Polish Aviation Engineering: Past, Present and Future

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ABSTRACT

The paper presents the history and present status of the Polish aviation engineering. The authors discus the development and evaluation of the Polish aviation concept and its impact on the domestic and international industry. Before and after the WWII Polish aviation sector belonged to the leaders of the world market, unfortunately after the fall of the Berlin wall industry experienced a deep crisis. The marked of former Warsaw Pact was shrunk significantly, and number of orders for new aircraft have dropped dramatically. However, thanks to proper experience and knowledge of the Polish aviation engineers, new opportunities for the domestic aviation sector have emerged recently.

1.0 INTRODUCTON

The beginnings of the Polish aviation is dated back to the end of the First World War. The remnants of aircraft equipment, left by former military forces of occupying powers (Germany, Austro-Hungarian Empire, Russia) were taken over and later applied by newly-born Polish Air Force squadrons. The hung over aircraft were in poor technical conditions so it became absolutely necessary to repaired them. It was a task for the technical personnel, who gathered an appropriate amount of technological experience while serving as engineers and technicians under the banners of foreign powers. However, the increasingly growing number of upgraded and delivered from abroad aircraft stopped for moment the development of the Polish aviation industry. Fortunately, the Polish Government soon took a decision, paving the way for the domestic aircraft industry to take its shape. The aviation industry had to be launched from bare scratches. It is worth reminding that Poland, which during more than 130 years suffered under the occupation of neighboring powers, lacked both proper research facilities as well as aviation plants and technological universities to develop any comparable capabilities in the above-mentioned field. One must be also aware of the fact that only a handful of Poles wrapped up their studies in the field of aviation engineering, while staying at French universities, just on the eve of the First World War.

2.0 DEVELOPMENT OF AVIATION INDUSTRY AT ITS EARLY STAGES

All major universities of technology resumed their activities in 1921, just as the war between Poland and Soviet Russia came to a close. In the new academic year 1922/23 the study in the field of an aircraft engineering was inaugurated at the Faculty of Mechanics of the University of Technology in Warsaw. For the needs of aviation education the new departments were launched at this university: Aerodynamics, Propulsion Systems, Aircraft Design, Flight Mechanics. In 1928 an aircraft engineering studies were launched at the Faculty of Mechanics of the State University of Technology in Lvov. Many Polish scholars were sent to France and Germany to gain knowledge and experience in aviation engineering, more than 300 highly-skilled engineers completed their studies till 1939, when the WWII broke up.

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In 1921 the first aerodynamic wind tunnel was set up at the University of Technology in Warsaw, and in 1926 the Institute of Aerodynamics was established at the same university as detachable institute. The main purpose of this Institute was to carry out research activities in order to investigate aerodynamic and flight properties of the aircraft and new aviation structures.

The Aviation Institute of Technological Research was also created in the following months. The scientific staff, employed there, was kept indeed very busy providing both all necessary technological support as well as overseeing maintenance patterns which had been applied at the time by domestic military and civilian aviation. In 1932 the Institute of Glider Technology was established. It was the second such research facility, ever created in the world. Its activities were focused on exploring new ways of designing both gliders and propelled gliders. The development of independent research and development capabilities paved the way for a creation of a modern aircraft industry in Poland.

The first aircraft manufacturing plants were opened in Poznan and Biala Podlaska in 1923. Other major investment efforts in this field were to follow suit. In 1925 the state-owned enterprise, Polish Aviation Companies (in short PZL) started its activities in Warsaw. The production of technically-advanced aircraft engines and propellers was launched at the manufacturing facility, owned by the Czech's car-making company Skoda. In the ensuing period of 1930's further important steps were taken to foster the development of our domestic aircraft industry and encourage all relevant enterprises to gradually merge their manufacturing activities. Between 1921-25 there were approximately 30-60 aircraft which left manufacturing plants, each year. In 1925 that number grew significantly with 220 planes delivered to both domestic as well as foreign customers.

3.0 PRE-WAR PERIOD

3.1 THE FIRST POLISH-DESIGNED AIRCRAFT

The BM-4 and BM-5 trainers can be considered as the first domestically-built aircraft designed by Ryszard Bartel who graduated from the Faculty of Aircraft Engineering at the University of Technology in Warsaw. Thanks to their unique anti-spin features, both the BM-4 and BM-5 managed to attract an attention of domestic and foreign customers. Its worth mentioning that by successfully combining relevant aerodynamic properties (trimming mass-balance, precisely adjusted the angles of incidences of both upper and lower wing), the designer was able to create one of the safest training planes, ever constructed worldwide. The mass production of these highly-capable trainers was launched in 1928/1929.

