FEATURE

Chasing the Chimera of the Indigenous Jet Fighter

China's Stealth Fighters and the Lessons of Recent Aviation History

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Abstract

China has demonstrated an apparent capability to develop stealth fighters. While Chinese aviation technology should not be underestimated, this essay strikes a cautionary note. Using historical examples from Argentina, Egypt, and India, the author contends that Chinese stealth fighters are being unveiled in part to highlight China's arrival as a global power; however, future Chinese jet fighter development will be hindered by technical challenges such as the development of indigenous engines—not to mention advanced weapons and sensors.

Introduction

In recent years China has unveiled two stealth fighters on the eve of visits to Beijing by two US secretaries of defense. These apparent stealth projects generate obvious concern in Washington, yet US officials concede they know little about China's stealth capabilities and how they fit into that country's overall force modernization.[1]

At first glance, the development of China's stealth fighters appears to be motivated by the US deployment of similar aircraft for more than two decades; from Beijing's perspective American capabilities must be matched if China is to maintain a credible air force. Yet, behind military need, other forces seem to be at work too: according to one observer, stealth fighters reveal China's ambitions to become more than just a regional power armed with "Soviet hand-me-down" weapons.[2] Still, questions linger: Are these aircraft technology demonstrators or prototypes intended for eventual production? Are they mainly political symbols, and if so, will they ever enter service? How indigenous are they? Will China rely solely on Russian engines to power these aircraft, or are viable domestic alternatives in the offing? What about advanced radars, avionics, and weapons systems?[3]

History can help answer some of these questions. While historical cases never exactly parallel current realities, there are certain boundaries imposed by physics and technology that offer pointers in evaluating China's stealth capabilities. For

instance, we know that few countries have successfully developed and produced their own jet fighters with indigenous resources and technology. Indeed, other than the United States, Russia, France, the United Kingdom, and a few others, many indigenous fighter programs failed, compelling their sponsors to obtain combat fighters from abroad.[4]

This essay explores why some states engage in costly aviation projects and analyzes the reasons behind numerous aviation failures. In doing so we examine the failed jet fighter programs of Argentina, Egypt, and India.[5] These countries were selected in part because they are regional powers, albeit in different parts of the globe. During the Cold War, these nations were led by ambitious leaders who shared the notion of "non-alignment" between the superpowers and a belief that aviation was a potent symbol of technical prowess, strength, and political legitimacy.[6] All three were at similar levels of aviation development when they embarked on their jet fighter projects, and each relied on German design teams led by Kurt Tank or Willy Messerschmitt. In the end, all three failed. This paper attempts to explain why they failed and then applies those lessons to the more recent Chinese case.

Argentina's Pulqui-II

Argentina's Pulqui-II was inspired by the expansive vision of Juan Domingo Perón, who first governed the country from 1946 to 1955. Essentially a political totem, the Pulqui-II's fortunes were closely tied to those of its promoter. When Perón was ousted in a 1955 coup, the dreams of an Argentine jet fighter were over.

Context

At the end of World War II, Argentina was a rising power with strong regional leadership aspirations. Few were able to express those ambitions in a more charismatic manner than Juan Perón, an army officer who was elected president in 1946. In Perón's view, Argentina deserved to be one of the world's great powers because of its natural resources, young population, national will, and his dynamic leadership.[7] Perón was equally convinced that only a neutral Argentina could avoid the catastrophic nuclear war between the superpowers that he believed was imminent.[8]

Motivations

Economic autarky was essential to Perón's "Third Way": Argentina must nationalize infrastructure, pursue import substitution, and promote state industry to augment her status as an independent actor in world affairs. Above all, Argentina

eventually had to be self-sufficient in supplying her military needs, and that meant weaning her armed forces off their traditional British and American suppliers.[9]

From 1938–1940, Perón had served as a military attaché in Mussolini's Italy, where he developed a lifelong interest in fascism.[10] Like Il Duce, Perón viewed indigenous aviation as a propaganda symbol that extolled national progress, pride and strength: "It was only recently that we considered aviation as the means of transport of the future. To-day that dream has materialized. Aeroplanes are no longer a future promise but the miracle of the present. . . . In the war waged against time and distance, aviation represents a victory."[11]

Argentine officers were impressed by aviation-related technologies unleashed during World War II such as atomic bombs, long-range bombers, radar, jet fighters, and rockets. Aviation represented the cutting edge of the scientific frontier, and Perón made the development of a national aeronautical industry a top priority in Argentina's first five-year plan.[12] Indeed, for Perón, aviation *symbolized* the import substitution approach; it would spur industrial development and provide political legitimacy to the government.[13]

Aviation offered potent images of progress, technological advancement, and national strength, but above all, it conferred legitimacy to regime policies.[14] In 1948, the government issued a lavishly illustrated study of Argentina's aviation potential, which established bold objectives in grandiose terms: "[N]ational aviation is created on the basis of courage and fortitude, a nest of condors where civilians and military officers alike, united by the same ideals, are forging the nascent 'aeronautical conscience' . . . imbued with progress and well-being while leaving the past behind."[15]

Jets also symbolized speed. According to one account the genesis for the Pulqui-II lay in the regime's desire to break a world speed record recently set by a British Gloster Meteor.[16] If there was a military requirement for the Pulqui-II, it lay in the fact that the Argentine Air Force (Fuerza Aérea Argentina or FAA) wanted to replace its own British-origin Meteors.[17]

Program History

Argentina enjoyed advantages in finance and technology when she embarked on the Pulqui-II. During the war, the country was a major creditor to the United Kingdom and built substantial sterling reserves based on exports of wheat, beef, and other goods.[18] Indeed, as part of Britain's postwar debt payments, London delivered Rolls Royce Derwent 5 and Nene II engines to Buenos Aires.[19] Argentina also possessed a small aeronautical institute in Córdoba dedicated to the licensed production of foreign aircraft designs, although it also developed a jet prototype called the Pulqui-I.[20] Underpowered and hampered by design defects,

the Pulqui-I nonetheless sustained Argentina's claim to be the eighth country to design and fly its own jet aircraft.[21]

The Pulqui-I's failures motivated the Argentines to recruit Kurt Tank, a German aviation expert who had designed the Luftwaffe's FW-190 fighter and long-range FW-200 Condor reconnaissance airplane during World War II. Tank was an ideal candidate: his expertise in aviation design, testing, and production management were crucial to the Pulqui-II's success.[22]

Shortly after Tank's arrival in Argentina, he met Perón, and throughout the remainder of his stay in Argentina, Tank enjoyed direct access to the president. Not only did this show Perón's personal interest in the Pulqui-II, it also helped Tank overcome the bureaucratic obstacles thrown in front of him.[23] After signing his contract, Tank recruited some 60 German aviation experts who helped him refine his incomplete paper design for a jet fighter called the Ta-183.[24] With a swept wing and all-metal construction, the Ta-183 evolved into the Pulqui-II, a revolutionary plane for its time and a rough equivalent to the Soviet MiG-15 and the American F-86 Sabre.[25]

Five prototypes were built between 1950 and 1959. The first was a glider to test aerodynamic properties, while the second flew for the first time on 16 June 1950, powered by a Rolls Royce Nene II engine. This second prototype crashed the following year, along with the third and fourth in 1952 and 1954 respectively. The fifth first flew on 18 September 1959 and was later transferred to the National Aviation Museum in Morón.[26]

Reasons for Failure

Why did the Pulqui-II never enter production even though most of its developmental problems were eventually resolved? One answer lies in the aircraft's poorly defined mission requirements. As noted earlier, this program was built mainly as a status symbol, and by 1951, it had become a propaganda tool in Juan Perón's reelection campaign and a symbol of his "new Argentina."[27] On 8 February 1951, Perón hosted an air show in Buenos Aires in which Kurt Tank put the Pulqui-II through its paces in front of the president, senior officials, and a large crowd of onlookers.[28] For Perón and his supporters, this was heady stuff: "It was truly a day of joy with the public converging in large numbers from all parts of the city. Expectations were very high for this proud model of aeronautical engineering which had influenced national public opinion and extended beyond our borders."[29]

Yet the Pulqui-IIs' future remained in doubt, and Argentina sponsored another jet fighter program that competed with it for scarce funding and technical resources. Reimar Horten, a German aviation designer, led a much smaller team in researching a supersonic, delta-winged fighter. While Tank occasionally assisted

Horten's projects, the two otherwise did not work together.[30] The existence of two competing and underresourced jet programs suggested a lack of coordination and poor management by the government.

