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AEROSPACE RESEARCH CONDUCTED AT THE MOSTAR TECHNICAL UNIVERSITY

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Abstract

Yugoslavian Air Forces (VVKJ) during WW2 possessed essential combat capabilities. During 1940 Britain supplied to Belgrade a significant military aid, to strengthen its forces against the increasing German threat. In early March 1941, the German Luftwaffe forces started arriving in neighbouring Bulgaria. On March 12, 1941, VVKJ units began to deploy to their wartime airfields. On 27 March 1941, the overthrow of the government that had signed the Tripartite Pact in Belgrade two days earlier, by a group of officers led by Dušan Simović, an air force general, brought an end to hopes of a settlement with Germany. On April 6, 1941, Luftwaffe units in Bulgaria and Romania attacked Yugoslavia during the Bombing of Belgrade. Equipped with a combination of obsolete equipment and new aircraft still being introduced into service, the VVKJ was forced to defend the country's long borders against multiple attacks from many directions. The dubious loyalty of some military personnel did not help matters. Yugoslav fighter aircraft and anti-aircraft artillery brought down about 90–100 enemy aircraft, but defending forces were unable to make any significant impact on the enemy advance. During the attack of German aircraft on Niš Airport Medoševac on 6 April, fire from the ground shot down the plane of German fighter ace Herbert Ihlefeld. In 1940, Britain attempted to bring Yugoslavia to the Allied side by supplying military aid to the Royal Yugoslav Air Force, including new Hawker Hurricane fighter aircraft. However Germany sold a large number of Messerschmitt Bf 109 fighters to Yugoslavia and in early 1941, and German dismay towards a Balkans campaign convinced Yugoslavia to join the Axis forces. Little wonder then that after a combination of air combat losses, losses on the ground to enemy air attack on bases and the overrunning of airfields by enemy troops that after 11 days the VVKJ almost ceased to exist. It must, however, be noted that between 6 and 17 April 1941 the VVKJ received an additional 8 Hawker Hurricane Is, 6 Dornier Do 17Ks, 4 Bristol Blenheim Is, 2 Ikarus IK 2s, 1 Rogožarski IK-3 and 1 Messerschmitt Bf 109 from the aircraft factories and workshops. In the years after WW2 we observed tremendous development of Yugoslavian Air Forces and it was due to research and maintenance support delivered by research centres (SOKO) and academia. Important role in this process played the Mostar Technical university, too.

Keywords: Aircraft design, history

1. Establishment of Yugoslavia

After the end of the First World War in 1918, the conditions were created for the creation of a state that would gather the South Slavs who lived in the territory of Serbia, Montenegro and the Slovenian parts of Austria-Hungary. The SHS Kingdom was created with the crucial help and arbitration of Serbia's western allies [1]. From the very beginning, the unresolved national question represented the main problem of Yugoslav internal politics and strained relations with neighboring countries (Italy, Bulgaria, Albania, Austria and Hungary).

2. The Yugoslav Royal Air Force in the attack on Yugoslavia

The attack on Yugoslavia began on April 6. in 1941. The Yugoslav Royal Air Force was the only branch of the army of the Kingdom of Yugoslavia that met the beginning of the April War in full force and in a state of readiness. With the secret mobilization that began on March 12, 1941, the aviation units occupied 23 military airfields and airfields provided for in the "R-41" war plan [1]. According to this plan, the number of fighter planes was 142, while the number of bombers was 147. On 4/7/1941, the Yugoslav 8th Bomber Regiment attacked German airfields near Szeged and Pécs (in Hungary), losing 8 aircraft [2].

