywords: Civil-Military Relations; Defense Industry; Defense Technology; Technology Transfer

INTRODUCTION

The characteristics of the Japanese defense industry are abnormal. Japan's defense industry is tiny compared to that of other developed nations—its defense production accounts for just 0.5% of total Japanese industrial production.[1] Indeed, the top-ranked Japanese defense manufacturer, Mitsubishi Heavy Industries (MHI), is only 25th in the global standings, with the second largest manufacturer, Kawasaki Heavy Industries (KHI), a distant 47th.[2] The Japanese defense industry is subject to prohibitive legislature that curtails its normal functioning within the international arms market. Hamstrung by sanctions from its own government, most notably the 1976 ban on arms exports, ostensibly in reverence of Article 9 of the 1947 Constitution, it has had to exploit loopholes and resort to creative packaging options in order to export. Hence it produces almost exclusively for the domestic market. This is not necessarily a bad thing, considering that it effectively enjoys monopoly patronage of what is in absolute terms the seventh biggest defense budget in the world.[3] What is abnormal about the Japanese defense industry, apart from its size and market, is that in spite of its quasi-isolationism it has managed to become a world leader in the design and manufacture of components essential for defense systems worldwide.[4]

How Japan managed to go from making graphite composites for golf clubs to wing components of the FS-X/F-2 fighter is at once a rebuttal and validation of the established norms of the defense market. "Normal" defense markets are characterized by strong government intervention to promote local defense industries and encourage exports in order to maintain a sovereign defense industrial base and guarantee the security of

supply. Japan's legislature curtails and severely limits its defense industry. "Normal" defense industries understand that price and value-for-money (VFM) are key considerations in defense procurement and thus seek to lower cost-per-unit through efficient supply chains and increased production runs of the product for export. Japan, who officially does not export and hence conducts only small-lot manufacturing for the Ministry of Defense (MoD),[5] has nonetheless managed to produce, at low cost,[6] world-class defense equipment that meets military specifications of performance, reliability and quality. "Normal" defense industries are driven by international competition to interact and collaborate to generate innovation and offer better VFM propositions. Japan's defense industry has managed to achieve that in relative isolation. In theory therefore, Japan's defense industry should not have survived, let alone prospered technologically.

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Japan's success formula is simple: to counter its legislative constraints and late-start, it has relied on the force-multiplier effect of technology transfers as the primary means of accessing and managing defense technology. By creating conditions conducive to technology transfer such as civil-military clusters, by focusing on the development of dual-use technologies, and by hugging its only security ally, the United States (US) close, Japan has produced such advanced platforms as the FS-X/F-2 fighter, the Aegis-equipped destroyer and the four Mitsubishi intelligence-gathering satellites. This essay, a case study of the FS-X/F-2 fighter collaboration, will investigate just how technology transfer allowed the Japanese defense industry to defy the odds.

THE MITSUBISHI F-2 (FS-X)[7]

The delivery of the 94th and final F-2 multirole fighter aircraft will mark the completion of the first joint development and production project undertaken by the US and Japan. The project is a watershed because in previous cooperation, Japanese companies undertook no development work—they merely license-produced.[8] This is significant because most of the value-added technology transfer takes place in the research and development (R&D) phase. This collaboration, which was not even initiated by Japan to begin with,[9] launched Japan into the exclusive club of advanced fighter aircraft weapon systems development. To convince Japan to abandon its pursuit of an autonomous fighter, the US agreed to a contract in which prime contractor MHI and principal US subcontractor Lockheed Martin, sharing the work in a 60:40 ratio, would jointly develop and build the new fighter based on the F-16 platform. The US had envisaged that technology transfers would be reciprocal and bidirectional; different from the one-way horizontal transfers, principally benefiting Japan, that had been occurring since the 1960s. Indeed, this contract opened new avenues for vertical and horizontal technology transfer, as the subsequent sections of this article will illustrate, but whether it reversed the unidirectional nature of the transfers is still a matter of debate. Declassified project progress updates and production agreements published by the US General Accounting Office for Congress state that "the value of technology transfers from Japan to the US was uncertain."[10] Others declared that the US had "[snatched] defeat from the jaws of victory."[11] The literature is unanimous in concluding that Japan was the

