



RETRACING THE PUCH TRACK

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Cover back outside: Motorcycle MV Agusta F4-750, owner Saša Margon, author Peter Grom

Cover front inside: source "100 Jahre Steyr-Daimler-Puch Graz", 1999

Cover back inside: source "100 Jahre Steyr-Daimler-Puch Graz", 1999

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THE CENTURY OF ENGINEERING AND MOTOR VEHICLES IN CROATIA

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ABSTRACT - Owing to its geographical position in the centre of Southern Europe, during the stormy 20th century Croatia not only participated in the promotion of technical inventions and ideas, but also took part in the development and production of machines, ships, and motor vehicles. This paper considers some of the most significant means of land, air, and water way transport that marked the last century in these areas, with special attention paid to the production of motor vehicles.

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INTRODUCTION

Late in the 19th century Europe witnessed a boom in technical development. The internal combustion engine, the motorcycle, the automobile, and the airship announced a new age. Yet, even the very few could have dreamed that the 20th century would throw into the shade the most daring Jules Verne's visions. A tiny spot on the map of Europe, situated on the crossroads between the East and the West, the North and the South of the continent, more often suffering years of hardship than enjoying the benefits of global changes, Croatia managed despite all that to take more than a humble part in the amazing development in the field of engineering.

THE NORTH ADRIATIC, THE DEEP BLUE SEA

Dividing land and sea, the coast has always symbolised a point of contact and separation, meeting and parting. From there, people set on long journeys to other parts of the world, and after having shared ideas with other people, return home enriched with new experiences. In the North Adriatic, where the Mediterranean thrusts deeply into mainland Europe, sailing, trade, shipbuilding, manufacture and exchange of goods have been developing from the very beginning of recorded history. On the coasts of Istria and Kvarner, as well as on the islands of Lošinj, Cres and Krk, wooden shipbuilding was well developed.

Important shipbuilding initially began in Kraljevica, way back in 1729, when the Emperor, Charles VI, ordered the construction of an arsenal and shipyard to build warships. By the year 1767, two frigates, *Aurora* and *Stella Matutina*, had been built, and in 1835 a steamer driven by side wheels was finished. The bark-clipper *Karlovac*, built in 1867, bears witness to the skill of Kraljevica's shipbuilders. The first steel ship was built in 1902.

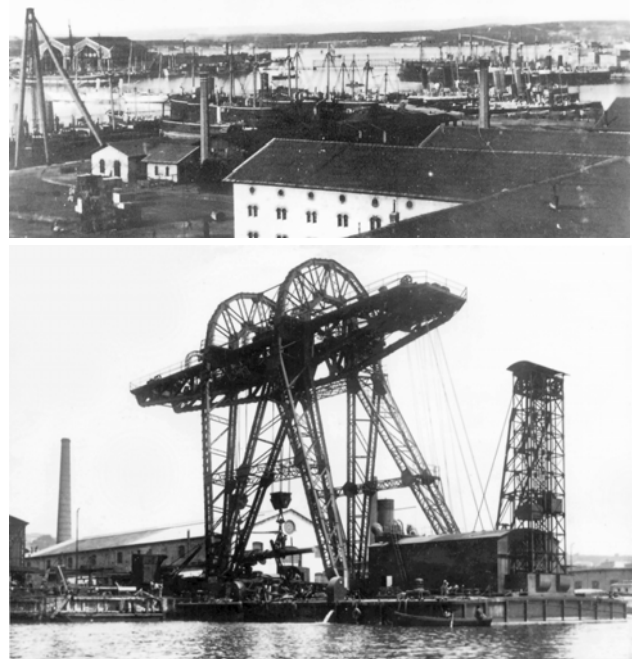


Figure 1: The shipyard in Pula was founded in 1856 under the name of K. und K. See Arsenal. Photographs were taken in the period between 1880 and 1914.