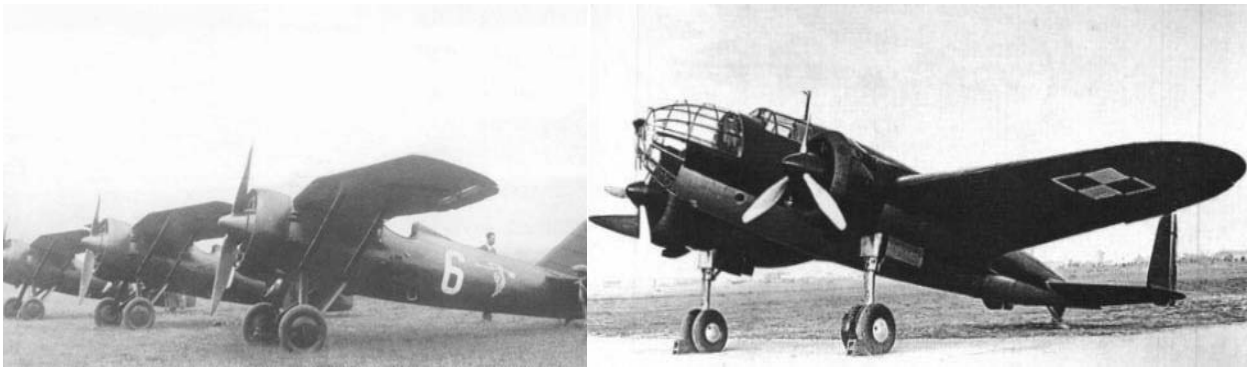

Figure 1: The most successful pre-war designs: PZL P.11 on the left and PZL P 37 Łoś (Elk) on the right

In the period of 1928-31 Zygmunt Puławski, one of the most talented Polish pre-war designer developed a new generation of fighter planes: PZL P.1, P.6, P.7, P.8 and P.11. The fighters, designed by Puławski had

been equipped with the sea-gull shape lifting surface. Given the fact that this unique shape of the wing had an outstanding maneuverability and provided pilots with excellent visibility from cockpit, it had become well-known world-wide, while being called as Pulaski's wing or Polish airfoil, at the same time. Puławski should also take credit for inventing the so called spar-type undercarriage with a shock-absorber mounted inside the fuselage. Unfortunately in 1931 Pulawski perished, when the prototype of the amphibious plane piloted by a designer crashed during a test flight. However his legacy remained intact, providing all necessary clues for the new generation of aviation engineers to follow on, and his unique aerodynamic form of the wing was used later in the P.24 project. The respected fighter, among others was sold overseas, notably to Bulgaria, Romania and Turkey. Its worth reminding that P. 24s were also produced in Romania and Turkey, following the government's decision to grant manufacturing rights to those countries. As far as aircraft construction patterns are concerned, it is worth mentioning PZL 23 Karaś and PZL 43 Sum fighters, which were designed by eng. Stanislaw Prus. These aircraft were apparently equipped with, an unique wing-box covered with corrugated aluminum ally skin designed by prof. Misztal, providing an excellent stiffness with very low mass of the wing structure.

3.2 THE FIRST INTERNATIONAL ACHIEVEMENTS

It is worth mentioning that Polish manufacturing companies were also able to provide a great bulk of highly-sophisticated leisure planes which paved a way for international respects and achievements. Capt. Stanisław Skarżyński managed to perform a non-stop solo flight over the South Atlantic, behind the controls of the RWD-5, the newly designed- plane. The other variants of RWD's family (notably RWD-6 and RWD-9) were widely recognized abroad, after winning twice (in 1932 and 1934) the prestigious Challenge Aircraft Competition. Given the fact that RWD-9 wing was equipped with the very effective high-lift devices, which provides very short take-off and landing performances, it could have been considered as a remarkable achievement in the field of the STOL capabilities (Short Take Off and Landing). Thanks to its unique performance and numerous distinguished awards, gained at various international competitions the RWD-class planes were sold on oversees markets.

