

Robert Bartini and His Contribution to the Development of Transport and Aviation

Sergej Težak¹

¹ University of Maribor - Faculty of Civil Engineering, Transportation Engineering and Architecture, Smetanova 17, 2250 Maribor, Slovenia

sergej.tezak@um.si

Abstract. After the First World War, the young Soviet Union (USSR) desperately needed new engineers and scientists who would provide the new country with development of modern industry and transportation. At that time, Western European countries had knowledge and experience, especially in the field of aviation. One of the young engineers was Robert Bartini, who was educated in Austria-Hungary and Italy, and graduated from Milan Polytechnic Institute. In 1923, he fled Italy to escape Fascists and emigrated in Soviet Union. This article is a brief description of aircraft designer Robert Bartini and his role in the development of the military, passenger and transport aviation. In addition, it presents his vision of the intercontinental and continental high-speed transport, which was his focus in the last years of his work and creation. He worked as a researcher and expert in the former Soviet Union, therefore, more detailed and relevant information on his work has been revealed to the public in recent years. In Russia, he is very popular as a researcher and developer. There are many books about him in Russian and Italian language, but not in English. Thus, his work is still quite unknown in the West. He was born in Kanjiza (today Serbia) in 1897, and spent his youth in Fiume (Rijeka, today Croatia).

1. Introduction

During the cold war, the superpowers the United States (USA) and the Soviet Union (USSR) wanted to demonstrate their achievements in development of military technique and technology. Furthermore, the two superpowers wanted to show their best in the field of engineering and technology for civil purposes. Above all, this competition was reflected in the conquest of space and in the field of aviation, where the former Soviet Union wanted to be presented abroad in the best light. Knowledge in this area could not be obtained in a short time, so it was necessary to invest years and years into development, testing and learning from mistakes. Due to the lack of prior knowledge, both superpowers were hungry for scientists and researchers, mainly from Europe. They contributed an important part in the development of space technology and aviation. Most of the necessary knowledge and human resources superpowers gained after the Second World War. However, many scientists fled from the unstable pre-war Europe to the United States before the war, whereas in the Soviet Union this phenomenon was not detected.

After the First World War, the Soviet Union wanted quicker progress in the field of aviation because of the size of this state. In the twenties, the most famous pioneers in space transportation (Tsiolkovsky) and builders of large airplanes (Sikorsky, Tupolev) came from Russia, but knowledge in Western Europe in the field of aerodynamics made great progress. Especially Italy at that time



possessed a superior knowledge in aerodynamics, which was rewarded with a world speed record in aviation in years 1927-1929 and 1933-1934. Therefore, it is not surprising that Robert Bartini immigrated to Russia in 1923. He was a young Italian aviation engineer and communist proving his skills in the fields of aviation in the next 50 years in the Soviet Union. In this case, it was a classic transfer of knowledge in the new young Soviet Republic.

2. Life and work of Robert Bartini in field of Aviation

Robert Bartini was born on May 14, 1897 in town Kanjiza (today, this is the town in Serbia near Hungarian border) which was stated in his documents when he lived in Soviet Union. [1]. When he was 3 years old, he was adopted by the family of rich state official in the town of Fiume in the Austro-Hungarian monarchy (today Rijeka in Croatia). In his youth, he had a surname Orozdi (Orozhd) [2]. As a young boy, he was very intelligent; therefore, he had additional education by the family teacher in natural science (chemistry, biology), music and foreign languages [3]. In 1912, he saw an airplane and airshow of Russian aviator Slavorossov in Rijeka, and he was fascinated. In 1915 he graduated from grammar school in Budapest [2], was drafted and sent to school of officers' reserve located in the town of Bystritsa (in Czechoslovakia) and then in 1916, he was sent to Russian-Austrian-Hungarian front where he was captured in June 1916 [4]. He was sent into captivity in the Far East in prison camps Khabarovsk and Vladivostok. He was released after the First World War, and then he worked as a taxi driver in Shanghai. In 1920, he returned home in Fiume. When working at Isotta-Fraschini facilities, he graduated from Milan Polytechnic Institute in 1922. In the same year, he graduated from pilot school in Rome. During the captivity in Russia, Bartini came under the influence of communist literature, and in 1921, he became a member of Communist party of Italy. In 1923, the Fascists took over the control in Italy and Bartini was sent to the Soviet Union. When he was leaving the Italy over Alps, he vowed, "red planes will always be faster than black" [3]. When he was the member of the Communist party of Italy, he worked underground and he got nickname »Red baron«, which he kept in Soviet Union as well.