Cultural and professional differences presented additional difficulties for the Pulqui-II team. When Tank started work on his project, the bulk of the Argentine engineers who had worked on the Pulqui-I were transferred out.[31] For those native experts who remained, there were frequent clashes with the Germans over design flaws and engineering deficiencies. The Germans were perceived by some as "closed," "arrogant," and generally reluctant to share their knowledge with their employers.[32] For their part some of the German experts also recorded differences with the Argentines: "Their temperament was of course different from [Tank's] own. There was a mercurial quality in their thinking which contrasted oddly with his own more thorough methods."[33]

Air force skepticism was another hurdle. The FAA was mulling a replacement for its obsolete Meteors, but it preferred the American F-86 over a risky, domestic alternative.[34] This suspicion was compounded by a 1951 accident with a Pulqui-II prototype that resulted in the death of an air force test pilot.[35]

Then there was the issue of cost. From the outset, the government was determined to produce as many Pulqui-II components domestically as possible. This insistence on relative autarky—the Rolls Royce engine was a major exception—meant that development costs were very high, even when research costs were excluded.[36]

Cost was not the only consequence of "national content." The Pulqui-II was also plagued by delays imposed by shoddy parts and inexperienced technicians, which deterred prospective customers like Egypt and the Netherlands from making firm commitments to buy.[37] Even when North American Aviation, the builder of the rival F-86, expressed interest in purchasing the Pulqui-II design, the Perón government refused to sell for "nationalist" reasons.[38] Thus, the costs of aircraft development were borne by Argentina alone.

Whether that country could fund the Pulqui-II on its own became increasingly doubtful as the program limped on. Unlike the early postwar years when Argentina was flush with foreign currency, the picture had changed dramatically by the early 1950s due to global economic forces and government policies. There was a decline in demand for Argentina's exports, and declining exports meant shrinking foreign currency earnings, even as the government spent heavily on social welfare and nationalization.[39] In the end, the Pulqui-II could not ride out the economic shocks that crippled the country and helped trigger the 1955 coup against Perón.

The vicissitudes of Argentine politics were the final blow. First was an ill-advised attempt to merge the Pulqui-II with the national automobile industry,

which diluted an already small pool of scientists, engineers, and technicians.[40] But the death knell came with the September 1955 anti-Perón coup that removed the Pulqui-II's most fervent backer and promoted some of the project's greatest skeptics. Even Tank was briefly arrested for possessing a false passport (given to him by Argentine intelligence when he first traveled to Argentina in 1949), and this only hastened the disintegration of the Pulqui-II team.[41] Shortly afterward, Tank departed for West Germany and then India. In December 1956, the FAA announced that it had selected the F-86 over the Pulqui-II.[42] The dream of an Argentine jet fighter was dead.

Long-term Consequences

Argentina went from the vanguard of combat aviation in the early 1950s to purchasing all its jet fighters from abroad by the end of the decade.[43] Although the Córdoba plant went on to design and produce a small number of turboprop combat aircraft like the Pucará, Argentina never exported a single plane.[44] There is nostalgia for the Pulqui-II among those Argentines who remember a brief period in their country's turbulent history when things seemed to be going right. In 2007, for example, a movie was released in Argentina with the telling title, *Pulqui: An Instant in a Country's Happiness*. As one reviewer put it, the film was about "lost dreams," an attempt "to resurrect an artifact that represented the once powerful rise of Argentina as an industrial player on the post-World War II landscape."[45]

Egypt's HA-300

While Argentina's hopes of producing indigenous fighters were fading by the mid-1950s, Egypt was laying the foundations for its own fighter called the HA-300. Just like Perón before him, Gamal Abd al-Nasser used the HA-300 as a propaganda tool for regime legitimacy.

Context

In July 1952, army officers ousted the monarchy and set Egypt on an ambitious course of land reform, industrialization, and rearmament. Their leader was Gamal Abd al-Nasser, a charismatic army colonel who intended to make Egypt the leading power in a newly independent Middle East and North Africa.[46] Nasser believed that Egypt must avoid entanglement in superpower struggles, and he became an early adherent to the Non-Aligned Movement (NAM) forged by India's Jawaharlal Nehru and Yugoslavia's Josip Broz Tito.[47] Yet, the NAM alone would not give Nasser the autonomy he craved. Just as Perón pursued economic autarky,

so too did Nasser eventually nationalize industry, create import substitutes, and expropriate property owners.[48]

Motivations

Self-sufficiency helped drive Egypt's jet fighter project. During the 1948–49 Arab–Israeli War and the 1956 Suez conflict, British and American arms embargoes hampered Egyptian military operations. As a result, Egypt sought long-term self-sufficiency in weapons production, but for the short term, she diversified her arms suppliers to include the Soviet Union.[49]

The symbolic importance of aviation for Nasser's regime cannot be underestimated.[50] Much as the Soviets did with their annual May Day and October Revolution parades, the Egyptians used the anniversary of the 23 July 1952 coup to showcase military hardware. For instance, in 1960, four "Egyptian-made" (they were actually Spanish) HA-200 jet trainers flew above Cairo; three years later, the HA-300 jet fighter was rolled out for public viewing.[51] Finally, just as Argentina had proudly announced that it was only the eighth country to build an indigenous jet fighter, so too did Egypt declare that it was the sixth country to design and build a *supersonic* jet when the HA-300 conducted its maiden flight in 1964.[52]

The military rationale for the HA-300 was rather vague. In 1960 discussions with American diplomats, Nasser made the case that Egypt was losing the arms race with Israel in part because the latter was acquiring supersonic aircraft from France. Nasser admitted he was seeking the Soviet MiG-19 to correct this imbalance; however, this confession undercut a military argument for investing scarce resources in a costly supersonic domestic fighter when cheaper, more reliable imports were available.[53] While a domestic fighter might have eventually saved money that would otherwise have been spent on imports, it certainly did not mean that the overall cost per plane would be lower—rather the contrary. Egypt may have been counting on export sales to other Arab states to keep unit costs down. For example, Algerian president Ahmed Ben Bella considered purchasing the HA-300 but opted for Soviet aircraft instead.[54]

Program History

Egypt embarked on its indigenous fighter quest with a basic aircraft design and license production capability. Built in 1950, Helwan's Aircraft Factory 36 was originally intended to produce the British de Havilland Vampire; however, that project foundered due to fraying UK–Egypt relations in the 1950s.[55] In 1959, the factory was retooled for production of Spain's HA-200 Saeta jet trainer.[56] Next

door to Factory 36 was a separate plant dedicated to designing and producing jet engines based on the reverse engineering of several French models.[57]

This infrastructure was meager when measured against the daunting requirements of designing and eventually producing a viable supersonic fighter. For starters, Egypt lacked experts, tools, materials, and wind tunnels. To correct some of these shortcomings, the Egyptians recruited Willy Messerschmitt, who had designed the first operational jet fighter, the Luftwaffe's Me-262.[58] Messerschmitt had been in Spain working on a delta-winged fighter capable of Mach 2, but Madrid cancelled the project in 1960 because of spiraling costs and cheaper American alternatives. Cairo, which had just purchased the rights to produce the HA-200, now acquired the plans and tooling for the HA-300 as well.[59]