3.3 POLISH INVENTIONS

The V-shape empennage arrangement, designed by eng. Jerzy Rudlicki, and first time utilized in the Lublin RXIX aircraft in 1934 can be considered as the Polish contribution to the development of the international aircraft industry. After the Second World War the V-shape tail unit was proliferated by the foreign designers in a completely new generation of planes including the US's Beach Bonanza, French-made Fouga Master and first of all the Lockheed F-117 Nighthawk. In the latter project, the Rudlicki empennage allow to achieve very low level of the aircraft Radar Cross Section. Rudlicki is also an inventor of so called tandem cockpit arrangement for the trainer aircraft (with the instructor's seat placed a bit above and behind of the student). This can be considered as widely recognized standard which can be applied to significantly improve the operational capabilities of both training planes as well as attack helicopters.

The two-engine bomber PZL 37 Łoś (Elk) designed in 1936 could have been considered as the most advanced military planes, built at the time by domestic aviation industry. The Elk light bomber was the first in the world aircraft fitted with the retractable undercarriage and landing flaps. What is more PZL 37 Łoś was equipped with the laminar aerofoil, worked out by engineer Dąbrowski. The laminar aerofoil allow the PZL 37 Łoś to achieve a max flight speed, comparable to that developed by fighters. Łoś was also equipped with the so called tandem-wheel undercarriage which was designed by eng. Kubicki.

It is worth acknowledging that new prototypes of domestically-built military and civilian planes were at an test stage in 1939, with the Second World War just on our doorsteps. Among others, the following prototypes are worth to be taking notice of: PZL 43 Sum (Catfish), PZL 44 Wicher (Storm) passenger

plane as well as PZL 50 Jastrząb (Hawk) fighter plane and PWS-33 Wyżeł (Greyhound) military trainer. This latter plane can be considered as particularly interesting because Wyżel was covered with the special type molded plywood**.** During the Second World War this type of the molded plywood was applied by Canadian aircraft industry, in the Mosquito manufacturing.

During the whole period, between 1918-1939 domestic aircraft industry managed to produce more than 4000 planes and 1400 gliders, as well as 3800 aircraft engines and propellers. It is also worth reminding that at least 12.000 highly-qualified technicians and engineers were employed at various industrial plants and research labs, across the country. The spare output capacity, developed by Polish aircraft industry branch, allowed our country to sell more than 234 planes on overseas markets. The major customers were: Romania, Turkey and Bulgaria. Smaller deliveries of aircraft equipment were also sent to Brazil, Estonia, Czech Republic and Yugoslavia.

4.0 POST WAR PROGRESS

Many respected members of Polish aircraft industrial community were forced into exile when the war started in 1939. Most of them were indeed very keen on putting their knowledge and skills at the disposal of allied states which had struggled at the time to ward off the ever imminent threat of being invaded by the Nazi Germany. Thus, it is quite understandable that Polish engineers did not hesitate to join the ranks of both scientific and research wards in the following countries: Great Britain, Canada, Turkey. Polish engineers should take credit for removing dangerous vibrations in the British-designed Hawker Typhoon and Tempest fighters as well as redesigning vertical tail unit, affecting the performance of Halifax bomber. They also took part in launching the production of the De Havilland Mosquito and Avro Lancaster in Canada. It is worth reminding that our scientists were designed DHC-1 Chipmunk and DHC2 Beaver general aviation aircraft as well. Their presence on the Canadian soil was also marked by setting up the Faculty of an Aircraft Engineering Studies at the University of Montreal. The Turkish government invited Polish engineers to help with efforts to build the domestic aircraft industry. The first manufacturing plant was set up at Etimusget, on the outskirts of the Turkish capital, Ankara. Polish engineers, working in a close cooperation with their British colleagues designed the THK-2, THK-5, THK-11 planes. It is also worth mentioning that the field of aircraft engineering studies was launched at the University of Technology in Stambul, at the time.

In the aftermath of the Second World War the polish aircraft industry was left in shatters, facing a serious shortage of highly-skilled workers. Senior members of managing staff, engineers and technicians fled the country in September 1939 and those who decided to stay in Poland after the war had been looked at with a great deal of suspicion by the new government. So it was quite understandable that everything had to be rebuilt from scratches. The respected Faculties of Aircraft Engineering resumed their activities at the universities in Warsaw, Cracow, Gdansk and Lodz. The Faculty of an Aircraft Engineering was inaugurated at Military University of Technology's in 1951. The main reason behind its creation was to ensure an appropriate level of maintenance and logistic support for aviation of the Polish Armed Forces. The Institute of Aviation re-launched its activities in 1945. Taking into account the need to develop new technical capabilities for military purposes, the government decided to reopen Air Force Institute of Technology, which acted within the structure of the Polish Air Forces.

