International Journal of Engineering and Advanced Research Technology (IJEART)
ISSN: 2454-9290, Volume-2, Issue-8, August 2016

Armament projects: The Japanese F- 4 case, 1960 to1990. Technology transfer in the Cold War era in the Pacific Region

Dimitrios Ziakkas

***Abstract*— Several studies in the past focused on the U.S. effort to promote Japan's economic reconstruction after the Second World War. This presentation as a much larger analysis of the connection between American economic and security policies at the Cold War's height, the origins of Japan's post - war economic success, and the character of the relationship between the United States and Japan since 1945 focuses on the military aviation projects and transfer of technology. Drawing upon the rich archival record now open to researchers, I argue here that U.S. national security policies and the escalating Cold War played a larger role in promoting Japanese economic welfare and in forging the pattern of post war economic integration and conflict between Japan and the United States. In other terms describes the military – industrial complex to U.S.A – Japan, via the F-4 project**

***Index Terms*— Aviation, doctrine, Japanese F-4, technical protocols.**

I. INTRODUCTION

Several studies in the past focused on the U.S. effort to promote Japan's economic reconstruction after the Second World War. This presentation as a much larger analysis of the connection between American economic and security policies at the Cold War's height, the origins of Japan's post - war economic success, and the character of the relationship between the United States and Japan since 1945 focuses on the military aviation projects and transfer of technology. Drawing upon the rich archival record now open to researchers, I argue here that U.S. national security policies and the escalating Cold War played a larger role in promoting Japanese economic welfare and in forging the pattern of post war economic integration and conflict between Japan and the United States. In other terms describes the military – industrial complex to U.S.A – Japan, via the F-4 project.

The 'McDonnell Douglas F-4 Phantom II' is known as the most developed marines' aircraft, which was originally initiated and launched by the McDonnell Aircraft for the U.S.A's navy. As soon as it entered in the service in the year of 1960 with the U.S. Navy its prominence started increasing in the military world. According to many military analysts, it is arguably the finest combat fighter invented in the 20th century. It was mostly used in the cold war period, and was produced in wide range. It became an all-performer when it began to serve USAF, USMC and USN. Its prominence remained same from 1960 to 1990 as it served as the main aircraft for U.S and many other countries. Initially it was used during Vietnam conflict and was further overstretched to serve in the 'Persian Gulf War' that took place in 1991. Although, the aircraft was originally invented as a 'missile-armed fleet defender,' eventually over the time, F-4 Phantom grew into a multi-service performing aircraft (Garza and Morelli, 2003). The Phantom could take on a number of combinations of fuel tanks, bombs, missiles and rockets pods as missions dictated (King and Nowack, 2003).
McDonnell introduced the Japanese to the Phantom in 1962, proposing that Mitsubishi Komaki invest in equipment so as to maintain initially U.S Air Force Phantoms stationed in the Pacific region (Bugos, 1996). Before forming the Japanese Self-Defence Forces after World War II, Japan did not have a separate Air Force branch. The Imperial Japanese Army Air Service and the Imperial Japanese Navy Air Service carried out aviation operations. Following World War II, the Imperial Japanese Army and Navy were dissolved and later replaced by the Japanese Self-Defence Forces (JSDF) with the passing of the 1954 Self-Defence Forces Law, with the JASDF as the aviation branch, (Defence of Japan, Annual White Paper).

By studying selected stories of the Cold War partnership and Japan's economic revival via the F-4 project, this presentation attempts to identify the role of critical episodes of the technology transfer in the Pacific region.

II. COLD WAR AND THE MILITARY AVIATION PROJECTS.

The Cold War was as much an ideological battle as it was a military struggle. Although the origins of the conflict can be traced as far back as the November 1917 Russian Revolution, the Cold War began to take form in late 1945 and formally it did not end until December 1991. Simply put, the Cold War can de defined as a state of mutual hostility, distrust, and rivalry between the United States and the Soviet Union. This contest soon pitted the capitalist West and its allies around the world against the Communist controlled East and its allies worldwide. A large part of the Cold War "battle" involved competing political and economic ideologies (M.Schaller, 1987). Although the Soviet Union and the United States never engaged in direct military action against one other, the Cold War was marked by a series of both small and large wars. These conflicts were fought in almost every corner of the world. In most cases the West backed one side while the East supported the other. In addition to the many small wars, the Cold War featured three major and prolonged conflicts: the Korean War (1950-1953); the Vietnam War (1946-1975); and the war in Afghanistan (1979-1989), (A. Forsberg, 2000).
The Cold War was also a period that witnessed a massive arms race and the rise of permanent and powerful defence

industries. Many historians have pointed out that the Cold War "militarized" everyday life in both the East and West. The world's major powers spent trillions of dollars on large standing armies and advanced weaponry. The idea of a Military Industrial Complex in the U.S. was introduced by President Dwight Eisenhower who in his 1961 farewell address warned against the potentially strong influence and power generated by the 'conjunction of a immense military establishment and a large arms industry' that had been created through the massive military mobilization during World War II. This led him to plead that 'we must guard against the acquisition of unwarranted influence, whether sought or unsought, by the military-industrial complex. The potential for the disastrous rise or misplaced power exists and will persist' (Eisenhower 1961).

Within this Cold War context, the national governments were clearly the main customers of the defence companies and this meant that the arms market evolved into a new structure, a market with one dominant customer and a number of suppliers. This was bound to influence the behaviour of the firms as they moved from being more general manufacturers to become defence specialists, because of the high potential returns, and started to become experts at getting money out of the government rather than competing in the market (J.P Dunne and E. Scons, 2009).

In 1950 the United States and Japan began the negotiations to end the state of war between them. In these negotiations, the U.S. government also desired a Japanese commitment to the American side in the Cold War while the Japanese government sought an American guarantee of Japan's external defence, (M.Schaller, 1987). The result was the conclusion of two treaties in 1951 (that entered into force the following year): the multilateral San Francisco Peace Treaty, which brought the Occupation to a close; and the bilateral U.S. - Japan Security Treaty, in which the United States pledged to maintain its military forces in and around Japan. The security treaty was in reality a military base agreement; it did not contain any formal American obligation to act in the event Japan was attacked. Thus, however closely the security treaty reflected the asymmetrical balance of power at the time, it was never popular in Japan. Many conservative advocates of the American alliance wanted both a stronger American commitment to defend Japan and provisions for joint consultation in the implementation of defence measures. Japanese opponents of the Cold War alliance fought against entering into any sort of security pact with the United States at all, (A.Forsberg, 2000).