After the arrival in the Soviet Union, Bartini served next six years as a mechanical engineer and the head of department at scientific and test aerodrome (now Chkalovsky). Later, he was transferred to the First Squadron of Naval forces of the Black and Azov Seas. In 1925, he participated in the national gliding championship in Crimea and together with designer Myasitchev cooperated as a constructor and pilot [1]. In 1928, he became the head of the department of amphibious experimental aircraft design and was appointed as the chief engineer of the Black Sea aviation. Next year he participated in organization of ANT-4 "Soviet Country" aircraft flight to America, servicing in sea segment of the route. In the red army, Bartini reached the rank of a brigadier (Brigadier General).

Bartini returned to Moscow and worked as Chief designer of his projects in seaplane design bureaus at facilities No 22 and 39 until the August 1930. He was dismissed from the design bureau due to his critical letter to Stalin, but Air Forces authorities organized small design bureau for him at facility No 22. In this office, he began to design a new aircraft, Stal-6 (Steel-6) with an incredible clean contour. "I saw an airplane like a beautiful naked girl", said former test pilot a half century later, when he saw the "top-secret" aircraft for the first time [2]. The "Stal-6" aircraft was a monoplane configuration fighter airplane with inventive solutions: full retraction of bicycle landing wheel, closed cockpit with transmission gear in elevator control linkage, and engine evaporative cooling system with coolers-wing tips. Structure and aerodynamics of this aircraft permitted the speed 420 km/h in 1933, [5]. It was 150 km/h more than best fighters in Soviet Union at the time. The aircraft had V-12 engine with 630 hp and it was made of stainless steel "enerzh 6". Two years later (1935), Bartini designed the "Steel-8" fighter reaching the speed 630 km / h, but it was not selected for the proposed Soviet fighter. If the Soviet Union had chosen this plane for further development, then they would have had a superior fighter for defending "mother Russia" from Germans by 1941.

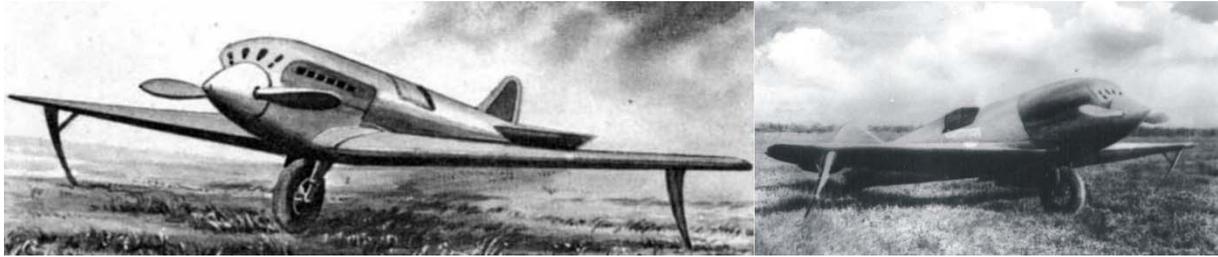


Figure 1: Aircraft Bartini Stal-6 (Steel 6), [11]

In 1934, Bartini began developing the Stal-7 aircraft, which was twin-engine passenger aircraft, exhibited at the Paris Salon in 1936. In 1939, the aircraft reached a new world record for a distance of 5000 km, it was flying over 5068 km with average speed 405 km/h. The top speed of this aircraft was 450 km/h. The Stal-7 was ready for the flight around the world, which was prevented by the arrest of the chief designer Bartini. They imprisoned him in 1938 and accused of being Mussolini's agent and participating in the burning of building no. 240, where the aircraft Stal-7 was placed. First, he was sentenced to death and imprisoned in the disreputable NKVD prison Lubyanka in Moscow. When his plane reached a world record, Stalin “personally” took care that Bartini’s sentence was reduced to standard 10 years in prison. Bartini was transferred to secret research and development camps KB (Sharaskas) in different towns: Moscow, Omsk, Kazan and Taganrog. At that time, the Stal-7 aircraft was one of the greatest secrets of the Soviet Union, leaving behind only one short film clip and some photos. Under the leadership of V. Ermolajev and advice of Bartini, the plane began to transform into the long-range Yer-2 bomber, resulting in about 400 Yer-2 aircrafts.