4.1 THE FIRST PROJECTS

Most of our domestic aircraft manufacturing plants and design bureaus were left on the verge of collapse as a direct result of the Second World War. The already difficult situation was additionally aggravated by the politically-motivated decision to close all domestic research facilities and design bureaus. Having been forced by the communist Soviet Union's authorities, Poland was obliged to launch the production of the Soviet-design aircraft and helicopters. The Soviet-design Po-2 utility plane was the first post-war aircraft which rolled out from Polish factories. In the incoming period (1949-50) our aircraft industry was charged

with manufacturing the Soviet-design Mikoyan MiG-15, MIG-17 fighter jets (more than 1500 planes were produced). The latter decision was taken due to the mounting tensions in relations between Moscow and Western Allies, marked notably by the beginning of the war on the Korean Peninsula. The new, more flexible political approach, brought about by Stalin's death caused the demand for war planes to diminish significantly, thus turning attention to civilian aviation. The large-scale production of the Soviet-made civilian planes replaced the the Mikoyan fighters in the period between 1955-56. The Yakovlev Jak–12 reconnaissance aircraft, Antonov An-12 multi-purpose aircraft as well as Mil Mi-1 and Mi-2 light-weight helicopters were sent to production. The output capacity of the Polish aircraft industry branch was significantly improved in the early 1960's, providing job for approximately 29 000 employees.

After taking a highly-contentious decision to halt any independently–conducted research and designing activities, the authorities gradually allowed our aviation designers and engineers to develop and produce domestically-designed aircraft and helicopters.

The large-scale production of the first Polish post-war aircraft the Junak-2 (Junior) trainer (including its improved variant Junak-3) was launched in 1948. The aircraft were designed by Eng. Tadeusz Sołtyk, who also took credit for designing the TS-8 Bies (Boogy) next generation training plane, designed to meet requirement set by the Polish Air Force. Thanks to its unique capabilities Polish pilots managed to set a couple of world's records. The TS-8 Bies was the first metal-designed aircraft in postwar Poland, which was also driven by domestically-designed and built aviation piston engine. It was the most commonly used military training plane till 1967 when it had been replaced by the TS-11 Iskra first next generation jet-propelled aircraft, also designed by eng Sołtyk.

4.2 THE FIRST JESTS

The TS-11 Iskra (Spark) opened the era of domestically-built jet-propelled plane. Her maiden flight took place on February the 5th 1960. The test flights confirmed her outstanding flight performances and very good handling qualities. What is more among the many technological advantages, the TS-11 Iskra posses excellent maintenance capability, and requires very limited serviceability. The large-scale production of TS-11 Iskra was launched shortly afterwards. Many different versions of the TS-11 jet-trainer are still being used by our Air Force. It is worth pointing out that Iskra used to enjoy quite good credentials on overseas markets, and the TS-11 is still in service of India military aviation. Many decommissioned Iskra trainers were also sold abroad, (with the US as a major customer) where they take part in numerous air-shows.

Figure 2: TS-8 Bies on the right and the PZL-130 Orlik (Eaglet) on the right

The TS-16 Grot (Spear) next generation, supersonic trainer was designed a replacement for the TS-11. It was designed to operate from grass-covered airfield, and to carry out combat operation including the CSA

(Close Support Operations). The aircraft was fitted with a delta wing and all mowing horizontal tail unit, was to be driven by two new generation Polish-design jet engines. A new aircraft was to be equipped with modern navigation system and a radar for the air to air operation. The novelty was the so called damage and failure simulator, quite new of concept of its time. The mock-up of the single-engined version of the TS-16RD for evaluation by the state-commission was ready in 1963, and that year it was presented at Paris Air Show where attracted attention of many visitors. Unfortunately, due to the reluctance of the Polish authorities, that ambitious project was unexpectedly halted and later canceled, and the prototype of a new TS " Grot" training plane and jet engine were never built, what is more the Soltyk design-bureau was splat out.