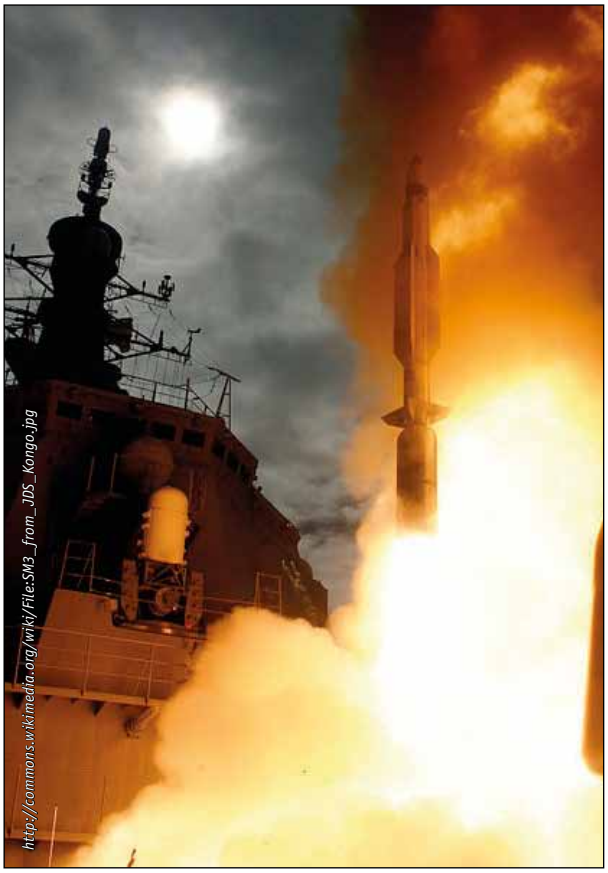
Japan Air Self Defense Force F-2 Fighters

clear victor in this collaboration,[12] hence the rest of this essay will analyze how Japan managed to generate technology transfer gains.

Technology transfer takes place when systematic, rational knowledge developed by one group or institution is incorporated into the processes and methods of other groups or institutions.[13] The success of technology transfer depends heavily on the receiver's willingness to engage in the transfer process, and its ability to internalize and apply the transferred technology.[14] Receivers cannot be passive and their information processing capabilities must meet the requirements of the technology transfer in question.[15] Summarizing these requirements and conditions,[16] there are three phases of technology transfer: preparation, installation and utilization. Each of these phases is influenced by technological age and size, organizational capacity, capability and efficiency of the organization, and environmental, sociopolitical and industrial factors.

Evaluated in this context, Japan in 1990 was perfectly poised to embark on this collaboration. The domestic environment was ripe, as was the type of technology to be transferred. In terms of organization, the density of intra and inter-company linkages of experienced prime and subcontractors, all of whom are engaged in both civil and military work, further encouraged vertical and horizontal technology transfers across operational environments. Japan's masterstroke was in the way it laid the foundations for the implementation of the technology by the time the F-2 was conceived. To prepare the domestic industries for the technology, it engaged in licensed production, through offsets of US aerospace components and aircraft. To create the environment, it clustered similar industries and supporting services,

and insisted on production in Japan. To foster the organizational climate, it advocated the development of dual use technologies applicable across civil and military realms. It is now to each of these strategies that this essay will turn. It will analyze how these strategies prepared the Japanese defense industrial base to assimilate and apply the technologies involved in the F-2 project and postulate what new benefits the F-2 project has brought to the table. The strategies can be conceptualized as three levels of operating environments: the Macro-Alliance with the US, the Immediate Industrial Cluster in which the F-2's contractors are located, and the Micro-Internal Civil-Military organizational structure of the Contractors. The relationship between the environments is illustrated in Diagram 1, and the intersections are points at which technology transfer occurs.