Originally, the HA-300 was built around the British Orpheus 703 engine, but British production ceased before the HA-300 prototypes were completed, and Egypt had only a few on hand.[60] In any case, the Egyptians had decided to produce their own jet engines, even though this was an ambitious undertaking itself. However, Cairo was not deterred by the formidable challenges involved in designing and producing jet engines. To this day, few countries have consistently and successfully developed their own jet engines, and Egypt is not one of them. Even so, the Egyptians recruited some outstanding foreign talent, such as the Austrian Ferdinand Brandner, who had developed engines for Nazi Germany and the Soviets.[61] Once Brandner's contract was inked, he recruited some 250 German and Austrian engineers, technicians, and scientists to work alongside the Egyptians at Helwan. In June 1963, this team conducted its first static engine test of the new E-300 power plant—the engine intended for the HA-300.[62]

Engine development costs posed a major challenge, but fortune intervened when Brandner learned of Indian interest in the E-300.[63] As will be seen Kurt Tank was helping India design a supersonic fighter called the HF-24 Marut, which lacked an adequate engine. In March 1963, Brandner led a delegation to India, where he met Tank and negotiated a deal under which India would share E-300 costs, donate a modified HF-24 capable of carrying the E-300, train Egyptians as test pilots, and contribute a senior Indian test pilot to assist in HA-300 development.[64]

Egypt and India trumpeted the symbolic value of their new association. After all, these were two NAM giants working together on a shared dream of producing combat jets outside the superpower monopoly. As the Indian test pilot Kapil Bhargava commented later, "The Indian press was still full of euphoria generated by this. On seeing a hint of collaboration between India and Egypt, they wrote learned editorials about the emergence of a third military bloc, of the non-aligned and its impact on the global balance of military power."[65]

The HA-300 first flew on 7 March 1964, and a total of 135 test flights were completed before the program was halted in May 1969.[66]

Reasons for Failure

Nasser's political fortunes peaked between 1957 and 1961, and this period coincided with Egypt's pursuit of indigenous jet fighters and ballistic missiles. Nasser thrived on "power symbols" during these years, and the most prominent of these was the High Dam being built at Aswan. However, the dam was not alone, for every anniversary of the 23 July 1952 coup featured a new weapon such as the HA-200 jet trainer (1960) and the two-stage Al-Ra'id ballistic missile (1963).[67]

On 23 July 1963, the Egyptians unveiled yet another "triumph" to highlight their progress in national defense, when Indian test pilot Kapil Bhargava taxied the HA-300 in front of Nasser, Anwar al-Sadat, and others. According to Bhargava's later account, when the Egyptian president asked him for his opinion of the plane, Bhargava replied that the plane was an "interesting research project," but it would never enter production. In response, Nasser "just smiled. I concluded that, despite any difficulties that might hinder the project, he had his reasons for persisting with it and that too under the control of foreigners. He obviously believed that a successful flight test would be sufficient to strengthen his hand in international negotiations."[68]

None of Nasser's indigenous weapons ever achieved military success. The ballistic missile program was a costly failure, while the HA-300 limped along until the 1967 Arab–Israeli War put an end to it. Yet, as Bhargava observed, Naser did not view the HA-300 as a military priority but rather as a useful (if costly) symbol that buttressed his regime's claims to legitimacy.

We have already seen how German aviation experts encountered cultural differences with their Argentine colleagues, and the same was true in Egypt, where Messerschmitt's reputation for being an opinionated perfectionist grated on Egyptian and Indian sensitivities as well.[69] Matters only got worse when Messerschmitt fired some of his staff, and the Egyptians failed to pay salaries on time.[70]

The promising Egyptian–Indian partnership was also marred by discord. At least some Indian officials erroneously believed that Egypt would eventually buy the HF-24 Marut along with the E-300 power plant. However, the Egyptians had no intention of doing so, and their problems with the Indians were aggravated by technical difficulties that plagued and ultimately killed the E-300 project.[71]

Moreover, while Cairo made much of its "Egyptian-made" fighter, the fact remained that it was designed by a German, tested in European wind tunnels, employed foreign parts, and relied on a British engine.[72] Unlike the Argentines, who

made a spirited bid to ensure that the Pulqui-II used domestically produced components, the same could not be said for the Egyptian's efforts with the HA-300.

Cost was always a major issue for the Egyptians, who were committing scarce foreign currency reserves and technical talent to several projects like the High Dam, steel factories, and ballistic missiles. According to one estimate the HA-300 program cost over 100 million Egyptian pounds—or the equivalent of Egypt's total investment in its civilian industry throughout the 1960s.[73]

The June 1967 war, which began with a preemptive Israeli air raid that destroyed much of the Egyptian Air Force on the ground, doomed the HA-300. In the aftermath of that humiliation, Nasser needed a new air force and fast. He could not afford to pour more money into a white elephant jet fighter that was already obsolete. Only the Soviets could address the immediate needs of the devastated Egyptian Air Force, and the result was cancellation of the HA-300 in return for procuring the superior MiG-21 at favorable prices.[74]

Long-term Consequences

Egypt never designed and produced jet fighters. According to one source, the Helwan aviation plants were forced to lay off 5,000 workers, hundreds of skilled experts fled to aviation programs in North America, and Helwan resorted to producing parts for Egypt's Soviet-built fighters.[75] As for the HA-300, all that remains is a static display at a German aviation museum.

India's HF-24 Marut

Argentina's decision to cancel the Pulqui-II was India's gain, for in late 1955 Kurt Tank moved to Bangalore to help the Indians develop a supersonic fighter called the HF-24 Marut. While there are numerous similarities between the Indian, Argentine, and Egyptian fighter projects, one important distinction separates India from the others: the HF-24 entered production even though it never met its design objectives.

Context

Modern India was born out of a protracted struggle for independence from the United Kingdom followed by a bloody partition that created a hostile neighbor: Pakistan. The country's founding fathers were not only committed to independence through passive resistance, they also espoused an economic philosophy of self-sufficiency known as *swadeshi*.

As India's first prime minister, Jawaharlal Nehru sought to make his country a vibrant democracy that could overcome its sectarian, ethnic, and linguistic divides

and thereby become a great power in its own right.[76] After all, India possessed a considerable land area, large population, legacies of achievement in math and science, and a substantial natural resource base.[77] Indian leaders emphasized the value of science and technology in developing India's full potential, and Nehru framed this perspective in a 1958 speech: "Science has developed at an ever-increasing pace since the beginning of the century, so that the gap between the advanced and backward countries has widened more and more. It is only by adopting the most vigorous measures and by putting forward our utmost effort into the development of science that we can bridge the gap."[78]

Motivations

Nehru and his confidant, Defense Minister V.K. Krishna Menon, were convinced that India must be self-reliant in weapons research and production. Indeed, shortly after Indian independence Nehru sought advice on defense matters from a British physicist who recommended India develop its own aviation industry.[79] When Nehru joined Tito, Nasser, Indonesia's Sukarno, and others at Bandung, Indonesia, in 1955 to form the nucleus of the NAM, he was trying to position India as leader of a "third bloc" of nations that would stay neutral in the Cold War.[80] In this context, a domestic arms industry in general and an indigenous jet fighter in particular were the *sine qua non* of Indian prestige. In fact, Nehru and Menon ordered this fighter more with an eye to self-sufficiency and national pride than meeting military requirements.[81]

Nehru and Menon also concluded that the HF-24 could spur India's industrialization by stimulating research and development in other sectors of the economy. Knowledge gained in Bangalore could be shared with other technology-intensive industries and thereby facilitate India's modernization.[82]