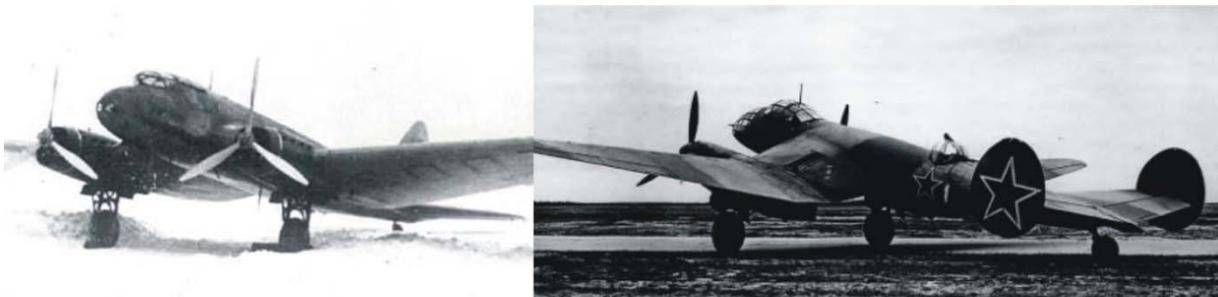


Figure 2: Passenger aircraft Bartini Stal-7 and bomber Yer-2 (Er-2), [12]

During the Molotov Ribbentrop pact, the aircraft was intended for attacks on Britain and France and their bases in the Middle East. Instead, the Yer-2 aircrafts were engaged in night-time attacks on Berlin at the time when Germans were sure they were invisible. The first bombing was already on August 8 1941. In fact, the Soviets bombed Berlin directly from Moscow. At the beginning, Germans did not even know what they were dealing with. Their fighters were simply too slow in 1941.

During the period from 1940 to 1943, Bartinini’s main concern in the custody in Moscow and Omsk was faster-than-sound aircraft with rocket power. The project of his first P-114 (Cyrillic P = R for rocket) interceptor with swept wing was not realized. [4]. The P-114 was designed for speed more than 2000 km/h. At that time (1943), Bartini already knew that the best wing shape for speeds beyond Mach 2 is delta wings.

Then he started constructing the first wide fuselage (wide-body) transport aircraft T-117 for transport tanks. This was the first aircraft with transport ramp/door at the back of the plane, for easier loading/unloading of cargo. The plane was already constructed in Taganrog, but necessary engines were not supplied. Those engines were required for the production of Tupolev Tu-4 bombers, which

were a copy of the American B-29 bombers. Stalin said that Russia needed bombers, not transport aircrafts. In addition, new invented aircraft T-117 did not flight, so the project was laid off. T-117 aircraft drawings were sent to Antonov's company in Kiev. Many of Bartini's designs were later used on Antonov aircrafts. In 1946, Bartini was released and his design bureau in Taganrog was closed, the T-117 plane was destroyed and cut. Antonov design bureau was the first wide-body transport aircraft constructed a decade later.