A Standard Missile-3 launched from the Japanese Aegis Destroyer JS Kongo

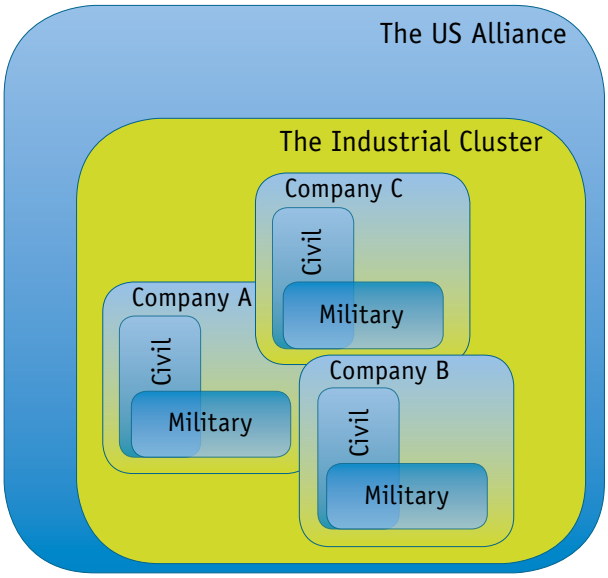


Diagram 1: The Operating Environments for Technology Transfer in the Japanese Defense Industry

BUILDING THE FIGHTER TECHNOLOGY KNOWLEDGE BASE: THE US ALLIANCE AND LICENSED PRODUCTION

Japanese aerospace industries have had a long history of cooperation with US companies. Since the post-war embargo on aircraft production and development was lifted in 1952, and following the unwritten principles of *kokusanka*,[17] there have been 14 projects to license-produce US military aircraft in Japan.[18] Many more civilian projects were also undertaken. The prime contractor and main Japanese subcontractor of the F-2 project, MHI and KHI were pioneers in the field, having begun licensed-production of North American F-86Fs and Lockheed T-33As in 1955. The technology transferred from the F-86 then went into the production of the locally developed T-1 jet trainer, which ultimately featured mainframes and engines developed and produced by Fuji Heavy Industries (FHI) and Ishikawajima-Harima Heavy Industries (IHI) respectively.[19] This is an early instance of intra-industry horizontal technology transfer, from MHI to FHI and IHI. Each time a new project was undertaken, Japan would insist on

local licensed-production to reap the technology transfer benefits. With each production, the Japanese components of the aircraft increased, from 60 percent in the F-86 to 85 percent in the F-104.[20] The Japanese industrial strategy for the defense industry was clear: the ultimate aim was autonomy, and with each cooperation and technology transfer, the industry would move yet closer. Even Japan's newest fighter, the F-2, does not realize autonomy, but the fully indigenous Mitsubishi ATD-X Shinshin stealth aircraft, scheduled for test flights in 2014, might just be it. It took 60 years of preparation to ready the industry for this milestone, but without the benefit of technology transfers from the world's most advanced defense aerospace industry, this journey would have taken decades longer.

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CREATING THE ENVIRONMENT FOR TECHNOLOGY TRANSFER: THE CLUSTER EFFECT

It is deliberate that Japan's largest defense manufacturers,[21] MHI, KHI, Mitsubishi Electric, NEC and IHI, as well as other principle and lower-tier subcontractors of the F-2 project, are all located in one particular cluster, the Greater Nagoya Industrial Cluster. MHI, who built the F-2's forward fuselage and wings, and performed the final assembly; FHI, who worked on upper wing components, nose cone and tail assemblies; KHI, who built the fuselage mid-section, engine and doors; Japan Aviation, who co-developed the fly-by-wire system; IHI, who supplied the engine; and NEC and Hitachi-Kokusai Electric, who produced components of the command, control, communications and intelligence (C4I) systems all operate out of the Nagoya Industrial Cluster to reap the benefits of physical proximity and specialized infrastructure, and ultimately, of innovation. Developers of the Greater Nagoya Initiative envisioned a living community in which like industries would share technology and new discoveries, driving innovation and exemplifying the *monozukuri* way.[22] Comprising sub-clusters of automotive, aerospace, information technology, biotechnology, ceramics and environmental technology, it houses universities and research institutes and generates 1% of the world's Gross Domestic Product. According to Michael Porter, that fact, whilst mind-boggling, is only to be expected.[23] In his seminal work, "Clusters and the New Economics of Competition," he identifies clusters: geographical concentrations of interconnected companies and institutions in a particular field, as the generators of competitive advantage. This competitive advantage is generated when companies compete to be more productive, innovative and efficient, and when they share their best practices and discoveries so that they may be better than other groupings of competitors. Krugman's parallel argument is that the clusters' ability to pool the labor market, agglomerate specialized inputs and generate technology spillovers creates this competitive advantage. As clusters are particularly excellent incubators of competition and cooperation, the corollary, therefore, is that they are also particularly effective conduits for technology transfer.