India did have a military requirement for a supersonic fighter in the late 1950s. To New Delhi's consternation, the United States sold Pakistan F-86s and F-104/Starfighters, which upset the regional balance of power—at least from India's perspective.[83] Rather than approach the United Kingdom, France, or Soviet Union for additional jet fighters, Nehru and Menon opted for a domestic program aimed at producing an indigenous, multirole jet fighter capable of high-altitude interception and strike missions. The specifications called for a maximum speed of Mach 2, combat radius of 500 miles, and an airframe that could be modified for all-weather, aircraft carrier, and advanced trainer missions.[84]

Program History

India had a small aviation infrastructure that maintained, repaired, and overhauled Allied warplanes during World War II. After the war, this facility near Bangalore was renamed Hindustan Aviation Limited (HAL) and produced the de Havilland Chipmunk, the Vampire, and the Folland Gnat.[85] What HAL lacked, however, were aviation designers, testing infrastructure, and experienced production engineers.[86] In the words of one expert, the research-and-development shop was "woefully inadequate."[87] Not only was there no hangar space for building prototypes, India also lacked tools, test stands, and runways for flight testing.[88] In other words, India faced many of the same technical challenges that plagued Argentina and Egypt when they embarked on their respective jet projects.

The Indian government sought German experts to help bridge the gap between ambition and reality. As early as 1948, Willy Messerschmitt was approached for advice on establishing a national aviation industry.[89] Since Messerschmitt was content at that time with his work in Spain, the Indians searched for another aviation designer of equal stature, and eventually found Kurt Tank, who had departed Argentina after the September 1955 coup. In August 1956, Tank visited HAL, accepted the Indian job offer, and began recruiting assistants.[90]

Eventually Tank hired 18 German designers to work on the HF-24, a much smaller number than the 60 or so employed in Córdoba. In fact, Tank agreed to a division of labor, whereby his European team was employed strictly for design, while the Indians focused on prototype construction and eventual production.[91] Concurrent with Tank's hiring was a major expansion of HAL's domestic labor force to handle the new requirement.[92]

Work on the Marut began in June 1957, and four years later, the first jet-propelled prototype commenced flight testing.[93] At the end of 1962, orders were placed for Maruts, although the plane still lacked viable engines after the British firm backed out of the project.[94] As a consequence, HAL had to switch to the less powerful Orpheus-703, which could not meet the Marut's performance requirements.[95]

The engine impediment refused to go away. First, the Indians failed to convince the Orpheus-703 builder to add an afterburner.[96] Then the Soviets were approached with a proposal to modify an existing engine for use on the HF-24, but this was rejected for technical reasons.[97] Then the Indians cooperated with Egypt on the Brandner E-300, an engine whose projected capabilities were adequate for the Marut; however, trials in Egypt proved that even this engine could not power the plane past Mach 1.1. On 1 July 1969, the Indian team was recalled from Egypt and cooperation ceased.[98] Failure to obtain a suitable engine meant that the Marut was never able to meet its designed speed. Still, 145 Maruts were eventu-

ally produced, of which 130 entered service with the Indian Air Force (IAF). The last HF-24s were retired in 1990.[99]

Reasons for Failure

Unlike the other cases, the HF-24 raises the question of what constitutes failure. After all, this aircraft entered production and served in the IAF for more than two decades. Moreover, as one observer put it, the Marut could hardly be called a failure when "its accident rate was unbelievable—just one accident and no aircraft lost in combat."[100] Others were less charitable, with one judging the Marut to be a "long drawn-out failure."[101] So how do we explain these discrepancies? If the measuring stick is production for its own sake, then the Marut was a success when compared with the Pulqui-II and the HA-300. On the other hand, if performance criteria laid down by the Indian Air Staff are selected, such as speed or aircraft carrier operability, then the Marut was a failure.

Although the original Air Staff specifications were intended to fill a military need, it was equally apparent that political forces were driving a project that exceeded Indian capabilities. One observer later noted, "As the project proceeded it passed from the hands of politicians to the military and finally to industry. Or, to put it another way, the politicians defined the possibilities, the military defined the problem and industry was left to define the answer."[102]

Poor management hindered the Marut as well. When the aircraft failed to reach its performance objectives, the IAF ordered design changes, even as production was underway. This inevitably caused delays and increased costs. The engine fiasco in particular highlighted an ad hoc approach to a problem that was never resolved.[103]

From a cost-benefit analysis, the HF-24 was an embarrassment. Not only did the IAF receive an aircraft incapable of performing several intended missions, it did so at a cost greater than superior aircraft offered by the Soviets.[104] Furthermore, excessive production costs, frequent delays, and disappointing performance meant that India could not attract foreign buyers.[105]

For an aircraft touted as "Indian-made," the Marut was surprisingly cosmopolitan when it came to its designers, parts, and tools.[106] One expert put it this way: "India remained dependent upon external design sources for all vital systems and materials. Lacking a significant commercial-industrial base, it also remained dependent on foreign sources for high-grade steel and aluminum for aircraft production."[107]

Still, India had to start somewhere, and the costs and delays plaguing the HF-24—even its relatively poor performance—were not unusual for a first effort. Unfortunately, there are few indications that India used the lessons learned from the Marut to build better aircraft in the future. This point is discussed further below.

Not surprisingly, the IAF had its doubts about the HF-24. The Air Staff preferred foreign aircraft and, if given the choice, would have selected imports like the MiG-21 or Mirage III instead.[108] However, the IAF did not have options in a matter already decided by the politicians and was forced to settle for an aircraft incapable of fulfilling many of its design requirements.[109]

As with any new aircraft, the HF-24 had its share of design faults, many of which were not adequately addressed as the aircraft was rushed into production. For instance, the Marut suffered from excessive aerodynamic tail drag, and it was incapable of firing all four of its 30-mm cannons at once.[110] Finally, constant redesign, plus an over-burdened production shop, resulted in chronic parts shortages early in the HF-24's career; many became "hangar queens" awaiting delivery of parts.[111]

Meanwhile, the Soviets were marketing the superior MiG-21 fighter at an attractive price. This was an offer that could not be refused, and in August 1962—only one year after the first Marut test flight—India signed a MiG-21 contract with favorable financing and licensed production of this aircraft at home.[112]

Long-term Consequences

India never achieved Nehru's dream of self-sufficiency in combat aviation, despite the vast sums poured into the HF-24. During the 1971 war with Pakistan, 40 percent of India's air order of battle was of Soviet origin. Twenty years later, the picture had not improved: 75 percent of India's interceptors and 60 percent of its strike aircraft were of Soviet origin.[113] Moreover, license production of the MiG-21 was not equivalent to designing and producing domestic combat jets. Unlike Argentina and Egypt, however, India never lost the desire to develop her own fighters. In the early 1980s, the IAF issued a requirement for a light combat aircraft that would be designed and produced domestically. Nearly three decades later, and after numerous delays and cost overruns, those requirements crystalized in HAL's Tejas fighter—an aircraft that may be obsolete before it has been built.[114] Others point to the Tejas's American engine and question the aircraft's claim to indigenous origins.[115] Still, a country embarking on the road to self-sufficiency in combat jets has to start somewhere. While the HF-24 Marut was essentially stillborn, perhaps the Tejas will be the start of a promising future for India's military aviation industry.

Conclusions

At the beginning of this article we proposed to examine indigenous jet fighter development through two key questions: (1) what motivates some states to pursue domestic fighter jets? (2) Why do many of these projects fail? The scope was nar-

rowed to Argentina, Egypt, and India, each of whom pursued indigenous fighters for similar motives and with disappointing results.