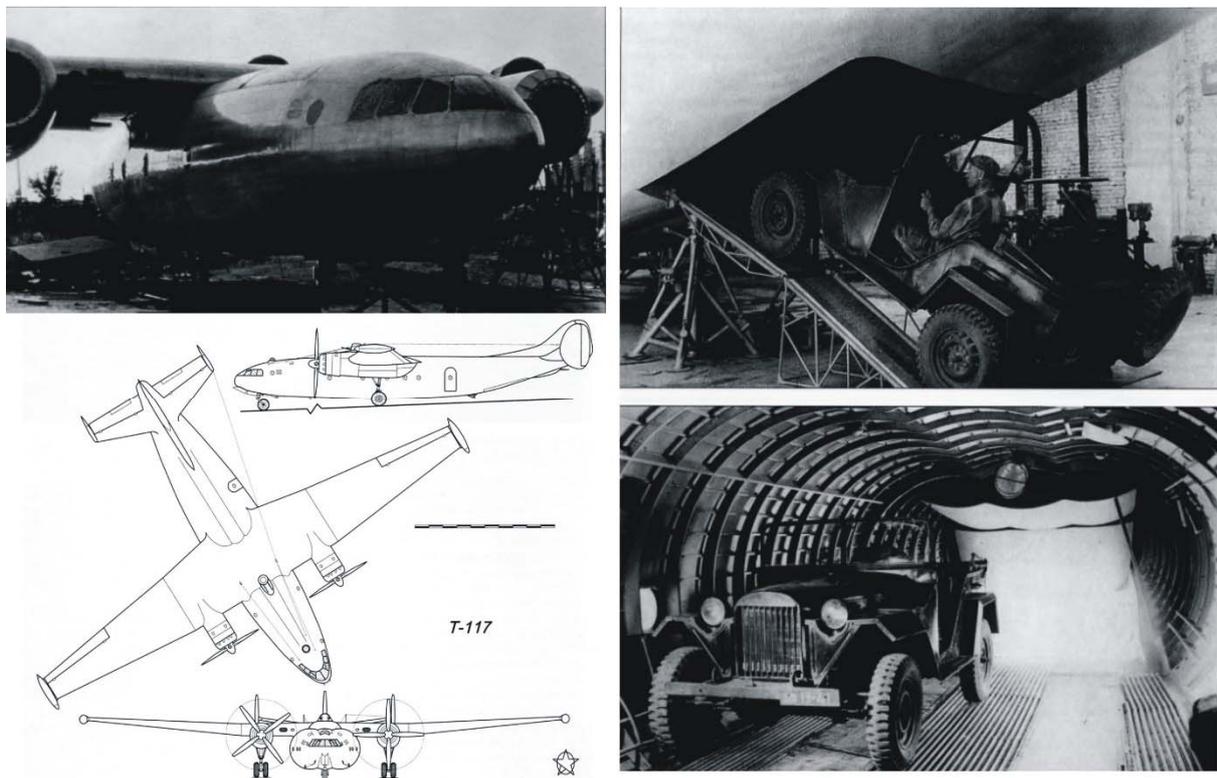


Figure 3: First wide body aircraft: Bartini T-117, [5]

After the release, Bartini decided to continue the work in Taganrog and design even more T-200 and T-210 transport aircrafts, but the realization of projects did not occur. In 1952, Bartini moved to Novosibirsk where he began his research and made aerodynamic calculation for the optimum shape of wings for supersonic speeds. Based on these investigations, he designed T-203 project - variable sweep wing with aerodynamic twist. Therefore, he began to develop the plans for strategic bombers A-57 and A-55 at speeds of 2200 to 2500 km / h with the possibility of landing on the water. At that time, Soviet bombers did not have sufficient range to reach the coast of the United States and returned to Soviet Union. Bartini found an innovative solution for aircraft landing on the water, where Soviet submarines could supply fuel to the aircraft. However, Soviet authorities refused the project in favour of the development of ballistic missiles. The results of Bartini's research and results about wings for large aircrafts in supersonic speeds were sent to the Tupolev design bureau. These solutions were used there to design the supersonic Tu-144 passenger aircraft and the Concorde aircraft had the same wing design, too.

3. Bartini's vision of the intercontinental high speed transport

Bartini was completely rehabilitated in 1957 and he returned to Moscow, where he worked in a small Kamov construction bureau. During this time, he began to study and compare the various forms of the transport and determine the most energy corresponding type to a certain speed.

Bartın developed a "Theory of intercontinental transport on Earth", which was completed in the sixties. This theory takes into account the entire planet Earth for the implementation of transport services for ships, planes, helicopters, railways.... In addition, the interdependencies between the various criteria are considered: the amount of load, speed of delivery, the weather conditions and the area required for various operations (stopping and moving vehicles, facilities for loading and unloading ...). He came to the solution that the most optimal vehicle can fly just above the surface; it can take off and land vertically and can be applied on all surfaces - snow, water, earth, ice, and sand. [6]