To an extent that is difficult for later generations to grasp, Japanese politics during the 1950s revolved around the issue of the alliance with the United States. Throughout the decade, the U.S. government both worried about Japan's future political orientation, and attempted to shore up the alliance by emphasizing the economic opportunity flowing from close association with the United States. The climax came in 1960 after the two governments concluded a new mutual security treaty. In the face of massive public demonstrations against both the treaty and the government of Kishi Nobusuke, the Japanese political actors ratified the revised security treaty, thus confirming Japan's position at America's side in the world, (M.Schaller, 1987). Economic affairs of the decade of the fifties also display a certain unity.

In early 1950, Japan's economy was languishing and the nation's industries were unable to produce goods that were competitive in international markets. Later in the year, the outbreak of war in Korea brought a flood of American war orders that temporarily alleviated Japan's chronic foreign trade imbalance. Throughout the decade both the American and Japanese governments attempted to find markets for Japanese goods and to promote the modernization of Japanese industry. By 1960 Japan's economy was growing at a rate of about 10 per cent per year, and many of its manufactured goods were highly competitive abroad. In short, the fifties was the decade when Japan made the transition from post-war recovery to high-speed growth (A.Forsberg, 2000).

Many Japanese regarded the Cold War alliance with the United States as necessary, but it was not popular. Furthermore, Japanese political leaders had rarely emphasized the strategic importance of the alliance when recommending it to the public. More often they had stressed the economic advantages accruing to Japan, (M.Schaller, 1987).[i] On another front of the arms race in U.S, political and military advisers agreed on a policy of massive military build-up, as outlined in National Security Council document 68, known simply as NSC-68. This policy called for vast increases in defence spending to match the forces that the Soviet Union could muster. NSC-68 established a policy that meant massive federal subsidies would go to defence industries and fund military aviation projects, thus contributing substantially to the arms race, (R.Weber, 2001). The following Fig. 1 shows the selected major fixed-wings aircraft, missile and space programs of the Department of Defence U.S from 1960-1980.

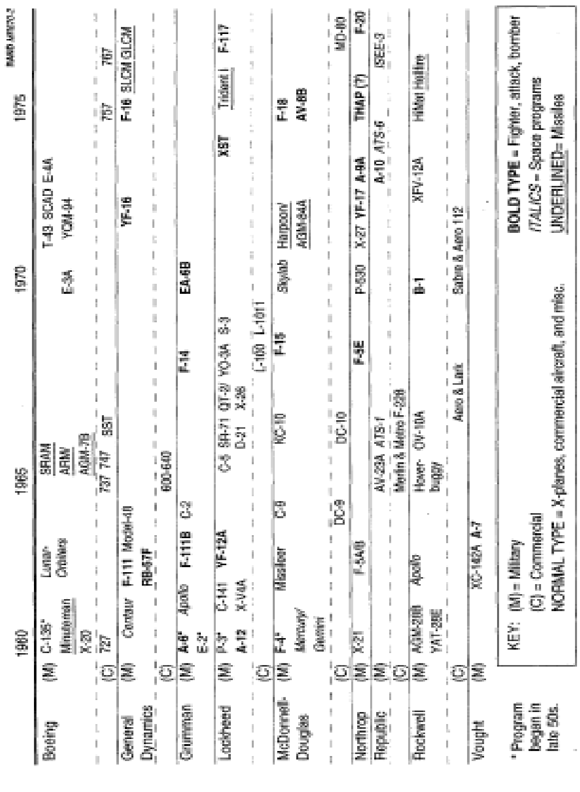

Fig 1. Selected major fixed wings aircraft, missile and space programs of the Department of Defence U.S from 1960-1980, (Lorell Mark A. - Saunders Alison - Levaux Hugh P, 1995).[ii]

It is obvious that the F-4 Phantom II project had dominant role from 1950 up to 1980 in the formation of military aviation projects. As an operational service aircraft, F-4 Phantom played a huge role in the cold war. F-4 Phantom II terminated its first operational American warfare over the 'Vietnam from USS Constellation' on the date of August 5th 1964. However, all the armament projects such as F-4J, F-4B and F4-N aced as American aircrafts until the Korean War. Later on, a technology transfer took place during the era of Cold War in the region of Pacific Ocean and F-4 Phantom became the next military fighter of US that was co-produced in Japan. The technology transfer basically took place from a U.S. company to Japanese company being the manufacturer of the aircraft; to put simply, Mitsubishi of Japan got selected as the contractor for the 'F-4 E' (Kloesel and Clark, 2013).

III. The Technology Transfer; 'Case of F-4 Phantom II'.

After the necessary introduction regarding the Cold war and the military aviation projects, it is time to focus on the research and technology transfer theories. Many questions arise regarding the content of the military aviation projects and the technology transfer. How do the current domestic and foreign regulatory environments affect the structuring of industry-initiated cross-border relationships, and how are Department of Defense and Foreign Affairs limitations change the environment? How are legitimate security of supply, technology transfer, and other technology security issues being handled, particularly in the new multipolar, multinational business environment?

Technology Transfer also called Transfer of Technology (TOT) and Technology Commercialisation, is the process of transferring skills, knowledge, technologies, methods of manufacturing, samples of manufacturing and facilities among governments or universities and other institutions to ensure that scientific and technological developments are accessible to a wider range of users who can then further develop and exploit the technology into new products, processes, applications, materials or services. It is closely related to (and may arguably be considered a subset of knowledge transfer. Some also consider technology transfer as a process of moving promising research topics into a level of maturity ready for bulk manufacturing or production.iii By analogy to the computer industry, we would expect U.S. aerospace firms to take the lead in the design and integration of complete aircraft. Indeed, the data do show that U.S. exports of complete combat aircraft dominated the world market. This may be due to U.S. government promotion of defense aerospace systems through several mechanisms.iv

In any case, however and with no attempt to analyze the cost-effectiveness of these types of export promotion programs—it is clear that strong exports were beneficial for the Air Force on purely economic grounds. They also helped firms to survive in periods of low Air Force demand, making possible to retain skilled employees and maintain facilities that might otherwise be forced to close. They could, in addition, significantly lower the costs to the Air Force of holding legacy equipment in inventory by keeping production lines open (whether in the United States or elsewhere) for replacement parts and components.v Finally, the potential for export sales minimized the risks to firms associated with participation in Air Force contracts. Focusing now on the F-4 E Japan project we had co – production agreement, instead of the common policy of "export sale" of the aviation project (Bugos, 1995). In relation to computer industry analogy, we would also expect to see economically significant U.S. imports of aerospace products, especially at the level of components and small parts (initial phase in Mitsubishi industry before F-4 project). These types of items are presumably less technically sophisticated than complete aircraft and should thus be well within the design and production capabilities of U.S. trading partners.vi

As a conclusion, aerospace exports on the weapon system platform level, (which once involved the relatively straightforward sale and transfer of finished goods from the supplier / developer to the purchaser), had evolved to encompass a wide variety of complex business arrangements involving a range of activities including countertrade, offsets, coproduction, foreign investment, marketing agreements, major cooperative R&D and modification efforts, and significant technology transfer issues (D. Ziakkas, 2014).