Motivations

In each case, ambitious political leaders shared the goal of non-alignment and decreased reliance on the superpowers for weapons. They viewed aviation as a symbol of status, prestige, and power or, as one historian puts it, "nation-building experiments."[116]

Why aviation? During the Cold War, aircraft, missiles, and satellites represented the cutting edge of science, and as such, they were not only status symbols but also measuring sticks used in comparisons with rivals. The Soviet Union's launch of Sputnik in 1957 represented a highly visible advance in the superpower competition that triggered a national drive for science education in the United States. Yet, the superpowers were by no means unique in exploiting the symbolic value of aerospace. In his study of aviation in Mussolini's Italy, Federico Caprotti encapsulates the airplane's attraction for regimes searching for legitimacy: "Almost every visible part of the aeroplane was fetishized, in some form or other, by the time the fascist regime took power in Italy. Aeroplanes, wings, engines and flight were used as metaphors both in the political and economic sphere."[117]

This study shows how Perón, Nasser, and Nehru used aviation to enhance regime legitimacy. From the beginning, Argentina's Pulqui-II was very much a political device, whose impetus was breaking a speed record and building popular support for Perón's policies. The public exhibition of the Pulqui-II was very much in line with traditions established by other countries like Mussolini's Italy. According to Caprotti, "One of the characteristics of propaganda flights which should be highlighted is that the aeroplane, technology and the *ebbrezza* (thrill) of flight were to be as central as mass participation by crowds of onlookers in the spectacle of aviation and, by corollary, in the spectacle of fascism."[118]

A similar example is found in Egypt, where Nasser used "Egyptian-made" missiles and jets to celebrate important anniversaries, highlight scientific achievement, and build support for government policies.[119] Indeed, other countries like the USSR appreciated the utility of aviation to celebrate national holidays. As Soviet aviation expert, K.E. Bailes writes, "The twentieth anniversary of the October Revolution in 1937 gave special emphasis to air records as symbolic of the regime's attainments in numerous scientific and technical fields; massive flights of aircraft became traditional on this holiday."[120] In the end, whether it was Argentina, Egypt, Italy, or the Soviet Union, aviation often helped confer legitimacy by demonstrating that a regime was "progressive" and "modern."

So, what about military imperatives? The degree to which national politics overrode military necessity varied from case to case, yet even in the Indian example, politicians insisted on a domestic aircraft when their air force chiefs preferred superior foreign alternatives. At bottom, the mixture of political versus military inputs in these cases offers clues to the failure of each of the indigenous jet projects.

Reasons for Failure

In each case, infrastructure available at the start of the aviation project was roughly the same. None of the countries in question had any experience in fighter jet design, nor did they have a deep bench of native experts. So, they turned to the Germans, Kurt Tank and Willy Messerschmitt, to lead their design teams. All invested heavily in infrastructure to lay the foundation for their jet fighter efforts. This yields another reason for program failure: cost.

For developing countries like Argentina, Egypt, and India, indigenous fighters were a questionable expense when measured against competing civilian priorities such as a national automobile industry or public works. As noted, jets demand large, often prohibitive, outlays in capital for infrastructure, material, tools, and trained labor; it was these expenses that ultimately drove Argentina and Egypt to cancel their programs before production began. As for India, the HF-24 did enter production but was hampered by another hurdle: engines.

Argentina and India chose foreign designs to power their aircraft, raising the question of what constitutes true self-sufficiency.[121] As for Egypt, a bold attempt was made to develop an indigenous jet engine; yet, this project used foreign suppliers for virtually all its parts, tools, and materials. In the end, Egypt's E-300 jet engine was a failure.

Jet engines are a major challenge for any country seeking to develop and produce jet fighters. In most cases, foreign engines are selected, even if this comes at the expense of national self-sufficiency. Indeed, the jet engine is the "long pole in the tent" of any country seeking true self-sufficiency in indigenous combat jet design. Michael Neufeld puts a finer point on this: "Jet engines were the Achilles heel of advanced aircraft projects outside the leading powers, as they were complex, expensive and difficult to develop, and much easier to subject to export controls than airframe design expertise."[122]

Engines aside, there are other roadblocks in combat jet development, such as sensors and weapons. As the fighter jet evolved from the relatively primitive designs of the early 1950s, a veritable revolution in capabilities was taking place. It was no longer a matter of fusing together airframes, swept wings, and jet engines but now involved the integration of radars, electronic countermeasures equipment, avionics, and missiles. In light of such developments, it is doubtful whether

Argentina, Egypt, and India could ever have kept pace with more technologically advanced powers.

Indeed, obsolescence haunted each of the cases studied here. Even as Argentina, Egypt, and India struggled with their pioneering efforts, delays were inevitable, and the result was fighters that were increasingly outdated before production. This was the inevitable cost of the "learning curve," but none of the governments seemed to accept it as the necessary price of a long-term, indigenous combat jet capability. India is especially noteworthy in this regard by neglecting to build on her Marut learning curve to develop new generations of aircraft. Instead, several decades were to pass before India once again entered the domestic jet fighter business with the Tejas light combat aircraft.

In at least two of the three cases, the domestic fighter failed to overcome the skepticism of its air force customer. Neither the Argentine nor the Indian air staffs were enthusiastic about the prospect of operating home-grown fighter jets, preferring cheaper, superior foreign aircraft such as the MiG-21. In all three cases, the services ultimately imported fighters to address most—if not all—of their military requirements.

As noted above, politics and symbolism were powerful considerations in each of the case studies. In the Argentina and Egypt examples, politics motivated the Pulqui-II and HA-300 projects respectively, but politics offered an easy rationale to kill them too. After the 1955 coup removed Perón from power, it was relatively easy for the new junta to pull the plug on his Pulqui-II. For Egypt, the disastrous 1967 war with Israel provided cover to terminate the HA-300, which had outlived its usefulness as a political totem anyway.

Chinese Stealth Fighters

So, let's return to the Chinese J-20 and J-31 "stealth" fighters that introduced this discussion. To the extent that history can serve as a guide, we may now examine these fighters more closely.

First: Appearance is not always reality when it comes to indigenous fighter jets. As the historical cases demonstrate, regimes often pursue combat aviation more for political symbolism than military need. In a characteristically subtle manner, China is using its stealth prototypes to demonstrate its growing power and authority on the world stage. Still, opportune "glimpses" of prototypes from a distance should not lead observers to make initial, alarmist conclusions, since much about these aircraft is still wrapped in mystery.

Second: China's development of jet fighters has been uneven. It has made tremendous strides in indigenous aviation design in recent years; yet, to date, its frontline operational fighters still rely exclusively on Russian-built jet engines.[123]

Both stealth prototypes so far appear to be using Russian engines; yet, by relying on Russia for its engine needs, China is still not demonstrably self-sufficient in one of the most important technologies in fighter aviation. This lack will affect aircraft performance and export potential.[124] What about low observability, avionics, weapons systems, electronic countermeasures, and radar? More than ever it is the integration of these latter technologies and capabilities that determine the true worth of a modern fighter.[125] As a leading US aviation journal cautions, "[I]t's one thing to develop a prototype or technology demonstrator and test the aircraft. It is an entirely different matter to take such a design and perfect it into a multi-mission stealthy aircraft that can be manufactured and is as advanced as, say, the F-22 or F-35."[126]

Third: Obsolescence is another consideration. As the cases show, aviation technology is extremely time sensitive, and what seems advanced today will, inexorably, be obsolete several years from now (if not sooner). So how advanced will the J-20 or J-31 be when and if they enter production eight to ten years from now as some anticipate? Recall that these aircraft will be employing technologies that were, in some cases, pioneered by the United States more than two decades ago. Finally, advances in aviation technology, especially sensors and combat drones, could render some of these Chinese stealth capabilities obsolete.