Figure 3: The jet trainers: TS-11 Iskra (Spark) on the left and PZL I-22 on the right

4.3 BREAKTHROUGH OF THE 80'S

The works on a new generation of military jets were resumed in the late 1970's. The government grew aware of the urgent need to replace the increasingly obsolete-becoming TS-11 Iskra training planes. Unfortunately, diminishing of the Sołtyk design-bureau had a negative impact on the new project. Lack of experienced designers and engineers as well as economical crisis caused that the works on the PZL I-22 were delayed many times. Finally the PZL I-22 Iryda made its maiden flight in 1985. A project was designed on the line of the British Hawk and French-Germany Alpha-Jet advanced trainers with attack capabilities, but it became a real aircraft almost 15 year later, meantime a concept of the advanced trainer had been changed. What is more the PZL-22 suffered many technical problems, and in spite of many modifications and improvements the Polish Air Force was very reluctant to a new aircraft. Finally after the air crash in 1996, the 20 manufactured the PZL-22's were grounded, and later decommissioned from the service. Fortunately designing works on the turbo-propelled trainer were successfully completed with production of the PLZ-130 ORLIK (Eaglet). The first bath of the PZL-130 entered its service with the PAF in 1984, nowadays after many improvement the latest version the PZL-130 Turbo remains the basic trainer of military aviation.

4.4 GENERAL AVIATION

In 1959 the that time Council of Mutual Economic Cooperation took a decision to launch in Poland the production of the lightweight utility planes. The first lightweight aircraft were rolled out soon afterwards. The PZL-104 Wilga (Oriole) multi-purpose aircraft was rolled out in 1960's. This particular aircraft was capable to attract attention of foreign customers. It is worth reminding that modern, significantly improved PZL-104 variants are still being manufactured and sold including to foreign customers. Thanks to its unique short take-off and landing performance and good handling qualities, Polish pilots are able to secure numerous prestigious titles, during the so called precision flight international competition. Up to date over 1000 pieces of the PZL-104 were manufactured.

From the 70's agriculture aviation have became a Polish specialization. Having carefully studied all relevant construction patterns of the Russian-made Jak-12, Polish engineers were able to design the PZL-101 Gawron (Vogel) ag plane. It was designed as a lightweight, driven by a 190 HP piston-radial engine, high-wing monoplane. Its agricultural, crop-duster version was also equipped with chemical container, capable of storing 600 kilos of various agents and substances. In 1974 quite daring attempt was made to develop the jet-propelled agricultural aircraft the PZL M-15 Belfegor. The first jet agriculture aircraft and only one in its class so far, was to draw a common attention not only of unique propulsion system and something obsolete biplane configuration, but also because of its satisfactory flight performance, relatively small flight velocity, as well as excellent maneuverability. Unfortunately it quickly turned out that domestic application of PZI M-15 aircraft would be running on the red because of its limited storage capacity (not exceeding 1450 litres of chemicals), but the M-15's were sold in great number to the former Soviet Union. However the production was suspended, in the late 1980's, following collapse of the Russian economy.

Meanwhile, Polish aircraft engineers did not spare their efforts to submit new draft-version of PZL-106 Kruk (Raven) and PZL M-18 Dromader (Camel) agricultural aircraft. Success of the Dromader at the domestic and international marked prompted the designers to develop a family of a new generation M-18-based agricultural planes. At least 700 of the M-18 planes were delivered to customers, almost 90 percent of the production were sent abroad, and nowadays the M-18 is the most proliferated ag-aircraft of the world.

The license-production of the Russian-design Mil Mi-1 and then Mi-2 helicopters was launched in 1955. More than 5500 Mi-2 models, including: patrol, medevac, fire-fighter, agriculture and military variants were built and sold overseas. Having thoroughly assessed a recently gained experience, Polish engineers designed in 80's the PZL W-3 Sokół (Falcon) a medium weight utility (cargo and passenger) helicopter, including its naval version (better known as W-3 RM) as well as the W-3WB multipurpose military helicopter. Orders for PZL W-3 have been placed not only from domestic customers but from overseas such as: Burma, Pakistan, India. The other newly-developed models were to be put on display soon afterwards, among them, the PZL SW-4 lightweight helicopter designed in 1996 and was sent into production line in 2003.