Major trends in U.S. combat aircraft exports since the 1950s included the growing importance of industrial and technological offsets and an increasing trend toward licensed coproduction of the purchased item in the purchasing country. Contrary to previous projects, in the F-4 E Japan project we had a complete technology transfer case study.

Like the C-47 Dakota or the Spitfire of World War II fame, the F-4 is a classic airplane. Designed in the mid-1950s, it played a vital role in Vietnam and the Arab-Israeli wars and even served in the Persian Gulf War as a suppressor of enemy air defenses. Also in its upgraded variants it will continue to fly well into the first decades of the 21st century. The content of this section tells the tale not only of its design but also of its bureaucratic history - how the U.S Air Force came to adopt a navy aircraft, how other nations as Japan decided to purchase it, and what role it had in deciding the outcome of various conflicts. This is, in short, a model of history of technology transfer, written and accessible to a much broader audience than simply aviation experts, (Bugos, 1995).

The F-4 Phantom is a tandem-seat fighter-bomber designed as a carrier-based interceptor to fill the U.S. Navy's fleet defense fighter role. Innovations in the F-4 included advanced pulse - Doppler radar, extensive use of titanium in its airframe and increased performance. vii Like other interceptors of this period, the F-4 was designed without internal cannon due to a proposed change in the air doctrine. Its baseline performance of a Mach 2+ class fighter with long range and a bomber-sized payload was designed to be the template for the next generation of large and light/middle-weight fighters optimized for all weather air combat operations. In air combat, the Phantom's greatest advantage was its thrust, which permitted a skilled pilot to engage and disengage from the dogfight, revising the situation awareness. This heavy aircraft, designed to fire mostly radar-guided missiles from beyond visual range, had initially great disadvantage in dogfights in comparison to its Soviet opponents as it was subjected to adverse yaw during hard manoeuvring. In 1972, the F-4E model was upgraded with leading edge slats on the wing, greatly improving high angle of attack manoeuvrability at the expense of top speed, improving the dogfight capability of this aircraft utilizing its new M-61 cannon. Using the same engine as F-104, the J79 engines produced noticeable amounts of black smoke, a severe disadvantage as the enemy could easily spot the aircraft.viii

As stated before, the F-4's biggest weakness, as it was initially designed, was its lack of an internal cannon. For a brief period, doctrine held that close combat – dogfight operations would be impossible at supersonic speeds and little effort was made to teach pilots air combat manoeuvring, as F-4 was using state of the art radar/ avionics systems and missiles.ix In reality, engagements quickly became subsonic, as pilots would slow down in an effort to get behind their adversaries. Furthermore, the relatively new heat-seeking and radar-guided missiles at the time were frequently reported as unreliable and pilots had to use multiple shots just to hit one enemy fighter. Many pilots found themselves on the tail of an enemy aircraft but too close to fire short-range missiles. Although in 1967 USAF F-4Cs began carrying SUU-16 external gun pods containing a 20 mm M61 Vulcan Gatling cannon, USAF cockpits were not equipped with lead-computing gun sights until the introduction of the SUU-23, virtually assuring a miss in a manoeuvring fight. Some Marine Corps aircrafts carried two pods for strafing. In addition to the loss of performance due to drag, combat showed that the externally mounted cannon to be inaccurate unless frequently bore sighted, yet far more cost-effective than missiles. This lack of cannon was finally addressed by adding an internally mounted 20 mm (.79 in) M61 Vulcan on F-4E. We can see that an initial design story of failure with early recognition and corrective action using lead computing gun sight and digital electronics turned into a story of success (Fig.2).

Date/Year	Firing Aircraft	Vulcan 20mm M-61Gun Model	Aircraft Downed	USAF Unit
29 June 1966	F-105D	M61A1	MiG-17	421st TFS (Tactical Fighter Squadron)
18 August 1966	F-105D	M61A1	MiG-17	34th TFS
21September 1966	F-105D	M61A1	MiG-17	333rd TFS
21 September 1966	F-105D	M61A1	MiG-17	431st TFS
04 December 1966	F-105D	M61A1	MiG-17	469th TFS
1967	F-105D/F	M61A1	(5) MiG-17s	333rd TFS
1967	F-105D	M61A1	(8) MiG-17s	354th TFS
1967	F-105D/F	M61A1	(4) MiG-17s	357th TFS
1967	F-4 C Phantom II	SUU-16	(2) MiG-17s	480th TFS
13 May 1967	F-105D	M61A1	MiG-17	44th TFS
03 June 1967	F-105D	M61A1	MiG-17	13th TFS
23 August 1967	F-105D	M61A1	MiG-17	34th TFS
24 October 1967	F-4 D	SUU-23	MiG-21	433rd TFS
1967	F-4 D	SUU-23	(3) MiG-17s	435th TFS
03 January 1968	F-4 D	SUU-23	MiG-17	433rd TFS
14 February 1968	F-4 D	SUU-23	MiG-17	555th TFS
1972	F-4 E	M61A1	(3) MiG-21s	35th TFSx
02 June 1972	F-4 E	M61A1	MiG-19	58th TFS
09 September 1972	F-4 E	M61A1	MiG-21	555th TFS
15 October 1972	F-4 E	M61A1	MiG-21	307th TFS
Total MiG-17s: 32				
Total MiG-19s: 1				
Total MiG-21s: 6				
MiG Total: 39				

Fig 2. M-61 Vulcan cannon increased the capabilities of the F-4.xi

As stated before the F-4 faced a lot of changes as a result of the demanding changes in air doctrine, improvement of avionics systems and accuracy of digital systems. The improvements in the F-4 Phantom project had been a demanding R&D effort. As we can easily realize from the figure bellow (Fig. 3), after the initial necessary airframe and engine establishment, the electronics / avionics area domain the R&D unit cost in the project.