More than 70 years after the first jet fighter took to the skies over Germany, only a small handful of countries are capable of designing, testing, and producing each of the core technologies necessary for an advanced fighter to enter service.[127] The membership of this unique club is unlikely to expand by much in the near term for reasons of cost and technological complexity. If anything, the gap between haves and have-nots in the world of combat aviation is expanding rather than shrinking, as fighter jets evolve into a "system of systems," an integrated, software-intensive package of sensors, weapons, engines, electronic countermeasures, and avionics. Unlike the historical examples cited above, China is likely to one day join this elite given its ample financial, technical, and personnel resources; however, numerous obstacles loom on the horizon before we see China's first operational stealth fighter take flight. ✪

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Notes

1. Paul Koring, "China Trumpets Stealth Warplane as New Status Symbol," *Globe and Mail*, 6 January 2011, https://www.theglobeandmail.com/; and David Axe, "Questions Abound as China Unveils another Stealth Jet," 16 September 2012, http://www.wired.com/.

2. Koring, "China Trumpets Stealth Warplane."

3. David A. Fulghum, Bill Sweetman, Bradley Perrett, and Robert Wall, "Expanded Reach: China's Power Projection and Space Activities are Steadily Increasing," *Aviation Week and Space Technology* 173, no. 31 (2011), 29; and Bill Sweetman, "Out of the Mist," *Aviation Week and Space Technology* 173, no. 31 (2011), 18.

4. In addition to the examples discussed in this paper, other failed indigenous jet fighter programs include Canada's CF-105 Arrow and Israel's Lavi.

5. Studying the cases of Argentina, Egypt, and India also helps fill information gaps identified by Michael Neufeld, "The Nazi Aerospace Exodus: Towards a Global, Transnational History," *History and Technology* 28, no. 1 (2012): 49–67.

6. For more on the rich symbolic value of fighter aircraft see, for example, Thomas F. Crowder-Taraborrelli, "Evita in Wonderland: Pulqui and the Workshop of Underdevelopment," *CineAction* 77, no. 3 (2009), 2; and Federico Caprotti, "Technology and Geographical Imaginations: Representing Aviation in 1930s Italy," *Journal of Cultural Geography* 25, no. 2 (2008): 181–205.

7. Robert Jackson Alexander, *The Peron Era* (New York: Columbia University Press, 1951) 171.

8. Ricardo Burzaco, "Perón y Los Científicos Alemanes," *Todo es Historia* 334 (1995): 11–27; Isidoro Gilbert, *El Oro de Moscú* (Buenos Aires: Editorial Sudamericana, 2007) 175; Jonathan D. Hagood, Hagood, "Why Does Technology Transfer Fail : Two Technology Transfer Projects from Peronist Argentina," *Comparative Technology Transfer and Society* 4, no.1 (2006), 77; and Alexander, *Peron Era*, 74.

9. Hagood, "Why Does Technology Transfer Fail," 75; Alejandro Artopoulos, *Technología e Innovación en Países Emergentes: Aventura del Pulqui II* (Buenos Aires: Lenguajeclaro Editora, 2012) 7; and Burzaco, "Perón y Los Científicos Alemanes." Burzaco notes that Argentina relied heavily on wood for its airframes during World War II since it was largely cut off from aluminum: Ricardo Burzaco, *Las Alas de Perón: La Aeronáutica Argentina 1945–1960* (Buenos Aires: Ediciones Eugenio B, 2007) 4–5,21.

10. Stanley G. Payne, *A History of Fascism 1914–1945* (Madison: University of Wisconsin Press, 1996) 347–49; and Federico Finchelstein, *Transatlantic Fascism: Ideology, Violence and the Sacred in Argentina and Italy 1919–1945* (Durham, NC: Duke University Press, 2010) 165–66.

11. Government of Argentina, *Peron Speaks* (Buenos Aires: Office of the Presidency, 1949) 61–62.

12. Artopoulos, *Technología e Innovación en Países Emergentes*, 14; Burzaco, "Perón y Los Científicos Alemanes"; and Burzaco, *Las Alas de Perón II*, 22.

13. Hagood, "Why Does Technology Transfer Fail," 80, 89.

14. Hagood, "Why Does Technology Transfer Fail," 93. The British Air Attaché to Argentina put it this way in 1949: "As a political weapon, however, it [Argentine Air Force], is powerful and the effect of persistent propaganda has earned for it the esteem of the masses." British Air Attaché, Buenos Aires, "Annual Report on Argentine Air Force: 1949," FO 371/81210.

15. República de Argentina, *La Aeronáutica Nacional al Servicio del País* (Buenos Aires: Secretaría de la Aeronáutica de la Nación, 1948). This "mission statement" for national aviation is filled with illustrations of winged Greek and Roman deities such as Icarus and Victoria as well as evocative symbols linking aviation with progress.

16. Artopoulos, *Technología e Innovación en Países Emergentes*, 13 .

17. Burzaco, "Perón y Los Científicos Alemanes." In 1949, Argentina had over 90 Meteors in its order of battle: British Air Attaché, "Annual Report," FO 371/81210.

18. Burzaco, "Perón y Los Científicos Alemanes.»

19. Artopoulos, *Technología e Innovación en Países Emergentes*, 13, 27. Under the terms of the Rolls Royce agreement, Argentina assembled Derwent 5 engines under license. *See* British Air Attaché, "Annual Report," FO 371/81210

20. Artopoulos, *Technología e Innovación en Países Emergentes*, 18.

21. Artopoulos, *Technología e Innovación en Países Emergentes*, 26; Heniz Conradis, *Design for Flight: The Kurt Tank Story*, translated by Kenneth Kettle (London: Macdonald, 1960) 181–82; Hagood, "Why Does Technology Transfer Fail," 74, 80. According to Artopoulos, the countries and dates of their indigenous jets are: (1) Germany - 1938; (2) United Kingdom - 1941; (3) United States - 1942; (4) Japan - 1945; (5) Soviet Union - 1946); (6) France - 1946; (7) Sweden – 1948; and (8) Argentina - 1949.

22. Conradis, *Design for Flight*, 14, 49, 182; Artopoulos, *Technología e Innovación en Países Emergentes*, 13, 25–26, 37; and Burzaco, *Alas de Perón*, 29.

23. Burzaco, "Perón y Los Científicos Alemanes"; and Conradis, *Design for Flight* 181–84.

24. Artopoulos, *Technología e Innovación en Países Emergentes*, 36–37; Conradis, *Design for Flight*, 185. Others suggest a lower number of 45. *See* Neufeld, "The Nazi Aerospace Exodus," 53.

25. Artopoulos, *Technología e Innovación en Países Emergentes*, 15, 34–35.

26. Artopoulos, *Technología e Innovación en Países Emergentes*, 15, 60.

27. Burzaco, "Perón y Los Científicos Alemanes."

28. Conradis, *Design for Flight*, 187; and Artopoulos, *Technología e Innovación en Países Emergentes*, 43.

29. Burzaco, "Perón y Los Científicos Alemanes"

30. Burzaco, "Perón y Los Científicos Alemanes"; Artopoulos, *Technología e Innovación en Países Emergentes*, 54–55; and Burzaco, Alas de *Perón*, 25. The official designation for Horten's fighter jet was IAe-37.

31. Artopoulos, *Technología e Innovación en Países Emergentes*, 35–36.

32. Hagood, "Why Does Technology Transfer Fail," 76, 84–85; and Artopoulos, *Technología e Innovación en Países Emergentes*, 70.

33. Conradis, *Design for Flight*, 181.

34. Burzaco, "Perón y Los Científicos Alemanes"; and Artopoulos, *Technología e Innovación en Países Emergentes*, 13, 15, 29, 56.