The shipyard in Pula was founded in 1856 as an arsenal of Austro-Hungarian navy. In 1858 the warship *Kaiser* equipped with sails and a steam turbine was launched as the first ship from that shipyard. The history records its taking part in the battle at the island of Vis in 1866 when she, although heavily damaged, gained a victory in combats against armour-plated ships. Later on, the same shipyard built different types of warships, submarines and other ship types. It is worth mentioning that the shipyard in Pula boasted of the first floating dock built in Europe. By 1914, the shipyard had 8 floating docks and 3 dry docks altogether. Facilities used for equipping ships were numerous cranes, the biggest among them being a floating crane with the lifting capacity of 260 tons. Near the arsenal in Pula, an anchorage of Austro-Hungarian navy was situated, having remained there to the very end of the First World War.



Figure 2: Launching of the battleship *Szent Istvan* from the shipyard in Rijeka in 1914.

In 1862 there were as many as 12 small-scale shipyards in the Rijeka area. It was in the contemporary Howaldt's shipyard in Rijeka that the building of big steel ships began. Since 1905 that shipyard was known under the name of *Danubius Schiffbau-u. Maschinenfabriks A. G.*, and after expansion in 1911 it changed its name to *Ganz-Danubius*. More than 70 submarines (i. e. more than 80% submarines of the Austro-Hungarian navy), together with numerous war ships of different sizes were built in that shipyard. In 1914, a giant battleship, *Szent Istvan*, one of 4 battleships of Austro-Hungarian navy, was built and launched. The ship was 143 m long, with a beam of 27.3 m, draught of 8.85 m, and displacement of 20,554 tons, and the crew of 1,094 navy sailors and officers. The ship was sunk near the island Premuda on 10 June 1918, toward the end of the First World War.



Figure 3: Above: Captain of the frigate, G. B. Luppis who conceived the idea of a torpedo, and the English engineer R. Whitehead who realised it. Below: Manufacture of torpedoes in Whitehead's plant in Rijeka, which was simply named after its product *Torpedo*.

The first modern mechanical engineering industry *Fonderia Metalli* was founded as a foundry and a workshop in Rijeka in 1854. With the arrival of Robert Whitehead, an English mechanical engineer, the production of steam engines commenced, and the company changed its name into *Stabilimento tecnico Fiumano*.

The dawn of the 1860s witnessed a new concept in naval arms for coastal protection whose creator was Giovanni Blasius Luppis. Robert Whitehead was the one to be entrusted of elaboration of that idea. Following the modification of the original idea and the initial trials carried out in 1866, the first torpedo prototype was completed, and the production of torpedoes started in the plant *Torpedofabrik Robert Whitehead*. Compressed air was used as the torpedo drive, and at a later stage, gyroscopes were used to keep torpedoes in the right direction. Torpedoes had been improved so that by 1918 they reached the length of 7 m and the diameter of 533 mm, and could reach the speed of over 30 knots. In 1867, in Rijeka, for the first time in the world, a torpedo-launching tube was built in on the ship *Gemse*. As far as 1960s, Rijeka still had the world famous torpedo production in the factory *Torpedo*. The factory produced an air compressor for the pressure of 250 bar, which was used by Prof. Carl von Linde in his tests to liquefy air on the *Engineering University in Munich (Technische Universität München)*. At that time it was still difficult to produce a good quality cast iron castings, and that was exactly the field in which the Rijeka-based factory was very successful. Professor Linde himself tested the compressor upon the delivery, and was impressed by the fact that the first trials produced satisfactory results. Today, that compressor can be seen in *Deutsches Museum* in Munich.