1) Costs 2)	3) F-4C	4) RF-4C	5) F-4D	6) F-4E
Unit 7) R&D cost	8)	61,200 (1965) by 1973 451,342 (Current) by 1973	9)	10) 22,700 (1965) by 1973 167,410 (Current) by 1973
11) Airf rame	1,388,725 (1965) 10,241,664 (Current)	1,679,000 (1965) 12,382,403 (Current)	1,018,682 (1965) 7,512,645 (2008)	12) 1,662,000 (1965) 12,257,031 (Current)
Engines	317,647 (1965) 2,342,605 (Current)	13) 1,679, 000 (1965) 12,382,403 (Current)	14) 260, 563 (1965) 1,921,618 (Current)	15) 393,000 (1965) 2,898,323 (Current
16) Elec tronics	17) 52,2 87 (1965) 385,610 (Current	18) 293,00 0 (1965) 2,160,836 (Current)	262,101 (1965) 1,932,960 (Current)	19) 299,000 (1965) 2,205,086 (Current)
20) Arm ament	21) 139, 706 (1965) 1,030,313 (Current)	22) 73,000 (1965) 538,365 (Current)	23) 133, 430 (1965) 984,029 (Current)	111,000 (1965) 818,610 (Current)
24) Ord nance	25) N/A	26) N/A	27) 6,81 7 (1965) 50,274 (Current)	8,000 (1965) 58,999 (Current)
28) 29) Flya way cost	30) 31) 1.9 million (1965) 14 million (Current)	32) 33) 2.3 mil lion (1965) 17 million (Current)	N/A	34) 35) 2.4 million (1965) 17.7 million (Current)

Modification costs	*36) 116, 289 (1965) by 1973* *857,616 (Current) by 1973*	*37) 55,217 (1965) by 1973* *407,218 (2008) by 1973*	*38) 233, 458 (1965) by 1973* *1,721,722 (Current) by 1973*	7,995 (1965) by 1973 58,962 (Current) by 1973
39) Cost per flying hour	***40) 924 (1965)*** ***6,814 (2008***	867 (1965) 6,394 (Current)	***41) 896 (1965)*** ***6,608 (Current)***	867 (1965) 6,608 (Current)
Maintenance cost per flying hour	***42) N/A***	***43) N/A***	545 (1965) 4,019 (Current	***44) N/A***

Fig 3. The F-4 project R&D analysis.xii

The F-4E had a flyaway Cost per Production Aircraft of $2.4 million for the airframe, $1,662,000 for the engines, $393,000 for the electronics and $299,000 for the ordnance.xiii R&D costs amounted to $22,700-cumulative through mid 1973 and included in the F-4E's flyaway cost. While few F-4s were funded under the Military Aid Program in Fiscal Year 1969, most of F-4 E followed the FMS option. The F-4E, utilizing leading-edge manoeuvring slats and updated weapons and radar controls, which were optimized for dogfighting, vastly improved the Phantom's air-to-air capabilities. Nevertheless, the Phantom's ultimate 3:1 kill ratio over the MiGs fell far short of the impressive advantage enjoyed by the Air Force in Korea. The return of close-in air-to-air combat during Vietnam unfortunately exposed a deficiency in the flying characteristics of the F-4. During hard turns so as to engage or escape enemy aircrafts, pilots began to fly the F-4 at high angles of attack where they experienced a marked deterioration in lateral-directional stability and control characteristics. Inadvertent loss of lateral-directional control and spin entries occurred, with an alarming number of accidents and losses of crew and aircraft during training and combat. McDonnell Douglas became interested in wing modifications for the F-4 that would improve buffet onset and increase lift and turning performance, while retaining satisfactory characteristics for approach and landing. Candidate configurations included the use of wing leading-edge flaps, leading-edge camber, trailing-edge flaps, and other devices; however, the most effective modification was a two-position leading-edge slat. Two slats were mounted on the leading edge of each wing panel in place of the earlier leading-edge flap. The inner slat was fully retractable at high speeds, but the outer slat remained deployed in both the cruise and high-lift configurations. With the slats deployed, the F-4 could make tighter turns, and approach speeds were also reduced by a significant amount. Another benefit of this modification was a dramatic improvement in the lateral-directional handling characteristics and spin resistance at high angles of attack. The slat configuration was evaluated during flight tests of a modified F-4 test aircraft with extremely impressive results. The wing leading-edge slats were incorporated on all F-4E aircraft built during and after 1972.

Later, the Navy received a slat-equipped version of the aircraft known as the F-4S. Starting in 1973, F-4E's were fitted with target-identification systems for long-range visual identification of airborne or ground targets. Each system is basically a television camera with zoom lens so as to aid in positive identification, and a system called Pave Tack, which provided day and night all-weather capability to acquire, track and designate ground targets for laser, infrared and electro-optically guided weapons. Another change was a digital intercept computer that included launch computations for all AIM-9 Sidewinder and AIM-7 Sparrow air-to-air missiles. Additionally, on F-4E/G models, the digital ARN-101 navigation system replaced the LN-12. Early F-4Es had no or incomplete AN/APQ-120 fire control systems. Even though the APQ-120 passed through several modifications, it was still inadequate in late 1972. Aerospace ground equipment for both the new APQ-120 and the M-61AI gun was initially short. Then, too, troubles existed in several new missiles and in the overall weapon systems. In January 1969, the Air Force began to correct these deficiencies arising mainly when the AIM-7E Sparrow was combined with any model of the F-4 (compatibly problem). Its project to mate AIM7F missiles with the F-4E had made little headway by December 1972. On the other hand, the Air Force had modified the AIM-9B Sidewinder and shipped the first newly configured AIM-9Es in early 1969 (patents).

After all these facts, the U.S Air Force decided to go ahead with Pave Spike in May, assuring in 1972 that the program's technical problems would not disrupt the operations. Pave Spike, estimated to cost $81 million. So after one year, U.S Air Force asked Westinghouse to produce 156 (AN/ASQ-153) pods for the modification of 317 aircraft (106 F-4Ds and 211 F-4Es). These modified aircraft and pods would provide a self-contained day tracking and laser target designator for the delivery of laser-guided weapons. We can consider the last upgrades in the avionics of F-4 E on the final phase, as the changeover from analog to digital, changeover, which will be completed totally with the next generation aircrafts.

In the F-4 E project presentation intentionally were presented many technical issues affected by the doctrine demands in Cold War conflicts, so as the comparison with the local stories of the Japan's case study will highlight the main differences which are essential to link- delink and relink the story regarding the technology transfer in Japan military aviation projects (Ziakkas 2014).