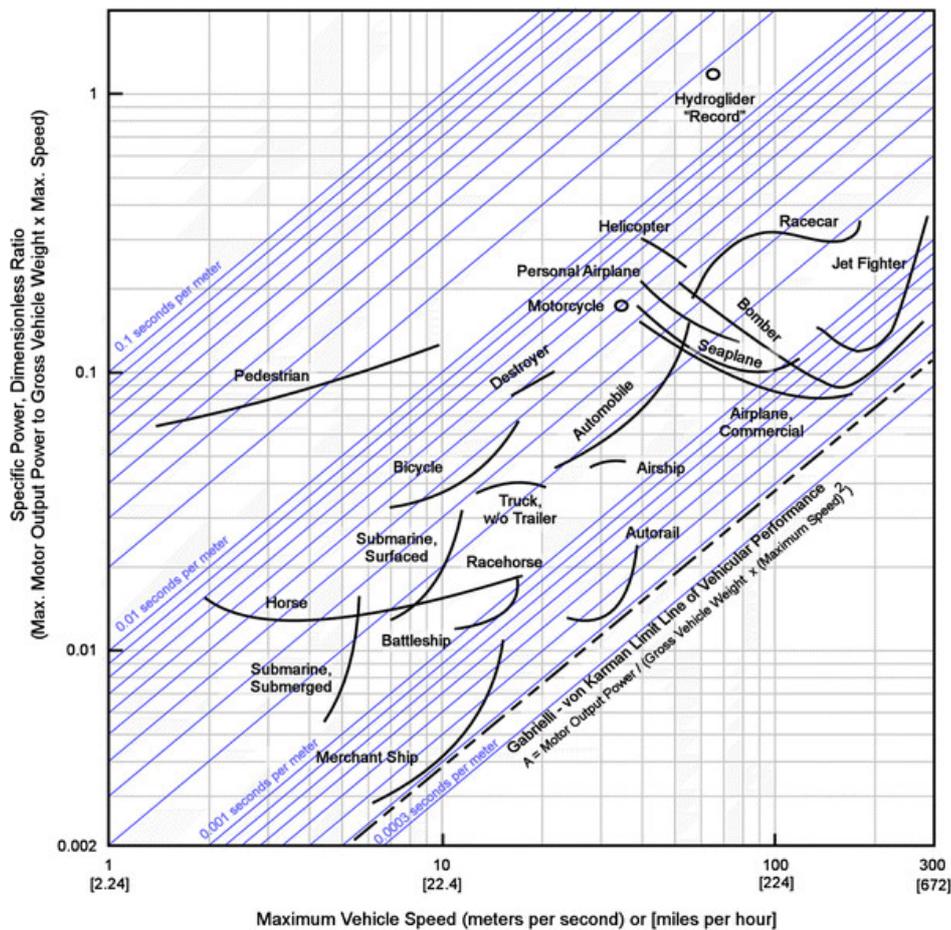


Figure 4: Transport efficiency diagram for different means of transport, [13]

Similar research about efficiency of the different means of the transport was launched by Von Karman in the fifties of the last century. He noted that the “hydroglider” had the highest efficiency; in those times, this was probably the original term for the WIG vehicle or for ekranoplan (Russian term). The term WIG vehicle or ekranoplan is used for vehicles that use ground effect – WIG effect (Wing in Ground effect).

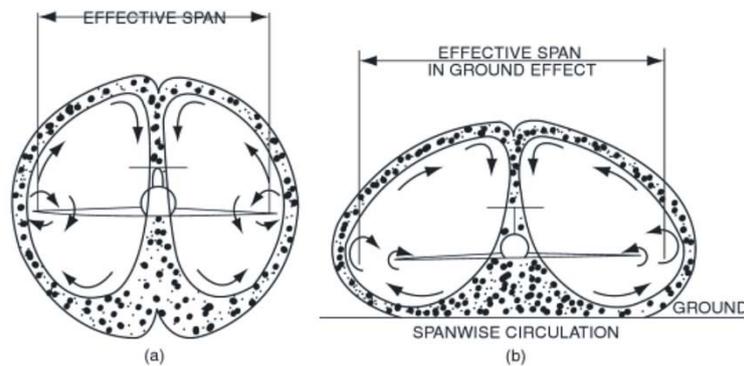


Figure 5: Airplane in normal flight and in flight with WIG effect, [14]

The optimum flight is just above the flat surface where vehicles can take advantage of ground effect. Vehicles using ground effect achieve up to 30 % more lift than normal planes at the same wing surface. Therefore, the ground effect enables less surface of the wings for the same lift force. Moreover, it is also less resistant, which is best seen in the diagram below.

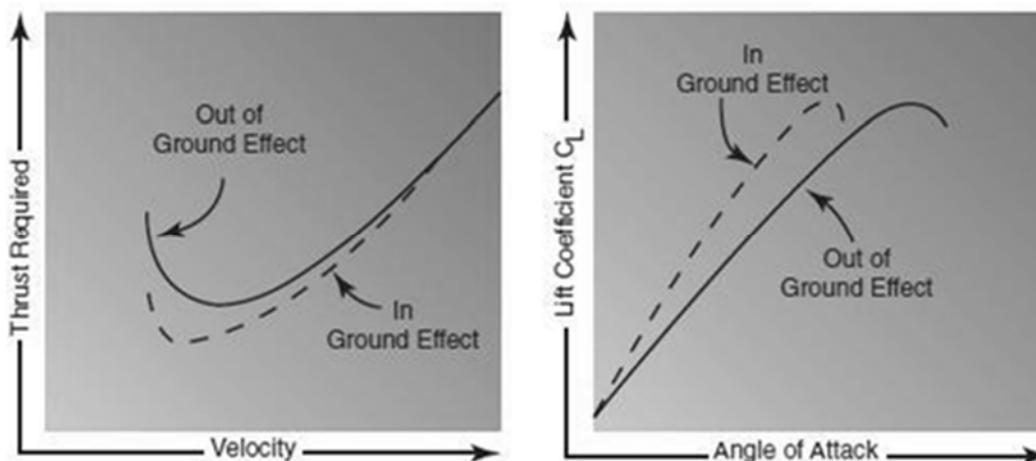


Figure 6: Wing in ground effect flight changes drag and lift, [15]