Figure 4: The PZL M-18 Dromader (Camel) on the left, and WSK W-3 Sokół (Falcon) on the right

Polish aircraft industry has performed particularly well as far as designing and constructing of gliders is concerned. It is estimated that more than 6000 gliders were produced and at least 3500 models were delivered abroad in the whole postwar period. Polish pilots managed to gain a wide-range of most-distinguished rewards, at various international aircraft competition venues. One can also remind that the PW-5 world-class glider plane, launched in 1992, was selected as the best Olympic glider by the International Federation of Aviation.

5.0 PRESENT AND FUTURE

During the period of 1980's our aircraft industry manufactured 600-750 aircraft yearly, to meet an increasingly growing demand of both Polish as well as former Warsaw Pact customers. However, domestic manufacturing plants were poised to face tough times ahead. The demise of the Soviet Union and the ensuing political turmoil forced the Polish manufacturers to reduce output levels significantly. The number of designed and manufactured planes have shrunk dramatically, and nowadays reaches level of 50 fixed and rotary wing aircraft per year.

Most of domestic aircraft industrial plants have been forced to merge their activities with major overseas players (incl Europe's EADS as well as US's General Electric, United Technologies, Goodrich and Aerotech) in order to remain competitive. It is worth reminding that a landmark of the breakthrough was made in 2002, when the Polish government took a decision to accept a bid by Lockheed Martin and purchase the F-16 multi-purpose fighter for the Polish Air Force. The offset program appears to meet the expectations for a quick recovery of the whole sector. According to the offset –investment scheme, various highly-sophisticated new technology capabilities are to be made available to Polish aviation branch over the years to come. And in reality, a sustained recovery on Polish aircraft market have been witnessed more recently. Many of domestic aircraft industrial plants have seen their output levels soaring again at the time. Among them the PZL consortium has earned a good credentials abroad, while providing certain parts of aviation units and equipment for such worldwide-known industry leaders, like for example: Airbus, Eurocopter, Agusta/Bell, Pratt & Whitney, also production of new agricultural planes, utility aircraft, especially designed to meet the requirements of the Asian customers has been re-launched. Polish aviation industry once more have regained its credibility and competitiveness and attracted foreign investors. The General Electric set up an engine's test bed in Warsaw. Its main contender the Pratt & Whitney launched the production of the F-100 turbojet, a propulsion system for the Polish version of the F-16. The latter enterprise has also decided to open the so called Aviation Material Research Center.

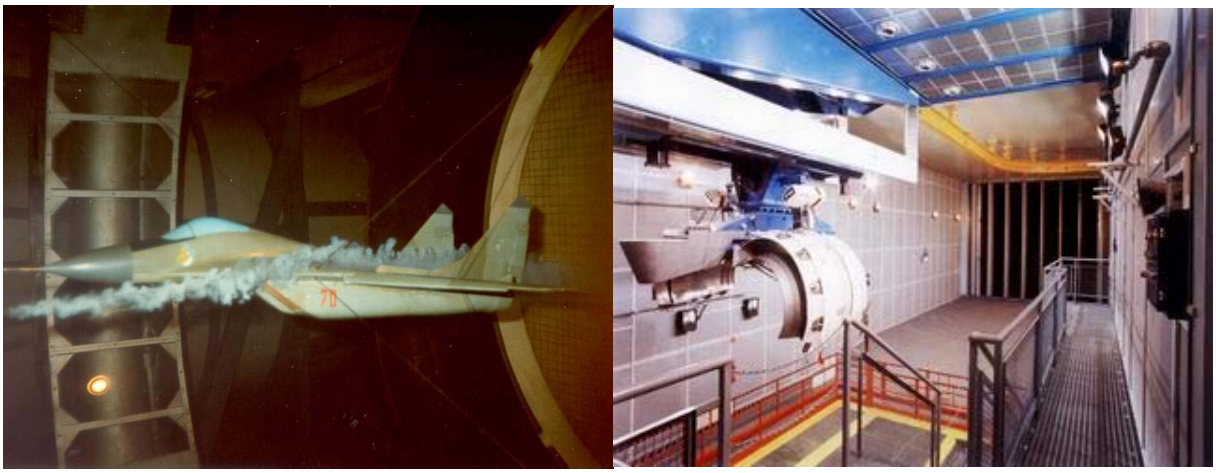

Figure 5: The wing tunnel investigation at the Military University of Technology on the left, and the engine test bed at the Military Aviation Works on the right

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