Due to this technology transfer that took place in the Pacific region, the F-4 brought new challenges in the manufacturing of the aircraft, as it was the first combat aircraft that made the use of titanium extensively well. The co-production phase came up with a lot of challenges; the agreements related to F-4 aircraft included 100% production of the airframe, Japan's engines' components and avionics of F-4. Mitsubishi was selected as the F-4 aircraft's contractor in November 1968. Japan manufactured a number of 138 F-4 combat aircrafts, (Photo 2). In July 1971, the first two were completed and ready for the warfare. However, the first two F-4 that were entirely produced from the parts of manufactured products made in Japan were completed in the month of May 1972. The extraordinary domestic content that was made in Japan showed how well Japan's aircraft industry could perform. The aircraft of Japan encouraged the widespread proficiencies to even reproduce the designs of the well-known and highly influential fighter aircraft. However, at the end of the 1970's, the Japanese faced a lot of chaos due to the shortcomings they were about to face, where Japanese were always well aware of these and so steps were taken to remedy these deficiencies in order to include the F-15's co-production (Paul et al., 2002).

During the entire history of this technology transfer, the contract has been constantly changed. Firstly, the contract stated that Japan became one of the fewest countries that 'licensed-produced' this combat aircraft with U.S. Most of the F-4 EJs had been manufactured entirely by the Mitsubishi Heavy Industries. However, due to military limitations of Japan to complete the end-product F4 EJs substituted to 'Lockheed F-104 Starfighters' and in the summers of 2007, this company signed a contract that several F-15 Eagles will be equipped with 'synthetic aperture.' While, in the case of cost-sharing the finance had been split into 60% by Japan and 40% by USA. Amounts have been kept controversial, especially by the USA's side. Many issues also occurred during the technology transfer due to cost-efficacy (Bugos, 1995).

IV. Some Significant Episodes of the Technology Transfer.

A description of the political situation in Japan will help us understand better, selected episodes of the technology transfer. Satō Eisaku was a visionary statesman and leader. However, he has generally been regarded, both during and after his tenure, as an obstinate, drab technocrat. His background as a Railway Ministry bureaucrat, together with his manner, which could appear aloof and unfeeling, accounts for this image. He was also noted for his taciturnity and his often confusingly indirect mode of speaking. However, he successfully led his country through a particularly testing time. While the Vietnam War and the Chinese Cultural Revolution convulsed Asia, Japan was a beacon of peace, stability and prosperity. His signal achievements were the reversion of Okinawa and, after almost a decade of both personal and national soul-searching, the rejection of an independent Japanese nuclear deterrent. Satō can also be credited with laying the groundwork for the swift normalisation of relations with China following his departure from office in 1972, (A. Forsberg, 2000).

The strongest influence on Satō's career was Yoshida, who articulated a grand strategy for Japan in the after math of war, defeat and occupation. By eschewing military power Japan could find success through economic development and a close alliance with the United States. Satō also drew inspiration from Japan's recent history and closely identified with the leaders and statesmen of the Meiji era, who led the process of centralisation and modernisation in the nineteenth century. He believed that the measure of Japan's success was articulated by the Meijiera slogan of fukoku (rich country). However, given the more recent history of war and defeat, this slogan's corollary of kyōhei (strong army) was side lined. He profoundly disagreed with the pacifist and neutralist inclinations of the Socialist and Communist opposition parties and saw a need for Japan to develop its own capacity for defence. This was always articulated in the context of the alliance with the United States, (M.Schaller, 1987). Taking into account the political situation in Japan in relation to Cold War political environment we proceed to a critical review of significant episodes of the technology transfer in the Pacific region.

In September 1967, JDA, which is the 'Japanese Defence Agency', designated Mitsubishi as the prime and major contractor for the upcoming XT-2 supersonic trainer that is also stated as the first ever domestically supersonic fighter produced in Japan. The first ever flight of XT-2 started in the month of July 1971. However, later on, the XT-2 supersonic trainer re-designated the Mitsubishi F-1 in June 1977. All of these events occurred in a very small amount of time, demonstrating the highly extraordinary work done by the Japanese aircraft industry. However, according to the other sources it is also stated that Mitsubishi F-1 was not considered as a successful and operational aircraft. Though, F-1 was developed as an 'all-weather fighter', it was restricted to take a flight in daylight only; also, the operational and security concerns resulted in the lack of production. This was the major downfall in the technology transformation of McDonnell Company to Mitsubishi Motors. Due to this, the amount of aircrafts produced was short by 80 (King and Driessnack, 2007).

It is also said that Phantom F-4's Japanese deal was highly unique in nature as it involved quite a lot of innovation episodes in the co-production phase. It involved co-production on a foreign soil; however, it nearly fitted into a pattern of 'Japanese acquisition' of the aerospace technology of America. In the initial phase of its production, McDonnell Company introduced Japanese organisations to the special and extraordinarily unique production techniques that were used by them earlier. Moreover, they introduced them to the high quality standards that also followed the local interception doctrine related requirements and it consisted of highly cost-effective solutions (Frano and Forasassi, 2011).

At a later stage, U.S. restricted the technology transfer that took place; also, delays and the increasing amount of production cost transformed the positioning of the technology transfer. This resulted in a tension between Japanese and Americans. As the price of the new projects started doubling and the schedule started to evaporate, the Japanese began to become sceptical about the notion of American people and started questioning their integrated system. This was one of the most critical episodes that occurred in the history of technology transfer (Wang et al., 2015).

On the other hand, F-15 aircraft is actually the recent American fighter aircraft co-produced in Japan. In August 1981, the first ever F-15 rolled off the assembly line of Mitsubishi that was produced by the Japanese. This exactly happened after the delivery of last F-4 from the similar Mitsubishi's assembly lane, where the duration between these events was three months. The first fifteen of the F-15 aircrafts rolled off and were highly assembled, and parts were shipped from the USA. It has been described that this event of the origination of F-15 aircraft motivated the U.S. for starting its co-production with Japan, while also focusing on the safety related concerns. Such an arrangement was not intended by either of the parties; nevertheless, it boosted the aircraft industrial abilities of Japan. It is further stated that the potential of the aimed technology transfer actually started increasing; it exceeded the F-series to a new path. F-86, F-4 and F-104 were delivered as black boxes including a number of components of F-15 as well. This also led to an interesting event in December 1984 when U.S. made a revision in the 'Memorandum of Understanding', which included that USA will receive 'flow-back technology' from Japan, and in this case, the government of U.S. will be entitled to the improvements needed in individual components or aircraft as a whole. This episode suggests that U.S. was interested in continuing her ties with Japan in terms of this project (Hull, 2007).