In the sixties, Bartini began to develop the VVA-14 prototype aircraft, an amphibian plane in order to prove his theory. This plane could land on all possible surfaces, sea, earth, ice, and sand. It had an option for vertical take-off and landing or conventional take-off and landing from both airports and water surfaces. More importantly, WIG flight could save enough fuel for the vertical take-off or landing of the aircraft. The plane was made in the Beriev factory. The first test flight was carried out in 1972, but 14 engines needed for vertical take-off were never delivered. The plane made a series of test flights, took off on land and water in the conventional way (without testing vertical take-off and landing). However, further development was not approved.

Bartini's design of WIG vehicles is probably the most efficient because the catamaran design with an open space between the floats, which accumulates compressed air, provides additional lift.

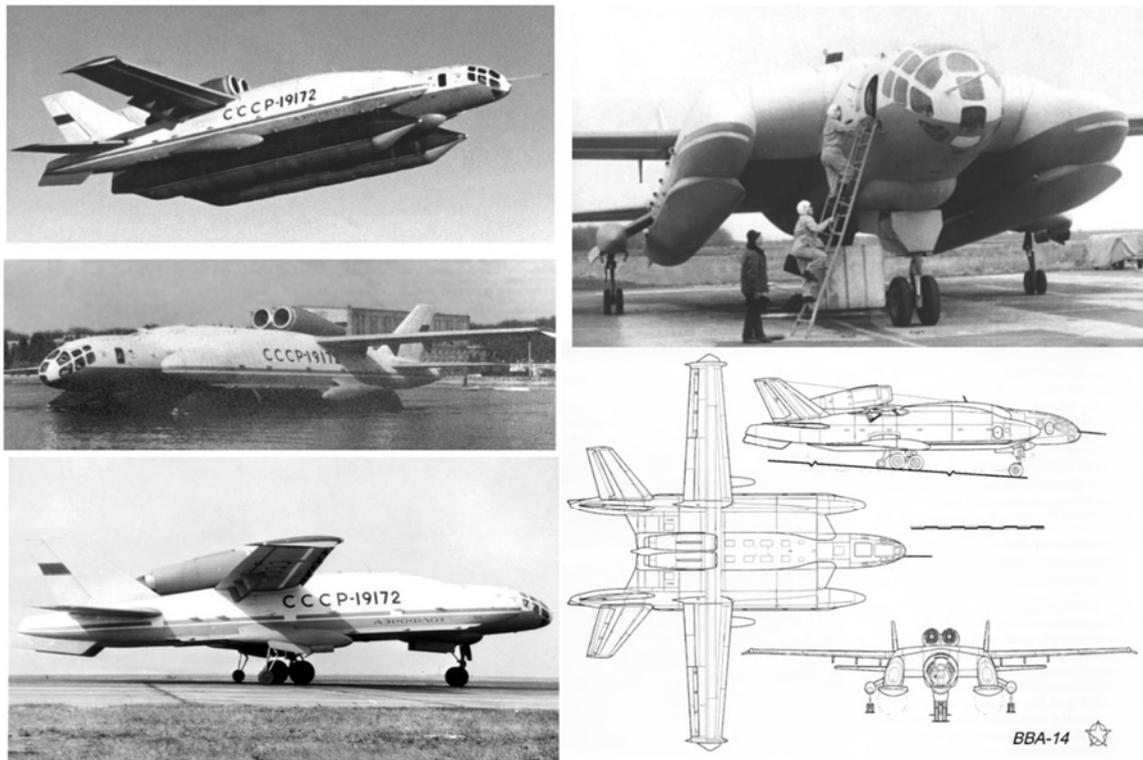


Figure 7: Amphibian airplane Bartini-Beriev VVA-14, [16]

Bartini imagined a vehicle with greater utilization of ground effect, which could be used at high-speed in transcontinental freight and passenger transport. Such ekranoplans would be more efficient than today's airplanes; they could transport more passengers and cargo, and could actually still work in “friendlier” environment such as height above 10 km.