Types of aircraft in the armament in the April War:

- Fighters:
 - Avia BH-33
 - Hawker hurries
 - Hawker Hurricane
 - IK-2
 - IK-3
 - Messerschmitt Bf 109
 - Move-63
- Bombers:
 - Breguet XIX
 - Dornier Do-17
 - Bristol Blenheim
 - Savoja Marchetti SM.79
 - Caproni Ca-310
- Seaplanes:
 - Dornier Do-22
 - Rogožarski SIM-XII-H
 - Rogožarski SIM-XIV-H
- School planes and liaison planes:
 - Potez XXV
 - Zmaj Fizir FN
 - Fieseler Fi-156
 - Rogožarski PVT
 - Rogožarski R-100
 - Messerschmitt BF-108 Typhoon
 - Rogožarski Freshman
 - Aero-2

3. Occupation of the Kingdom of Yugoslavia in 1941 and Resistance

The occupation of the Kingdom of Yugoslavia in the Second World War (1941) was carried out by German, Italian, Bulgarian and Hungarian occupation forces. In accordance with the policy of the Axis Powers, Yugoslavia was then effectively liquidated as a state.

Resistance to the occupier began in June 1941 with the formation of the first partisan detachments, and on March 1, 1945, it grew into the Yugoslav Army, a regular military formation of the Democratic Federative Yugoslavia. The People's Liberation Army was led by the Supreme Headquarters, and its members were called partisans. Partisan strategy rejected holding rigid fronts, because at first it was not up to the task of dealing with the strongest and cruelest army in the world, without heavy weapons, mechanized units and air force. The NOVJ forces fought in complete encirclement of the enemy, without help from the side, until the fall of 1943 [3].

Partisans won the air force on 23.5. In 1942, when the pilots of two NDH Air Force biplanes (Potez 25 and Breguet XIX), Franjo Kluz and Rudi Čajavec, defected to the partisans in Bosnia [4].

June 4, 1942. First partisan pilots Franjo Kluz and Rudi Čajavec performed their first combat mission: bombed and machine-gunned Banja Luka, Zalužane airport. Franjo Kluz's plane was damaged and shot down there over Zalužani.

June 7, 1942. Partisan plane with pilot Franjo Kluzc, taking off from the base on Mount Kozari, bombed and machine-gunned the enemy garrisons in Dvor na Una and Bos. New. Although short-lived due to lack of infrastructure, this was the first instance of a resistance movement with its own air force. During the war, the partisan aviation was destroyed and re-founded several times until it became a permanent institution. The Partisans later organized a permanent air force, receiving aircraft, equipment and training from captured or defected pilots of the NDH, the British RAF, and later the Soviet Air Force.

On October 14, 1943, Supreme Commander of the NOV and POJ Josip Broz Tito issued an order establishing the First Air Force Base in Livno at the NOV and POJ High School and determining its headquarters and tasks.

On December 31, 1943, US President Franklin Roosevelt ceremoniously handed over American planes - Liberators - to a group of Yugoslav aviators from the 15th Army Air Corps.

1.07.1944 In Benin (near Benghazi, in Libya) the 2nd aviation squadron NOVJ was formed, consisting of: 16 airplanes of the type - Hurricane MK IV and 196 other fighters.

5.01.1945 In Novi Sad, by order of the NOVJ Aviation Headquarters, the headquarters of the 11th Aviation (Fighter) Division and the 42nd Aviation (Assault) Division were formed. Three fighter regiments Jak (111th, 112th and 113th regiments) joined the 11th division, and three regiments - IL-2 (421st, 422nd and 423rd regiments) joined the 42nd division.

Table 2 (Chapter10). lists the names of the planes used by the partisans, the time of use of those planes, and the number of planes that were available. Many of the mentioned planes were later used for many years after the war.

4. Airplanes produced in Yugoslavia

After the Second World War, the reconstruction of the industry in SFR Yugoslavia began. Thus, the production of airplanes continued and expanded. During that period, the production of airplanes took place in the following factories (Table 1) [5].