Though, the statement according to the U.S. Memorandum stated that the improvements will be recognized, it wasn't needed. If this event is critically evaluated, it is highly obvious that U.S. did not believe in the potential of Japanese aircraft industry. Also, U.S. had a deficiency of knowledge about the technology developments that were being made in Japan. This also shows that U.S. had a lack of apparent interest in the research and development of military (Menon et al., 2007).

V. Critical Evaluation of the Episodes.

From the above events, it appears that Japan has managed to build an aircraft industry on domestic level mainly through sequential learning, foreign technology transfers from the U.S. and the trial and errors in the production and design of the local fighter aircraft. The technology transfer chiefly helped the aircraft industry of Japan and proved the country's potential in the perspective of U.S.; nonetheless U.S. has always neglected it.

Due to the opportunity of technology transfer, the Japanese government also curtailed the 'foreign firm ownership of technology markets' to promote the local capability of country as a whole. One of the major issues that occurred in the technology transfer, as also mentioned above, was the huge failure in sending sufficient number of aircrafts to U.S. However, it also shows a significant learning about the manufacturing of combat aircrafts (Marques et al., 2010).

Moreover, the following development of F-104 and F-86 maintained and restored the general capability of aircraft manufacturing. According to earlier researchers, it has been stated that the most capable aircrafts that were sent to U.S. were produced by Japan. Mitsubishi along with Fuji and Kawasaki being the leaders in the aircraft industry represent the industrial capabilities of components, aircraft subsystems, electronics and instrumentation. Also, similar to fighter aircrafts, another company known as Boeing has boosted the role of Japan by bringing the new commercial aircraft projects (Deurenberg, 2009).

The critical evaluation of the episodes of technology transfer has proved the immense progress in Japan's aircraft industry, and that its technological abilities cannot be denied. Moreover, it also led U.S. progressing in the sector of aerospace technologies. Also, one great example of the benefit of the event could be when between the years of 1990-1994, U.S. faced a huge trade surplus in the sector of aerospace technologies as relative to other nations and Japan became more competitive in supporting U.S. in this matter. The technology transfer also led U.S. taking interest in Japan's technological capabilities in the aircraft industry for future projects.

Additionally, when the bigger picture is considered, it can be observed that due to this event, U.S. started to recognize the Asian technology's value. However, although, this technology transfer undoubtedly resulted in the success of aircraft industry, it did not increase the competitiveness of other industries. Also, due to government's intervention, there have been several problems in the Japanese airline industry. Nevertheless, the technology transfer has proven to be a series of highly experimental and successful events for the aircraft industry of Japan (Citino, 2013).

VI. Conclusions.

Differences between expectation and reality were more gratifying to the Japanese. But for them the economic trends did not necessarily accord with previous plans. The re-orientation of Japan's trade westward was not the original object of Japan's leadership during the years Yoshida, Hatoyama, and Ishibashi were in power. Up until the late fifties, even Japan's conservative leaders envisioned restoring a profitable trade with the Chinese main land at some point to complement a growing presence in Southeast Asia. American pressure to limit such exchange, and the disruptive influence of the Cold War itself, combined to frustrate such designs. As Sino-American tension escalated, the economies of Japan and the People's Republic continued to develop separately. The significance of this development is not yet fully apparent. What is clear is that after the Cold War's end the economies of the two greatest powers in Northeast Asia stand largely apart from each other, as likely to reinforce political differences as to facilitate greater cooperation between them.
The success of Japan's industrial policy probably ranks as the greatest surprise of the era. By the late 1960s, however, many European countries as well as Japan increasingly insisted on coproducing U.S.- designed military aircraft under license rather than importing finished products.xiv

Specific variables – issues that the technology transfer optimization models had to take into account regarding third countries to U.S government/ firms or other countries are:
1. The time of delivery or time performance is so important that the government may reasonably expect to suffer damage in the homeland security if the delivery or performance is delinquent.
2. The extent or amount of such damage would be difficult or impossible to estimate accurately or prove, so a provision for claims and offsets have to be prepared and agreed. These might have the form of "If the Contractor fails to deliver the supplies or perform the services within the time specified in this contract, the Contractor shall, in place of actual damages, pay to the Government liquidated damages of a pre-agreed amount per calendar day of delay.
3.The compatibility of the military systems with the technical protocols that is described in the technical requirements, which the country has already demanded during the letter of interest procedure.
4. Global Project License: A single, comprehensive license to cover all exports planned to occur under a government-to -government international agreement for a cooperative

project. The Department of Defense for U.S will define a standard set of terms and conditions that will apply to all phases and activities identified in the international agreement. Once a firm receives an initial license permitting it to participate in some aspect of the project covered by the international agreement, it would need additional licenses only for activities that exceed the standard terms and conditions and/or exceed congressional notification thresholds, to add new end users or participants, and/or to expand the participation of existing end users or participants. Exports and reimports to and among the approved end users would require no additional licenses.xv

5. A single, comprehensive export authorization to permit qualified U.S./ other countries defense companies to exchange a broad set of technical data necessary for teaming arrangements, joint ventures, mergers, acquisitions, or similar arrangements with qualified foreign firms from NATO, or other countries. Unlike export authorizations for marketing, this authorization would cover the much broader range of technical data needed to assess with some degree of depth and transparency opportunities for such undertakings.

6. Interagency Export License Electronic Control Process: The Departments of State and Defense will enhance computer connectivity between the Department of Defense and the State Department's Office of Defense Trade Controls to permit greater and more timely exchange of data on license applications.xvi

All the above issues are basic factors in the formation of the optimized economic model that fulfils the technology transfer requirements and also meets the above described issues.

This report has managed to cover most of the critical episodes of the technology transfer of American to Japan which started from F-4 Phantom II covering the new contract theories for aviation projects – technology transfer and the examined failures. More particularly, the technology transfer has led McDonnell Company to give their co-production to Mitsubishi starting a new period in technology transfer. During a couple of episodes present in the technology transfer, Japan has shown their extraordinarily unique technological capabilities in the aircraft industry and has proven itself to the U.S. as well. This technology transfer not only helped Japan to boost their aircraft industry and their international value, but also increased the recognition of Asian aircraft industry as a whole according to the perspective of U.S. However, there have been some disturbing events such as decline in the production of aircraft sent to U.S. from Japan, but it was later on covered. Overall, the technology transfer has led to the success of Japanese airline industry and to the constant improvement in their technological abilities.