Figure 8: Model of the WIG aircraft carrier and ekranoplan T-500, [17]

He continued with his ideas, and designed an ekranoplane with weight of 2500 tons and 5000 tons, serving as an aircraft carrier and operating at speeds of 500 km/h. In such high speeds, aircrafts do not need a long runway for take-off from the aircraft carriers. Aircraft carrier would travel at the same speed as the airplane. Bartini was also considering quick continental transport. In the sixties, he imagined monorail vehicle traveling at high speed. Its performance based on the compressed air such as hovercraft (ekranohod) [3], or on magnetic levitation (magnitoplan) [1]. The project was presented to the minister of transport B.P. Beschev and was also approved, but never realized. Bartini constructed additional aerodynamic surfaces at the sides of the vehicle to increase the lift or to control the correct distance of vehicle from the track.

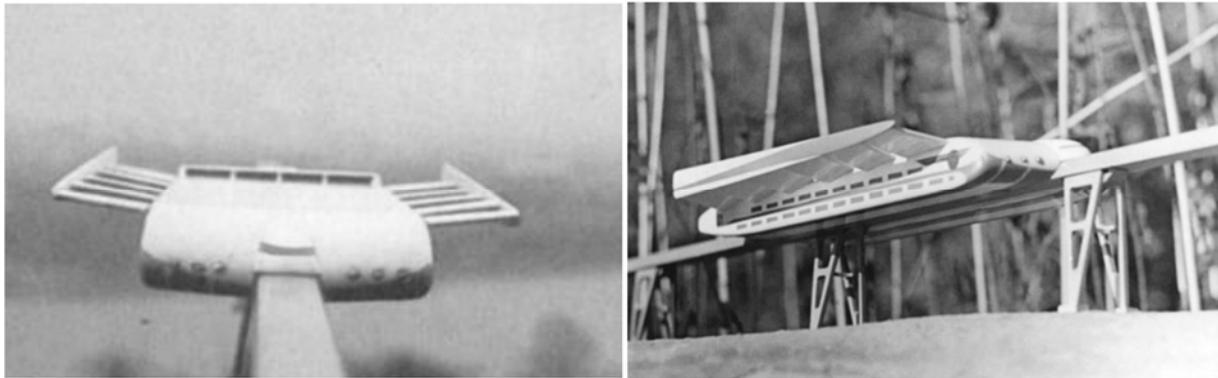


Figure 9: Model of the future transport system (magnitoplan or ekranohod), [5]

4. Bartini's work in other fields of cration

In today's Russia, Robert Ludcigovich Bartini is described as a misunderstood genius whose ideas were ahead of his time, comparing him with Nikola Tesla. He is portrayed as the aircraft designer, physicist, astronomer, philosopher, painter, musician, and polyglot (he spoke seven languages and read nine).

He cooperated many times in his life with Sergei Korolev. When Sergei Korolev was appointed as the head of the Russian space program, he requested Robert Bartini as his mentor twice. Before this, Korolev often called Bartini his teacher. Namely, Bartini was a head of Korolev for the first time before the second world war, when he worked in Bartini's design bureau. Secondly, they cooperated in captivity (sharaska) when Bartini developed the rocket interceptor P-114. Sergei Korolev personally exerted his influence with Soviet authorities over Bartini's project of the supersonic strategic bomber A-57. Korolev and Bartini also worked together on solutions to increase the range of the Myasitshev M-4 strategic bomber. Neither presence nor the role of Bartini in advising the Soviet space program is not yet fully known. In the last years of his life, he was primarily engaged in the exploration in physics, cosmology and philosophy.

Bartini always tried to encourage innovative solutions. He gave an interesting answer to the question about what to do if the class filled with young professionals is given a problem, which should be solved in an innovative way. "Class must be extended", he responded. This means that many experts with their ideas from different fields of activity are more capable to get a better solution. Bartini considered formulating mathematical method or model to determine the prosperity of the idea or the patent. He developed a method AND-AND, which based on recognized search solutions, which had already been used, and therefore could predict the success of a given patent/idea for a new problem. He developed the method already in the nineteen thirties and it was called a method for the detection of talents. A similar but more general method was developed over 20 years later by Genrich Altshuller, who became famous with the TRIZ method. TRIZ method was spread to Western countries with the disintegration of the Soviet Union and is now quite well known.