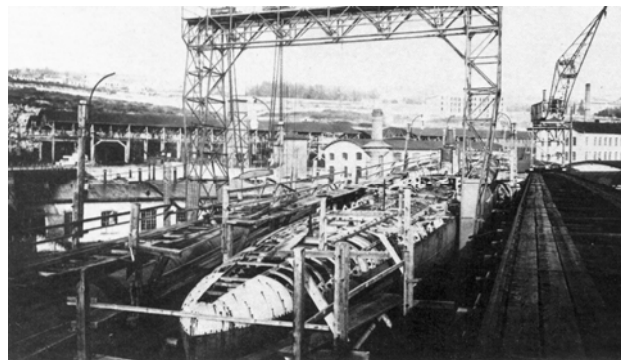


Figure 4: The shipyard *Ganz-Danubius* (today *3. maj*) in Rijeka. Above: building of the battle ship *Szent Istvan* (1913). Below: building of a submarine with displacement of 1,000 tons (1916).

In 1947, the factory *Torpedo* started the first mass production of Diesel engines in Yugoslavia. They started with a single-cylinder four-stroke engine, type *T-101*, with the power of 5 to 7 kW. In the period between 1950 and 1953, all efforts were focused on designing a reversible two-stroke slow speed Diesel engine for ship propulsion with direct drive. That task was successfully solved and the first marine engine of the type *Aran 420 B* successfully passed the acceptance testing in the presence of the Lloyd's and Bureau Veritas' representatives in 1953. Later on, those engines were produced in the newly built factory *Vladimir Bakarić* in Bregana (today, they are produced by

Adria-Diesel in Karlovac). In 1953, that engine type was built in the motor ship *Mura* which covered 30,644 nautical miles in the first year of voyage, thus having fully satisfied both the shipowner and, more importantly, the engine room crew members. It was the first ship built in a domestic shipyard to be equipped with the main marine engine of domestic production.

The majority of Austro-Hungarian navy ships were built in Pula, Rijeka and Kraljevica. On the basis of the ship design solutions and the equipment, those ships were considered to be the latest achievements in all engineering fields of that time. It was possible because the shipbuilding industry was supported by excellent design offices. *Danubius' Bureau for plan and development*, founded in Rijeka, had at its disposal excellent shipbuilding experts and naval architects. In 1866 Pula had its Imperial Royal Marine Engineering Administration with 8 departments and over 50 engineers, i.e. naval architects, mechanical engineers or electrical engineers. Contemporary experts carrying the burden of the modern shipbuilding industry and its technological and scientific development have grown up from their ranks.



Figure 5: Oil platform built in the *Shipyard Victor Lenac* Co. in Rijeka in the period from 1983 to 1986.

World-recognised discoveries and inventions made in Rijeka and its area are of special importance to the town and the whole area. In addition to the invention of a torpedo, we should point out the significance of experiments carried out by Professor Peter Salcher, Ph.D., in the field of scientific photography. Teaching at the *Nautical Academy* in Rijeka, in 1866, he managed to photograph the impact waves around a bullet flying at supersonic speed by using *Schlieren* technology. Doctor Ernst Mach, professor at the Academy in Prague, made use of the photographs and data obtained by Salcher. In 1889, P. Salcher discovered the phenomenon of impact waves and swirls accompanying a jet of compressed air. Hardly a month after Roentgen's discovery, P. Salcher managed to make his own X-rays.

All shipyards have undergone numerous changes, but

solid foundations have enabled the survival of shipbuilding industry to the present day. Arsenal from Pula has developed into *Uljanik Co.*, and the shipyard *Ganz-Danubius* into *3. maj Shipping Industry Co.*, Rijeka. The number of big shipyards has increased with the foundation of the ship-repairing yard *Viktor Lenac Co.* in Rijeka. The shipyards in Rijeka, Pula and Kraljevica constitute the skeleton of the contemporary shipbuilding industry in Croatia.

A great number of engineers born in this region at the turn of the 19th and the 20th centuries have become the leading experts and outstanding university teachers in the fields of shipbuilding and mechanical engineering in our country. Among them there are quite a few who should be brought to prominence: professor Adam Armanda from Mošćenice, Stanko Šilović from Praputnjak, Leopold Sorta, Miroslav Mikuličić and Ivo Hercigonja from Sušak, Boris Černe from Opatija, Lav Rajčić from Volosko, Stipan Ercegović and Rudolf Bosner from Rijeka, Feodor Petričević from Kraljevica, Silvije Crnković from Novalja, etc.