35. Conradis, *Design for Flight*, 187; and Artopoulos, *Technología e Innovación en Países Emergentes*, 56.

36. Hagood, "Why Does Technology Transfer Fail," 90.

37. Burzaco, "Perón y Los Científicos Alemanes."

38. Artopoulos, *Technología e Innovación en Países Emergentes*, 62–63; and Burzaco, *Las Alas de Perón*, 3.

39. Artopoulos, *Technología e Innovación en Países Emergentes*, 50, 58, 69.

40. British Air Attaché, Buenos Aires, "Annual Report on the Argentine Air Force for the Year, 1955," FO 371/119893; British Air Attaché, Buenos Aires, "Annual Report on the Argentine Air Force for the Year 1951," FO 371/97415; Hagood, "Why Does Technology Transfer Fail," 91, 94; Artopoulos, *Technología e Innovación en Países Emergentes*, 81, 63; and Burzaco, *Alas de Perón*, 23, 25.

41. Burzaco, "Perón y Los Científicos Alemanes."

42. Artopoulos, *Technología e Innovación en Países Emergentes*, 59. Burzaco suggests the FAA had abandoned the Pulqui-II in favor of Horten's IAe-37 delta-winged fighter, but nothing came of that project either. *See* Burzaco, *Alas de Perón*, 25.

43. Burzaco, "Perón y Los Científicos Alemanes."

44. Artopoulos, *Technología e Innovación en Países Emergentes*, 63.

45. Crowder-Taraborrelli, "Evita in Wonderland."

46. Gamal Abdel Nasser, *Egypt's Liberation: The Philosophy of the Revolution* (Washington, DC: Public Affairs Press, 1956); and Robert Stephens, *Nasser: A Political Biography* (New York: Simon & Schuster, 1971) 141–43.

47. Anthony Nutting, *Nasser* (New York: E.P. Dutton, 1972) 100–01.

48. Stephens, *Nasser*, 325–26.

49. Ali Muhammad Labib, *Al-Quwah al-Thalitha: Tarikh al-Quwat al-Jawwi yah al-Misriyah* (Cairo: al-Hayah al-Misriyah al-Ammah lil-Kitab, 1977) 119, 217–20; M. Jawadi, *Muddakirat Qadaal'Askariya al-Misriya 67–72: Fi 'Aqab al-Naksa* (Cairo: Dar al-Khayyal, 2001) 366; R.G. Matthews, "Egyptian Defense Industrialization," *Defense and Security Analysis* 8, no. 2 (1992), 119, 129.

50. Owen Sirrs, *Nasser and the Missile Age in the Middle East* (London: Routledge, 2006) 82–83.

51. Labib, *Al-Quwah al-Thalitha*, 221–22; Sanche de Gramont, "Nasser's Hired Germans," *Saturday Evening Post* 236, no. 26 (1963), 63; 'Naher Osten: *Rüstung*: 36, 135 und 333', *Der Spiegel* 19, no. 37 (1963) 58; "New Arab Steeds," *Flight International* 2872, no. 85 (1964) 467–68; and Frank Vann, *Willy Messerschmitt: First Full Biography of an Aeronautical Genius* (Somerset: Patrick Stephens, 1993) 242.

52. Labib, *Al-Quwah al-Thalitha*, 119, 221; and "New Arab Steeds," 467.

53. Telegram from Department of State to American Embassy Cairo, no subject, no. 465 (3 October 1960) National Archives and Records Administration, Reports Group 59.

54. Labib, *Al-Quwah al-Thalitha*, 221; 'Al-Majmua' 73 Mowarikhin Mashrua' al-Ta'era al-Qahera 300', https://group73historians.com/.

55. Lon Nordeen and David Nicolle, *Phoenix over the Nile* (Washington, DC: Smithsonian Institution Press, 2006) 178; Robert R. Ropelewski, "Improvisation Key to Egyptian Growth," *Aviation Week and Space Technology* (13 November 1978) 38; and Labib, *Al-Quwah al-Thalitha*, 222.

56. Inge Deutschkron, *Bonn and Jerusalem: The Strange Coalition* (Philadelphia: Chilton Book Company, 1970) 223; and Nordeen and Nicolle, *Phoenix over the Nile*, 178.

57. Michel Bar-Zohar, *The Hunt for German Scientists* (New York: Avon Books, 1967) 206–07; Ropelewski, "Improvisation Key to Egyptian Growth," 38; and '*Rüstung*: 36, 135 und 333,' 60.

58. Nordeen and Nicolle, *Phoenix over the Nile*, 178; Bar-Zohar, *Hunt for German Scientists*, 203; and Neufeld, "The Nazi Aerospace Exodus," 54.

59. Vann, *Willy Messerschmitt*, 238; "New Arab Steeds," 468; Kapil Bhargava, "Messerschmitt's HA-300 and Its Indian Connection," https://web.archive.org/; 'Al-Majmua' 73 Mowarikhin Mashrua' al-Ta'era al-Qahera 300'; and Labib, *Al-Quwah al-Thalitha*, 222.

60. Vann, *Willy Messerschmitt*, 242; and 'Al-Majmua' 73 Mowarikhin Mashrua' al-Ta'era al-Qahera 300.'

61. Labib, *Al-Quwah al-Thalitha*, 222; 'Al-Majmua' 73 Mowarikhin Mashrua' al-Ta'era al-Qahera 300'; Bar-Zohar, *Hunt for German Scientists*, 202–03; Deutschkron, *Bonn and Jerusalem*, 232; and '*Rüstung*: 36, 135 und 333,' 57–58.

62. 'Maudua: al-Muqattila al-Misriya Helwan 300 al-Nasr al-Misria la thimina'amin al-Tahliq,' https://web.archive.org/.

63. '*Rüstung*: 36, 135 und 333,' 60; and Bar-Zohar, *Hunt for German Scientists*, 206–207.

64. '*Rüstung*: 36, 135 und 333,' 60; Kapil Bhargava, "Eyewitness to the Six-Day War," https://web.archive.org/; Nordeen and Nicolle, *Phoenix over the Nile*, 178–79; and 'Maudua: al-Muqattila al-Misriya Helwan 300 al-Nasr al-Misria la thimina'amin al-Tahliq.' Under a July 1957 agreement, India was to train up to 1,000 Egyptian pilots, although this number was never achieved. *See* British National Archives, FO 371/125495.

65. Bhargava, "Eyewitness to the Six-Day War."

66. Clarence A. Robinson, "Nation Seeks Larger Production Base," *Aviation Week and Space Technology* (4 January 1982) 41; Bhargava, "Messerschmitt's HA-300"; Ropelewski, "Improvisation Key to Egyptian Growth," 38; and 'Maudua: al-Muqattila al-Misriya Helwan 300 al-Nasr al-Misria la thimina'amin al-Tahliq.'

67. Sirrs, *Nasser and the Missile Age*, 82–83. As a 1967 CIA intelligence assessment put it: "Although troublesome, time consuming, and costly, the problems associated with the [missile] program apparently have not been considered critical enough by [Egypt] to override the regime's desire for a domestically produced advanced weapons status symbol." *See* Central Intelligence Agency, Intelligence Report, *Soviet Military Aid to the United Arab Republic, 1955-66*, RR IR 67-9, March 1967, originally classified Top Secret, https://www.cia.gov/.

68. Bhargava, "Messerschmitt's HA-300."

69. Vann, *Willy Messerschmitt*, 240–41.

70. Wolfgang Lotz, *The Champagne Spy* (New York: St. Martin's, 1972) 120–21; Bhargava, "Messerschmitt's HA-300"; and Sirrs, *Nasser and the Missile Age*, 155.

71. Bhargava, "Messerschmitt's HA-300."

72. De Gramont, "Nasser's Hired Germans," 63; "New Arab Steeds," 468; Vann, *Willy Messerschmitt*, 238; and '*Rüstung*: 36, 135 und 333,' 59.

73. Matthews, "Egyptian Defense Industrialization," 121. Egyptian sources report the total amount of the HA-300 exceeded 135 million Egyptian Pounds. *See* 'Maudua: al-Muqattila al-Misriya Helwan 300 al-Nasr al-Misria la thimina'amin al-Tahliq.'