The whole time of working in the Soviet Union, Bartini was solving problems in aerodynamics in a special way. He said that mathematics was the most exact science, and there was no doubt in it, whereas physics is derived science and the physical findings change over the centuries. He most doubted about physical constants, which he considered to be dependent of the specific "time and space". In 1965, he published an article on this subject, entitled "The relation between physical constants" [7]. The English version of the article was published in 2005. [8]. He claimed that the universe takes the form of six dimensional torus - three dimensions of space and three dimensions of time. Dimensions of time include: the first dimension is a length of time (the duration of the existence of the object), the second dimension of time is the width of time (number of cases/copies/ images of body (parallel worlds), the third dimension is height of time (the speed of time is different in each of the worlds). Six-dimensional universe by Bartini is parallel streaming of times [1]. Of course, such

revolutionary ideas caused him great problems, and they did not want to publish his article (because he basically was not a physicist and was quite unknown in the world of science). However, Bruno Pontecorvo advocated for Robert Bartini and his article. Bartini gave to this article great importance, he signed it as the author with the full name Robert Oros di Bartini. [9] It is interesting that the article even promised the proof of author's theory, but he died soon. Bartini used this physical theory to deal with his aerodynamic problems and came to excellent solutions. What is more, Bartini developed entire philosophy on his physical theory of time. Therefore, his 6-dimensional world was named Bartini's world. Russian scientists considered Bartini's theory of time as a basis for development of a time machine.

Bartini drew pictures in his lifetime; some were on the walls of his apartment for his well-being and better concentration at work. He had 3 children, 2 sons and a daughter and three grandchildren. [10] The first son Gero was a climber and died in 1959, the second son Vladimir lives in Taganrog and is an engineer. In 1967, Bartini got order of Lenin for his life achievements. In 1957, he got order of October revolution.

Quite speculative and almost incredible or unbelievable but very interesting claims or mysterious stories appeared about life and work of Robert Bartini in Russia [2]:

- Bartini, in the twenties and thirties, founded and headed a secret group ATON, which members were renowned Soviet writers (sci-fi) and scientists,
- Bartini was as a prototype for Woland from the novel *The Master and Margarita*, since its writer Bulgakov was also a member of the ATON. The novel was written at the time when Stalin put in prisons and killed the "blossom" of Soviet intelligence (writers, engineers, scientists, officers) and during this time, Bartini was imprisoned as well.
- Bartini was mentioned as the mysterious aircraft designer "Dunaev" that constructed the invisible plane.
- The whole story of Bartini's youth was invented, so the NKVD was very suspicious about him.
- Altschuller summarized the ideas of Bartini to develop his own method of TRIZ, as they were in contact.
- Robert Bartini and Leo Szilard - physicist who discovered a chain reaction were sitting at the same table in high school in Budapest.
- Before his death, Bartini wrote a will in which he demanded that his manuscripts are sealed and opened in 2197 (at 300th anniversary of his birth).

5. Conclusion

The story of Robert Bartini is very interesting because he was unlike any other European scientists and researchers working in the Soviet Union. It is even more amazing that he was a son of powerful and rich Baron and he decided for communism. Otherwise, stormy first half of the 20th century with two world wars in Europe was not lenient to the fate of the people who are mutually intertwined in the most unusual combinations.

Early in his career, Bartini had luck and was rapidly promoted in the army and continued to work in the construction of aircraft, supported by his patron Marshal Tukhachevsky, former leader of the Soviet armed forces (Red army). When Tukhachevsky, Bartini and other officers were arrested before the Second World War, Bartini was lucky to survive. Since then, the authorities in Moscow did not support him any longer. After the war, he was able to realize only one idea - a prototype of the VVA-14 aircraft. With his work, Bartini was the most complete to his colleagues - Russian aircraft constructors. New ideas boiled out of him, so they were jealous and probably Soviet authorities could not allow their planes to have an Italian name.

As a designer, he managed to make fly only four aircrafts-prototypes; nevertheless, his ideas and solutions were used by other aircraft designers. Like many other geniuses, he was not suitable for the implementation of mass production of aircrafts but he was always looking for something new. His work includes about 60 aircraft designs and ideas for about 200 aircrafts. As a genius, Bartini had similar characteristics to Nikola Tesla, namely, he formed his devices in his head and then just draw

what he saw in his mind. Above all, he was acclaimed as a very good teacher, because he was happy to share his knowledge with younger Soviet designers, who later created very successful aircrafts such as Beriev, Korolev, Simonov (chief designer of Su-27) and others.

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