Factory	Airplanes
SOKO	Soko 522, G-2 Galeb, J-21 Jastreb, J-20 Kraguj, J-22 Orao, G-4 Super Galeb
UTVA	Utva 212, Utva 213 Vihor, Utva Aero 3, Utva 251 BC-3, Utva 56, Utva 60, Utva-65, Utva-66, Utva-75
Ikarus	Rogožarski IK-3, Ikarus IK-2, Ikarus 214, Ikarus 215, Ikarus S-49, Ikarus 451, Ikarus Aero 2, Ikarus Kurir
Ostali	Zmaj FP-2

Table 1 – Yugoslav airplanes

4.1 SOKO Mostar

Soko is a company for the production of combat aircraft in the former Yugoslavia with headquarters in Mostar. The company was founded in 1950 under the name Factory SOKO, and was later renamed to Soko Aircraft Industry.

In 1961, the first military model from independent development, SOKO Galeb, was released. Later, further models followed, as well as the production of a licensed helicopter under the name Gazela.

The main headquarters of the company is located near Mostar, with an area of 450,000 m². In addition to the main factory, there were plants in the surrounding towns with a total of about 8,000 workers (of which 5,000 in the parent factory). The company used Mostar Airport to test the aircraft.

The following planes were produced at the SOKO factory [3]:

a) Military planes:

- Soko 522
- Soko G-2 Galeb
- Soko J-21 Jastreb
- Soko J-20 Kraguj
- Soko J-22 Orao
- Soko G-4 Super Galeb

b) Helicopters:

- Aérospatiale Gazelle (produced under license)

c) Under development:

- Novi avion (NA)

4.2 The most important projects of the SOKO factory

The SOKO factory has successfully produced various types of airplanes. The most important projects will be briefly mentioned.

4.2.1 SOKO 522 (Falcon 522)

The Soko 522 (Figure 1) was a single-engine, two-seater aircraft of Yugoslav production intended for pilot training and light combat tasks [3]. The development of the Sokol 522 began due to the replacement of the wooden Utva 213 Vihor with an all-metal aircraft. As a large number of Pratt & Whitney R-1340-AN-1 radial engines were available at the time due to US military aid, the new aircraft was built as an Ikarus 213 metal structure with a Pratt & Whitney engine. It was designed by a team of engineers at the Ikarus aircraft factory in Zemun. After the production of the first two prototypes, all technical documentation is transferred to the Soko factory in Mostar, where a series of all 110 aircraft will ultimately be produced.

The first flight of the new aircraft Soko 522 took place on June 19, 1955.



Figure 1 – SOKO 522 aircraft

4.2.2 SOKO G-2 Galeb (Falcon G-2 Galeb)

The development of Galeb G-2 (Figure 2) began in 1957 at the Aviation Technical Institute with the creation of two prototypes, Galeb-1 (three rubber fuel tanks inside the hull) and Galeb-2 (two tanks in the hull + type tanks). The latter will become the basis for further serial production [1]. It made its first test flight on July 3, 1961, serial production began in 1963 at the Soko factory, Mostar, and the first example entered operational use on July 30, 1965. Development of the improved Galeb G-2 intended for export began in November 1969. A more powerful engine was installed, the fuel capacity was increased and the cockpit was improved. The only aircraft of this type was designated G-3 and was used for various tests.



Figure 2 – SOKO G2 Galeb jet training

4.2.3 SOKO J-22 Orao (Falcon J-22 Eagle)

The Soko J-22 Orao (Figure 3) is a Yugoslav-made attack aircraft that grew out of a cooperative project between SFR Yugoslavia and Romania called JUROM in the 1970s [3]. After the signing of the cooperation agreement in 1971, the JUROM cooperative association began research and processing of data on the then achievements in military aircraft. The Jaguar aircraft, also developed in joint cooperation between Great Britain and France, which was then approaching serial production, is often taken as a development model. The J-22 Orao is a high-wing aircraft that was made of duralumin, with conventional solutions. The Soko Mostar factories for Yugoslavia and the Central National al Industriiei Aeronautice Romane (CNIAR) were responsible for serial production. The first single-seat prototypes flew at the same time in Yugoslavia (J-22 Orao) and Romania (IAR-93) on October 31, 1974, shortly after on January 23, 1977, the two-seat NJ-22 prototype flew. Serial production began in Romania in 1979, while serial production in Yugoslavia began in 1980. In the first series, the Soko Mostar factory made 20 examples, which had certain modifications compared to the prototype aircraft.