THE AIRSHIP: ZEPPELIN OR SCHWARZ?

Towards the end of the 19th century the sky over Europe was crowded with numerous balloons of different sizes. They could move in the desired direction due to the drive motor suspended from the balloon, which propelled the airship, and to fins of different sizes for the purpose of changing the flight direction. Those were the first airships that could be steered at will. Their drive motors were not yet adequate for the purpose as they were either too heavy (steam engine), or the way the driving energy was stored was inadequate (battery-driven electric motors). The invention of the internal combustion engine solved the problem. The most serious problem of airships of that time was the problem of steering. The petrol engine suspended from the balloon did not bring about the anticipated improvement as the balloon was made of silk and did not have a solid shape. Consequently, the ship could not be steered by fins in any of their positions and was left to be at the mercy of wind.

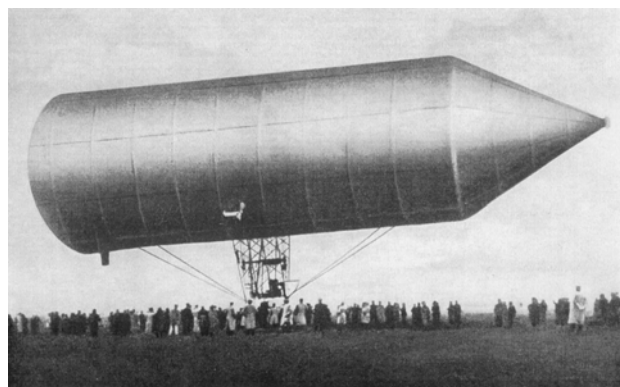


Figure 6: The first David Schwarz's airship, made of aluminium. Relevant data of the airship: length: 48 m, diameter: 14 m, volume of hydrogen: 3,700 m³, drive: Daimler's 9 kW petrol engine. The hydrogen was contained in special envelopes in the inside of the airship.

In 1897 the first David Schwarz's airship made of aluminium, steered at will, equipped with a 12 kW petrol-powered engine, took off from the airport Tempelhof near Berlin. At the altitude of 460 metres, flat propeller-driving belts slipped from rollers, and the airship could only hover

in the air like a balloon, exposed to fierce gusts of wind without any possibility of changing direction. Inexperienced German non-commissioned officer who was steering the airship, let the gas out of the balloon, the airship started swooping down and hit the ground uncontrollably. The pilot saved his life by jumping out of the basket. Among the crowd there was a German cavalry officer, count Ferdinand von Zeppelin, completely lost in his thoughts. For him, that trial flight of David Schwarz's airship, although unsuccessful, made it clear that the construction and use of such airship was possible.



Figure 7: David Schwarz with his wife Melanie.

Who is David Schwarz?

The persevering enthusiast, self-taught inventor-come constructor and self-sacrificing worker on dreams come true was born in 1850 in Keszthely, near Lake Balaton, in Hungary. When he was 13, he moved with his widowed mother to Županja to live with her elder brother, a merchant. Short of funds to enrol into a grammar school, Schwarz completed an apprenticeship with another merchant, where he made good progress and became a successful timber merchant. Soon after that, he built a sawmill in Našice, focusing all his intellectual and physical abilities on improving the mill and its machinery. Working on inventions for his sawmill, he became aware of his talent for engineering, in particular mechanical engineering. Driven by his urge to fly and fully aware of all drawbacks of balloons of his time, he plunged into the design of the first airship. He elaborated the theoretical background, carried out calculations and made a detailed engineering design of the future airship. Lacking the financial means to build a real airship, Schwarz built its model. He was the first inventor to install a petrol-powered engine on his prototype.