74. Robinson, "Nation Seeks Larger Production Base," 41; Nordeen and Nicolle, *Phoenix over the Nile*, 178–79, 227; "New Arab Steeds," 468; Neufeld, "The Nazi Aerospace Exodus," 58; and Central Intelligence Agency, *Soviet Military Aid to the United Arab Republic*, 5.

75. Ropelewski, "Improvisation Key to Egyptian Growth," 38; and Matthews, "Egyptian Defense Industrialization," 120. Some believe the Soviets killed the HA-300 in order to monopolize jet fighter sales to the Middle East and Africa and make Cairo more dependent on Moscow for combat aviation. *See* Labib, *Al-Quwah al-Thalitha*, 219; and 'Maudua: al-Muqattila al-Misriya Helwan 300 al-Nasr al-Misria la thimina'amin al-Tahliq.'

76. Raju G.C. Thomas, "Nonalignment and Indian Security: Nehru's Rationale and Legacy," *Journal of Strategic Studies* 2, no. 2 (1979), 156–58; and Stanley Wolpert, *Nehru: A Tryst with Destiny* (New York: Oxford University Press, 1996) 466.

77. M. Pardesi and R. Matthews, "India's Tortuous Road to Defence-Industrial Self-Reliance," *Defense & Security Analysis* 23, no. 4 (2007), 419.

78. *Quoted in* N. Jayapalan, *Indian Political Thinkers: Modern Indian Political Thought* (New Delhi: Atlantic Publishers, 2003) 286.

79. Pardesi and Matthews, "India's Tortuous Road," 419–20.

80. Ibid.

81. K. Chatterjee, "Hindustan Fighter HF-24 Marut; Part I: Building India's Jet Fighter," https://web.archive.org/; and Chris Smith, *India's Ad Hoc Arsenal: Direction or Drift in Defense Policy?* (Stockholm: SIPRI, 1994) 160–62.

82. Pardesi and Matthews, "India's Tortuous Road," 419–21.

83. Smith, *India's Ad Hoc Arsenal*, 160–62.

84. Chatterjee, "Hindustan Fighter HF-24 Marut"; Timothy D. Hoyt, *Military Industry and Regional Defense Policy* (London: Routledge, 2007) 32-33; Robert Guttman, "India's HAL HF-24 Confounded Detractors with Its Respectable Combat Record," *Aviation History* 12, no. 5 (2002): 6–19; and Pardesi and Matthews, "India's Tortuous Road," 419–21.

85. Kapil Bhargava, "Early Design & Development of the HF-24," 24 November 2010, https://marut-fans.wordpress.com/; Chatterjee, "Hindustan Fighter HF-24 Marut"; Hoyt, *Military Industry and Regional Defense Policy*, 32–33; Polly Singh, "When the Wind Blows," https://web.archive.org/; Guttman, "India's HAL HF-24," 16–19.

86. Chatterjee, "Hindustan Fighter HF-24 Marut."

87. Guttman, "India's HAL HF-24," 16–19.

88. Conradis, *Design for Flight*, 198–99; and Chatterjee, "Hindustan Fighter HF-24 Marut."

89. Pardesi and Matthews, "India's Tortuous Road," 421–23.

90. Chatterjee, "Hindustan Fighter HF-24 Marut"; Singh, "When the Wind Blows"; Conradis, *Design for Flight*, 194–95; and Hagood, "Why Does Technology Transfer Fail," 81–82.

91. Hagood, "Why Does Technology Transfer Fail," 85, 88; and Conradis, *Design for Flight*, 198–99.

92. Chatterjee, "Hindustan Fighter HF-24 Marut."

93. Burzaco, "Perón y Los Científicos Alemanes"; and Chatterjee, "Hindustan Fighter HF-24 Marut."

94. Chatterjee, "Hindustan Fighter HF-24 Marut."

95. India was counting on the Bristol Orpheus 12 to power its Marut; however, the British firm cancelled development. *See* Hoyt, *Military Industry and Regional Defense Policy*, 32–33; and Chatterjee, "Hindustan Fighter HF-24 Marut."

96. Smith, *India's Ad Hoc Arsenal*, 160–62.

97. Hoyt, *Military Industry and Regional Defense Policy*, 32–33; and Chatterjee, "Hindustan Fighter HF-24 Marut."

98. Chatterjee, "Hindustan Fighter HF-24 Marut."

99. Chatterjee, "Hindustan Fighter HF-24 Marut."

100. Arun Dev, "Pilots, Engineers Relive Their Tryst with Marut," *Times of India*, 18 June 2011, https://timesofindia.indiatimes.com/.

101. Smith, *India's Ad Hoc Arsenal*, 160. Pardesi and Matthews label the HF-24 a "complete failure." *See* Pardesi and Matthews, "India's Tortuous Road," 426.

102. Smith, *India's Ad Hoc Arsenal*, 161.

103. Smith, *India's Ad Hoc Arsenal*, 161.

104. Hoyt, *Military Industry and Regional Defense Policy*, 32–33; and Pardesi and Matthews, "India's Tortuous Road," 423.

105. David A. Brown, "India's Aircraft Industry Grows," *Aviation Week and Space Technology*, 17 January 1977, 14.

106. Hoyt, *Military Industry and Regional Defense Policy*, 32–33; and Smith, *India's Ad Hoc Arsenal*, 160–62.

107. Pardesi and Matthews, "India's Tortuous Road," 424.

108. Pardesi and Matthews, "India's Tortuous Road," 426; and Smith, *India's Ad Hoc Arsenal*, 160–62.

109. Smith, *India's Ad Hoc Arsenal*, 161.

110. Hoyt, *Military Industry and Regional Defense Policy*, 32–33.

111. Chatterjee, "Hindustan Fighter HF-24 Marut."

112. Pardesi and Matthews, "India's Tortuous Road," 424.

113. Pardesi and Matthews, "India's Tortuous Road," 425–26.

114. Neelam Matthews, 'Troubles for Tejas and…', *Aviation Week and Space Technology*, 17 January 2001, 26; and Pardesi and Matthews, "India's Tortuous Road," 427.

115. Matthews, "Troubles for Tejas," 26. The Tejas is powered by American-designed GE-404 and GE-414 engines.

116. Neufeld, "The Nazi Aerospace Exodus," 49.

117. Caprotti, "Technology and Geographical Imaginations," 187.

118. Caprotti, "Technology and Geographical Imaginations," 195–96.

119. The term "Egyptian-made" features prominently in Labib's history of the Egyptian Air Force: Labib, *Al-Quwah al-Thalitha*.

120. Kendall E. Bailes, "Technology and Legitimacy: Soviet Aviation and Stalinism in the 1930," *Technology and Culture* 17, no. 1 (1976), 66.

121. According to a 1955 report by the British Air Attaché, Argentina could not machine its own parts for the British-Derwent 5 engine let alone design, test and produce its own engines. *See* British Air Attaché, "Annual Report," FO 371/119893.

122. Neufeld, "The Nazi Aerospace Exodus," 57–58.

123. Bill Sweetman, "I Spy," *Aviation Week and Space Technology*, 5 November 2012, 72.

124. Bradley Perrett, Robert Hewson, and Reuben Johnson, "Stealth Bazaar," *Aviation Week and Space Technology*, 19 November 2012, 26.

125. Perrett, Hewson, and Johnson, "Stealth Bazaar"; Editorial, "Remain Watchful of China's Ascent," *Aviation Week and Space Technology*, 10 January 2011, 58.

126. "Remain Watchful of China's Ascent."

127. Among those producers, we find the United States, Russia, France, and various European consortiums consisting of the United Kingdom, Germany, Italy, and Spain.