Figure 3 – SOKO J22 Orao

4.2.4 SOKO G-4 Super Galeb (Falcon G-4 Super Galeb)

Soko G-4 Super Galeb (N-62) (Figure 4), school-attack aircraft of Yugoslav production. The crew consists of two members who sit in a tandem position, with the rear part slightly raised compared to the front part, for better visibility. The aircraft first flew on July 17, 1978, and serial production began in 1982. The G-4 Super Galeb was built to replace the G-2 Galeb and the Lockheed T-33 in the Yugoslav Air Force [3].



Figure 4 – SOKO G4 Super Galeb

4.2.5 New plane NA (Novi Avion)

The New Plane (Figure 5) was the working name for the Yugoslav program of a 4th generation multipurpose supersonic fighter. The abbreviation NA was used for that program, which simultaneously stood for New Aircraft and Supersonic Aircraft. The first ideas about starting the program arose in the SFRY after the prototype of the Soko J-22 Orao plane took off in the 1970s [3]. Since Yugoslavia only had to import military aircraft as part of its military equipment, the New Airplane was an effort to make the country completely independent in this regard. The implementation program was discussed and finally created in 1986. All work on that program was interrupted by the collapse of the SFRY in the early 1990s.



Figure 5 – An artist's rendering of an armed New plane NA in flight

4.2.6 Aérospatiale Gazelle

The Aérospatiale Gazelle (Figure 6) is a helicopter designed in France and manufactured by the Aérospatiale company. The Gazelle was created as a result of the French Army's demand for a light helicopter that would perform various combat tasks. The new project soon became interested in Great Britain, which joined the development with the Westland company. According to the contract signed in February 1967, 292 Gazelles and 48 Pumas would be produced in Britain, and in return, Aérospatiale

was given the role of a collaborator in the development of forty Westland Lynx helicopters, which were produced for the needs of the French Navy. Today, the Gazelle is slowly being replaced by the Eurocopter Tiger, but the Gazelle will remain in service as a light transporter. The Gazelle was also produced in the Yugoslavian factory Soko [3].



Figure 6 – Light helicopter Aérospatiale Gazelle

5. Establishment of the Faculty of Mechanical Engineering in Mostar

In 1959, the Higher Technical School of Mechanical Engineering was founded in Mostar. After its establishment, this institution experienced various transformations and organizational and legal structures. In 1976, it became an independent higher education institution under the name Faculty of Mechanical Engineering within the University of Mostar. There were four departments at the Faculty of Mechanical Engineering: Construction Department, Production Department, Organization Department and Aviation Department. A large part of the teaching and assistant staff was hired from the "SOKO" factory. Later, a large number of engineers from the Faculty of Mechanical Engineering worked at the SOKO factory to manufacture airplanes and helicopters. Also, teachers of the Faculty of Mechanical Engineering, together with their colleagues from SOKOL, conducted numerous experimental tests of materials and structures, manufacturing technologies and joining of structural parts, as well as numerous research projects related to titanium processing for the production of supersonic aircraft. It is also necessary to mention the very successful cooperation between the Faculty of Mechanical Engineering of the University of Mostar and the MEL Department of the University of Warsaw. From 1979 to 1990, there was a constant exchange of professors and assistants from the this two institutions. The purpose of this paper is to express gratitude to the many professors, assistants and engineers who participated in the mentioned projects.