* Dimitrios Ziakkas was born in Ioannina, Greece on June 12, 1972. He earned a B.S in Aviation Science in 1994 from Hellenic Air Force Academy, Athens Greece, and a B.S in Economics from National and Kapodistrian University of Athens, Athens, Greece in 2003. He earned a M.S in History and Philosophy of Science and Technology, National and Kapodistrian University of Athens and National Technical University of Athens, Greece in 2006. He holds a Ph.D. at the Graduate Program in the History and Philosophy of Science and Technology, National and Kapodistrian University of Athens and National Technical University of Athens. He works on a project in the history of the appropriation of aviation electronics and related technologies in Greece. He retired from Hellenic Air Force in 2008 and is now a commercial pilot. As a pilot he has a 8500 total flying hours experience with aircraft types such as McDonnell Douglas F-4E Phantom II, Lockheed C-130 H/B Hercules, Gulfstream G-V, Premier 1/A (RA-390), Airbus A-320, A330, A340, A-380. During his service with Hellenic Air Force, he was trained as an electronic war officer and also as a flight safety investigator officer. He was Head of Training in Flight Training Organizations / Type Rate Training Organizations, Flight Instructor, Type Rate Instructor, Crew Resource Management Instructor in Greece and U.A.E under JAR / EASA. He has also taught courses in the History, Technology and Doctrine Program in Hellenic Air Force Academy.

REFERANCE

Primary

[1] *Citino, R., 2013. THE PHANTOM MENACE: THE F-4 IN AIR COMBAT IN VIETNAM* (Doctoral dissertation, UNIVERSITY OF NORTH TEXAS).

[2] Deurenberg, R. (2009). Israel Aircraft Industries (IAI) Lavi.

[3] Fintan, Hoey. (2015). Sato, America and the Cold War. U.S – Japanese relations, 1964-1972, Palgrave, Macmillan.

[4] Forsberg, A (2000). America and the Japanese miracle, The Cold War Context of Japan's Postwar Economic Revival, 1950-1960 (Luther Hartwell Hodges Series on Business, Society, and the State).

[5] Frano, R. L. and Forasassi, G. (2011). Preliminary evaluation of aircraft impact on a near term nuclear power plant. *Nuclear Engineering and Design*, *241*(12), pp.5245-5250.

[6] Garza, F. R. and Morelli, E. A. (2003). A collection of nonlinear aircraft simulations in mathlab.

[7] Hull, S. S. (2007). Evaluation of ergonomic interventions for bucking bars in aircraft manufacturing.

[8] King, D. R. and Driessnack, J. D. (2007). Analysis Of Competition In The Defence Industrial Base: An F-22 Case Study. *Contemporary Economic Policy*, *25*(1), pp.57-66.

[9] King, D. R. and Nowack, M. L. (2003). The impact of government policy on technology transfer: an aircraft industry case study. *Journal of Engineering and Technology Management*, *20*(4), pp.303-318.

[10] Kloesel, K. J. and Clark, C. M. (2013). Preliminary MIPCC Enhanced F-4 and F-15 Performance Characteristics for a First Stage Reusable Launch Vehicle. In *AIAA SPACE 2013 Conference and Exposition*. pp. 5528.

[11] Marques, S., Badcock, K. J., Khodaparast, H. H. and Mottershead, J. E. (2010). Transonic aeroelastic stability predictions under the influence of structural variability. *Journal of Aircraft*, *47*(4), pp.1229-1239.

[12] Menon, P. K., Sweriduk, G. D. and Bowers, A. H. (2007). Study of near-optimal endurance-maximizing periodic cruise trajectories. *Journal of aircraft*, *44*(2), pp.393-398.

[13] Paul, D., Kelly, L., Venkayya, V. and Hess, T. (2002). Evolution of US military aircraft structures technology. *Journal of Aircraft*, *39*(1), pp.18-29.

[14] Schaller. M. (1987) The American Occupation of Japan, The Origins of the Cold War in Asia.

[15] Wang, X.K., Wei, S.C., Xu, B.S., Chen, Y., Yan, X. and Xia, H.H. (2015). Transparent organic materials of aircraft cockpit canopies: research status and development trends. *Materials Research Innovations*, *19* (sup10), pp.S10-19.

[16] Weber R. - Swords (2001). Dow Shares, Governing the Decline of the Military-Industrial Complex.

[17] Ziakkas D. (2014), Unpublished Doctorate Study, Adaptation of electronics in Greek military aviation Projects 1950-2000.

Secondary

Books

[1] David Edgerton, “From Innovation to use: Ten Eclectic Theses on the historiography of technology” , History and Technology 16 (1999).

[2] Coopey, Richard. ed. 2004. Information Technology Policy: An International History. Oxford: Oxford University Press.

[3] Corn, Joseph J,"Object Lessons/Object Myths? What historians of technology learn from things" in David Kingery, Learning from things: Method and Theory of material culture studies, Washington D.C : Smithsonian Institution Press,1996.

[4] L.F.E Coombs, Control in the Sky: The Evolution & History of the Aircraft Cockpit, (Pen &Sword,2005).

[5] Joseph J. Corn, "Object Lessons / Object Myths? What historians of technology learn from things" in David Kingery, Learning from things: Method and Theory of material culture studies, Washington D.C : Smithsonian Institution Press,1996.

[6] Caroll Pursell, "Seeing the invisible: New Perceptions in the history of technology ICON: Journal of the International Committee for the History if technology.

[7] R.Fox, Methods and themes in the history of technology, Amsterdam, The Netherlands: Hardwood Academics Publishers.

[8] D. Laudan, "Natural alliance or forced Marriage ? Changing relations between the histories of science and technology, technology and culture.

[9] D.McGee, "Making up mind: the early sociology of invention" , technology and culture.

[10] B. Sinclair, New perspectives on Technology and American Culture, Philadelphia, Pennsylvania: American Philosophical Society, 1986.

[11] Com, Joseph, ed. Imaging Tomorrow: History, Technology, and the American Future, Cambridge, Massachusetts, the MIT Press.1988.

[12] Hounshell, David, From the American System to Mass Production: The development of manufacturing technology in the United States. Baltimore, Maryland : The John Hopkins University Press,1985.

[13] D. Cardwell, Ιστορία της Τεχνολογίας, Μεταίχμιο, Αθήνα 2004.

[14] T.P.Hughes, T.J.Pinch, 'The social construction of technological Systems: New directions in the sociology and history, Cambridge, Massachusetts, the MIT Press.1987.