In the case of the Japanese defense industry, it is not unreasonable to conclude that clusters probably compensated for the time lost after the war, made up for the lack of international

competition, and effectively retained and transformed the technologies originally transferred through licensed-production. Yamawaki identifies three distinctive features of Japan's clusters that enabled these effects: the extensive use of subcontracting between manufacturers and suppliers, the hierarchically structured relationships between manufacturers, first-tier suppliers and second-tier suppliers, and the coexistence of many companies with different but complementary skills in the cluster.[24] A mapping of the supply chain of the F-2's single-piece co-cured composite wing reveals these features. Whilst the composite raw material to build the wing came from outside of the Nagoya cluster, subcontractors within the GNI cluster provided almost all subsequent components and skills down the supply chain.

STRUCTURING ORGANIZATIONS FOR TECHNOLOGY TRANSFER: CIVIL-MILITARY INTEGRATION AND DUAL-USE TECHNOLOGIES

In 1958, Japan passed the second Aircraft Promotion Law that called for the development of an indigenous military industry.[25] The caveat was that it had to be linked to the promotion of the commercial aircraft industry. The desire for a technologically advanced, internationally competitive civilian aerospace industry was the main driver of development—the technologies transferred through licensed-production of military aircraft were a means to achieve this end. The military and civilian sectors would be mutually reinforcing, spinning on and off expertise and developments as they were acquired. In acknowledgment of this industrial strategy, all the major contractors of the F-2 project, MHI, KHI and FHI, have civil and military divisions, and in practice the divisions are often more conceptual than physical. The same subsidiary in KHI that produces the turbofan for Airbus A380 engines also produces the turbo shaft engine for the MoD CH-47J, a transport helicopter.[26] This degree of civil military integration is especially critical for Japan's defense industry, where the export ban and the policy against the procurement of offensive weapon systems impose severe curbs on direct foreign defense contractor to Japanese defense contractor technology transfers. Perhaps more significantly, a merged civil-military structure removed what would have been an additional step in the dual-use technology transfer process.

The F-2's groundbreaking composite wing had its beginnings in the chemical industrial sector that produced carbon fibers for the manufacture of golf clubs and tennis rackets.[27] The government, recognizing the dual-use potential of Japan's world-class chemical composite technology in the defense aerospace industry, encouraged R&D efforts with funding in the 1970s and 1980s. These efforts opened up a vast market for the composite producers and spawned new networks of value and supply chains between the chemical and aerospace industries. Composite technology for military aircraft was spun-off into the licensed-production of structures for Boeing 767 airliners, fulfilling the aims of the second Aircraft Promotion Law. The seamless civil-military structure of Japan's aerospace industries meant that the technology reached the secondary users in one step, instead of having to cross from the "other" industry to civil aerospace first and then to military aerospace. In the same way that the US alliance and industrial clustering accelerated the technology transfers that help Japan overcome its limitations, the merged structure of Japanese manufacturers reduced the gradient and size of the learning curve.

CONCLUSION AND POLICY RECOMMENDATIONS

In producing the F-2, Japanese industries did more than lightly modify the F-16 or duplicate processes acquired from older licensed production runs—they produced groundbreaking innovations and developed new ways of doing things. As a testament to how far Japan has come, the wing technology developed for the F-2 and transferred to Lockheed Martin as part of the contract is now being used to build the Joint Strike Fighter. The technology transfers pivotal in bringing Japan to this point would not have been so successful without the catalysts of the US alliance, clusters and civil-military company structures to create dual-use technologies.