6. State before civil work

In 1991, Yugoslav Army had: 1,850 medium tanks, 13 light tanks, 240 reconnaissance armored vehicles, 490 infantry fighting vehicles, 500 armored personnel carriers, 1,934 large-caliber artillery pieces (from 105 mm upwards), about 3,000 120 mm mortars and 3,400 82 mm mortars. , 1799 anti-tank guns, 449 aircraft and 190 helicopters, 11 submarines, 15 missile boats and gunboats, 14 torpedo boats and 79 other ships [6].

Since the 1960s, the Air Force has been developed according to the requirement to have 400 combat aircraft. Fighter aviation had 167 combat aircraft of 16 modern MIG-29 fighters, and the rest were obsolete MIG-21 fighters, of which 77 were their best variant, type BIS. The bulk of the air force consisted of the obsolete subsonic attack planes Jastreb and Orao and the solid training plane Supergaleb, which was also used as a fighter-bomber.

7. The situation after the civil war

During the war in Bosnia and Herzegovina, the SOKO factory was in the conflict zone and most of the machines were destroyed or stolen. After the civil war, seven smaller states were created. The planes that were abandoned after the war are obsolete. Serbia bought 6 used MIG-29 planes. After that, Croatia ordered 12 used Rafale planes. A year later, Serbia ordered 12 new Rafale planes. Other countries are small and do not have enough funds to buy airplanes. That is why Montenegro, Kosovo and Bosnia and Herzegovina ordered 6 Barjaktar B2 drones each.

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10. Appendix

Names of the planes	Start of use	End of use	Number of planes
POTEZ 25 A2	23.5.1942.	6.7.1942.	1
BREGÉ 19 b2	23.5.1942.	4.7.1942.	1
FLEET TRAINER	6.10.1943.	10.10.1943.	1
S.A.I.M.A.N. 200	9.1943.	9.1943.	1
CAPRONI CA-311	1943.	1945.	12
FIESLER Fi 156 C-1	1943	1947	1
AVIA FL-3	29.10.1943.	1945.	5
DORNIER DO-17	13.11.1943.	1947.	6
FIZIR FP2	1944.	1947.	13
BUCKER BU 181	10.1944.	1945.	2
BUCKER BU 131	10.1944.	1948.	6
FIAT G50 BIS	2.9.1944.	1945.	2
FIESLER FI 167A0	25.9.1944.	1948.	4
JUNKERS JU 52/3M/AAC1 TUCKAN	24.10.1944.	1945.	4
MORANE-SAULNIER MS406	21.9.1944.	1945.	11
BENES-MRAZ BE51	21.9.1944.	1945.	2
BUCKER BU 133 JUNGMAISTER	1945.	1956.	3
SPITFIRE	22.4.1944.	18.8.1952.	21
HURRICANE	1.7.1944.	18.7.1952.	16
JAK-3	1944.	1957.	71
JAK-7	1944.	1947.	18
JAK-9	1944.	1960.	74
JAKOVLJEV UT2	1945.	1956.	46
ILJUSIN IL-2	1945.	1955.	122
GOTHA GO 145	1944.	1945.	1
JUNKERS JU-87B-2 STUKA	1945.	1947.	2
MESSERSCHMIT BF 109G	1944.	1946.	19
BRISTOL BLENHEIM MKI	1945.	1947.	1
PERCIVAL PROCTOR MK3	1945.	1947.	2
AVRO ANSON MKXI	1944.	1945.	3
De HAVILAND DH 82	1945.	1949.	49
NORTH HARVARD MKIIB	1945.	1960.	10
FOCKE WULF 190A-8	1945.	1947.	8
JUNKERS JU W 34Hi	1945.	1952.	2
ROGOZARSKI R100	1944.	1959.	6
ROGOZARSKI PVT	1945.	1947.	2
FIZIR FN	1945.	1948.	15
LISUNOV LI 2	1945.	1959.	17
SCERBAKOV SCE2	1945.	1952.	6
PETLJAKOV PE 2 FT	1945.	1954.	123

Table 2 – List of planes used by partisans