[15] D. Mackenzie, "Inventing Accuracy",Cambridge, Massachusetts, the MIT Press.1990.

[16] S.L.Macfarland, "America's Pursuit of Precision Bombing, 1910-1945", Smithsonian, 1995.

[17] D.A.Mindell, "Datum for its own annihilation :feedback, control and computing", (1999).

[18] R. E. Bilstein, "Flight in America: From the Wrights to the Astronauts", John Hopkins University Press, (Baltimore, Maryland, 2001).

[19] L.F.E Coombs, "Fighting Cockpits 1914-2000 : Design and development of military aircraft cockpits" , (London, 2001).

[20] Δ. Κ. Βογιατζής, «Ανακατασκευάζοντας την Αεροπορική Ιστορία στην Ελλάδα», (Δεκέλεια, 2003).

[21] C.Freeman, "Technology Policy and Economic Performance", Pinter, (London, 1987).

[22] G. Bassala," The Evolution of Technology", Cambridge University Press, (Cambridge, 1988).

[23] J.A. Schumpeter, "The theory of Economic Development. An inquiry into Profits, Capital, Credit, Interest and the Business Cycle", Harvard University Press, (Cambridge, Mass, 1934).

[24] M. Mort, "Building the Trident Network – A Study of the Enrollment of People, Knowledge and Machines", MIT Press, (Cambridge, Mass, 2001).

Articles

[1] Αριστοτέλης Τύμπας, "What have we been since we have never been modern?", ICON, Vol.8, (2002).

[2] M.A. Dennis, "Our first line of defense: two university laboratories on postwar American state" ISIS 85.3 (1992).

[3] Thomas J. Misa and Johan Schot, "Inventing Europe: Technology and the Hidden Integration of Europe", *History and Technology*, 2005, Vol.21, Issue 1.

[4] Helmuth Trischler and Hans Weinberger, "Engineering Europe: Big Technologies and Military Systems in the Making of 20th Century Europe", *History and Technology*, Vol.21, 2005, Issue 1.

[5] Erik van der Vleuten; Arne Kaijser, **"**Networking Europe**"**, *History and Technology*, Vol.21,2005, Issue 1.

[6] Ziakkas, Dimitrios 2007. "Has software development softened rigid European borders?" What about Electronics?" Third Plenary Conference of the Tensions of Europe Network and the Launch of Inventing Europe: ESF EUROCORES Program, Rotterdam, The Netherlands, and 2007 Conference Paper.

---

[i] Kishi was thus a convenient lightning rod for Japanese anxiety about American military power. More positively, Ikeda, the former Finance Ministry bureaucrat, was the perfect figure to distance both the government and the alliance from the acrimonious debates about militarism and war, (A.Forsberg, 2000).

[ii] Lorell Mark A. - Saunders Alison - Levaux Hugh P., "Bomber R & D since 1945, The Role of Experience".

[iii] The process to commercially exploit research varies widely. It can involve licensing agreements or setting up joint ventures and partnerships to share both the risks and rewards of bringing new technologies to market.

[iv] Rich Michael D. and Dews Edward – Batten C. L., *Improving the Military Acquisition Process: Lessons from RAND Research*, Santa Monica, Calif.: RAND, R-3373-AF/RC, 1986.

[v] Rich Ben R. - Janos Leo, *Skunk Works: A Personal Memoir from the U-2 to the Stealth Fighter: The Inside Story of America's Most Secret Aerospace Company, the Airplanes They Built, and the Dangerous Missions That Won the Cold War*, Boston (Mass: Little Brown & Company) 1994.

[vi] Lorell Mark A. - Hoffman Donna Kim, *The Use of Prototypes in Selected Foreign Fighter Aircraft Development Programs: Rafale, EAP, Lavi, and Gripen*, Santa Monica, Calif.: RAND, R-3687-P&L, September 1989.

[vii] Despite the imposing dimensions and a maximum takeoff weight of over 60,000 lb. (27,000 kg), the F-4 has a top speed of Mach 2.23 and an initial climb rate of over (210 m/s). The F-4's nine external hard points have a capability of up to 18,650 pounds (8,480 kg) of weapons, including air-to-air and air-to-ground missiles, such as unguided, guided, and nuclear bombs.

[viii] The event that Japan / Mitsubishi had already F-104 was a great advantage in the early adaptation of F-4 from engineers and pilots who were aware of the pros and cons of this engine.

[ix] A dogfight, or dog-fight, is a form of aerial combat between fighter aircraft; in particular, combat of maneuver at short range, where each side is aware of the other's presence. Dog fighting first appeared during World War I, shortly after the invention of the airplane. Until at least 1992, it was a component in every major war, despite beliefs after World War I that increasingly greater speeds and long-range weapons would make dog fighting obsolete. Modern terminology for air-to-air combat is Air Combat Maneuvering (ACM), which refers to tactical situations requiring the use of individual Basic Fighter Maneuvers (BFM) to attack or evade one or more opponents. This differs from aerial warfare, which deals with the strategy involved in planning and executing various missions.

[x] The F-4 E is the first Phantom II to enter the war with an internal Vulcan gun.

[xi] McCarthy Jr. - Donald J., *MiG Killers, A Chronology of U.S. Air Victories in the Vietnam War 1965*-1973, Specialty Press, pp.148-157.

[xii] Original amounts were in 1965 United States dollars. The figures in these tables have been adjusted for inflation. More details on: Bugos Glen E., *Engineering the F-4 Phantom II, Parts into systems*, Airlife Publishing Ltd, England 1996, also: Dorf and Bishop, 1996, p. 44.

[xiii] Bugos Glen E., *Engineering the F-4 Phantom II, Parts into* systems, Airlife Publishing Ltd, England 1996.

[xiv] One of the most important early programs involved the coproduction of the Lockheed F-104G (a specially modified variant of the F-104A) by a consortium of European countries that included Germany, Italy, Belgium, and the Netherlands.

[xv] Yoder C. E. (2004). *Engagement vs. Disengagement: How structural and commercially-based regulatory changes have increased government risks in Federal acquisitions*, Graduate School of Business and Public Policy, Monterey (CA). Acquisition Research Working Papers, NPS-AM-05-001.

[xvi] DoD Defense Security Cooperation Agency. (October 2003). Security Assistance Management Manual DOD 5105.38-M., Washington DC.

Author:-

Dimitrios Ziakkas, Bsc, Msc,Ph.D., National and Kapodistrian University of Athens and National Technical University of Athens