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Japan must now evolve the strategies that have proven so effective in the past. Its US ally is moving away from the expensive model of bilateral partnership to the more profitable international arms collaboration for economic, political and security reasons. If Japan does not revise its internal policies, specifically the legislature on arms exports and offensive weapons, it will find itself increasingly technologically isolated and shut out of a lucrative market. Technological innovations made Japan the second largest economy for half a century and they are what will maintain Japan's competitive edge. Yet there is increasing evidence that the environment is no longer welcoming of innovation. In a commentary on the sad state of innovation in the country, the author put the blame on the Japanese practice of privileging older, presumably less creative workers with "regular" jobs, at the expense of fresh graduates who are offered temporary jobs, if at all.[28] The non-competitive employment situation mirrors the innovation rut of Japanese industry at large. The return to global competitiveness must begin with a revolution of societal norms, starting with the abolition of protectionist or loyalty policies, and through the consolidation of conglomerates. This is something western defense industries have done in earnest for last two decades, but the Japanese defense industry has been slow to follow suit. The clusters and civil military structures can remain—in fact they should. What must change are the obsolete processes and mindsets that prevent the Japanese defense industry from really taking off.

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2. See *Defense News*, 2007.
3. "Data on National Arms Production," Stockholm International Peace Research Institute, 30 January 2011, http://www.sipri.org/research/armaments/production/resultoutput/national_aprod.
4. Thomas Berger, *Japan's International Relations: The Political and Security Dimensions* (Maryland: Rowman and Littlefield Publishers, Inc, 2004).
5. In this article, any reference to the Ministry of Defense can be assumed to also include its pre-2007 entity, the Japan Defense Agency.
6. Samuels notes that while the absolute price per unit of equipment may appear high, this is because the true cost has been inflated by a highly inefficient and corrupt procurement system. Cost savings from "spin-on" civil technologies are negated as a result. Of course, though, "low cost" is a relative term, and Samuels probably compares the cost to what would have been if there were no spin-ons. See Samuels, *Securing Japan*.
7. The literature on this multi-role fighter alternatively refers to it by its original project name "FS-X" or as "F-2," which was what it was renamed when it went into production phase in 1996. To avoid confusion, this essay will use "F-2" to refer to the entire project from development to production.
8. Mark A. Lorell, *Troubled Partnership: A History of US-Japan Collaboration on the FS-X Fighter* (New Jersey: Transaction Publishers, 1996).
9. Up to mid-1985, Japan was on track to develop its first world-class indigenous fighter. For reasons of security and economics, the US was opposed to this development. Following protracted negotiations, a compromise was struck in 1987, ostensibly to enhance US-Japan defense technology and promote the principles of Rationalization, Standardization and Interoperability (RSI). Research and development for the F-2 began in 1990 and production began in 1996. See Lorell, *Troubled Partnership*.
10. "US-Japan Fighter Aircraft: Agreement on F-2 Production," United States General Accounting Office, 11 February 1997, http://www.globalsecurity.org/military/library/report/gao/ns97076.pdf.
11. Lorell, *Troubled Partnership*.
12. It is acknowledged that most of this literature represents the American perspective. I shall nevertheless assume that academic parsimony has been practiced and, given the paucity of published perspectives from the Japanese side, take them to reflect a truth.
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17. The "technonationalism" defense industrial strategy that decreed that defense production should take place in Japan, part of the industrialization strategy of "autonomous development" (*jishu kaihatsu*).
18. Five fighter platforms (excluding the F-2): North American F-86F, Lockheed F-104J, McDonnell-Douglas F4EJ,and F-15J. Seven rotary-wing platforms: Boeing KV-107, Sikorsky S-61A, Bell UH-1B/H, Sikorsky SH-60, Boeing CH-47, Bell AH-1S, Hughes OH-6. Three other (trainer and transport) platforms: Lockheed T-33A, P-2J and P-3C.
19. Lorell, *Troubled Partnership*.
20. Lee Seungjoo, "Technological Change, US Pressure, and the Transformation of the Japanese Aircraft Industry," *Asian Perspective* 27, no. 2 (2003): 141-173.
21. As of 2007, by market share and revenue. See *Defense News*, 2007.
22. The *monozukuri* is "the art of making things and the spirit of research and creativity." See "Industry," Greater Nagoya Initiative, 1 February 2011, http://greaternagoya.org/en/ind.html.
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28. Martin Fackler, "The Great Deflation: In Japan, Young Face Generational Roadblocks," *New York Times*, 27 January 2005, A1.

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