Due to complex political situation in Zagreb, his invention was not accepted with approval, so he left for Germany where he found employment as a common labourer in an aluminium factory. There, together with the factory owner Carl Berg, he invented new aluminium alloy *dural* (Schwarz aluminium) which boasted a high strength. He then travelled to Austria and in Vienna he approached the Armed Forces minister, but the meeting achieved no success. Lucky enough, the Russian military attaché became interested in his invention, so, supported by Tsar Alexander II, Schwarz managed to build his airship. However, following the Tsar's death (1894), Schwarz was accused of spying for Austria. On the eve of the day his completed airship was supposed to be presented to the public, he was compelled to destroy it and to flee from Russia. Disappointed, he returned to Zagreb where he presented his project to the French, but suspecting deceit, he did not accept their co-operation. The project finally aroused interest of Germans who placed at his disposal the military airport Tempelhof near

Berlin. Among his supporters were Kaiser Wilhelm II, the balloonist Bartsch von Siegfeld, and the aluminium manufacturer Carl Berg of Eweking. The airship was scheduled to be presented to the public on 27 September 1896. However, only an unofficial flight took place on 8 October 1896. Due to the poor quality of the gas, the craft was lifted barely a meter off the ground, but it did fly in the desired direction. It was a sufficient proof of Schwarz's invention appropriateness, which earned him the title of honorary engineer from the Universities of Berlin and Vienna.



Figure 8: The wreck of Schwarz's airship on the Tempelhof airport on 4 November 1897, after the accident, which had happened the day before.

The official flight was finally set for 15 January 1897. However, on his way to Berlin Schwarz died from a stroke in Vienna. Melanie, his devoted wife decided to pursue the project herself, so she found a non-commissioned officer by the name of Jagels who agreed to fly the craft at the official test flight. As we already know, after a successful take-off, the ship fell down due to defects and inexperienced handling. Zeppelin bought the design accompanied with drawings and calculations from Schwarz's widow for 15,000 German marks to use them to build an airship in 1900. He claimed it to be its own invention. The design principle and all major elements of the skeleton of Zeppelin's airship are the same with the only difference in the material covering the craft's structure: Zeppelin used rubberised waterproof cloth instead of thin sheet of aluminium alloy. Public opinion was expressed violently in protests against and condemnation of stealing Schwarz's invention, so that even Kaiser could not help being involved. Nevertheless, the emperor insisted on laying the claim on the invention which "must be a German one", and not of some ordinary merchant coming from Zagreb.

Due to the untimely death of David Schwarz and the status of Count Zeppelin, the *schwarzplane* was recorded in history as *zeppelin*. Although the wreck of Schwarz's airship was completely destroyed during the Third Reich, experts and a number of influential people in Germany admit today that it was Schwarz who invented the first airship that could be steered at will. Deutsches Museum in Munich has a model of the airship as a constant exhibit of the collection *Aviation*. The legend accompanying the model clearly states that David Schwarz designed and built the first controllable airship and that its first flight, despite of the accident, proved that an airship made of a light metal could be steered.

THE FIRST CROATIAN AUTOMOBILE CLUB

The motorcar, a fascinating invention providing the man with the opportunity to travel over great distances

and thus creating an illusion of freedom, developed into an obsession in Croatia as well. As early as 1898 Count Marko Bombelles drove the first Benz car to his manor Opeka at Vinica in the vicinity of Varaždin. Varaždin was the centre of cultural events and public life of the then Croatia. The car, this explosive, noisy and smoky novelty, caused both protests and sighs. Very soon it became an object of desire and prestige among the nobles and the rich, who were beginning to purchase cars. One of the most famous car owners was a talented craftsman, wholesale merchant and a restless spirit Ferdinand Budicki known as Ferdo. In 1901, he bought a used Opel car in Vienna at the price of 4,000 kronen, and driving her over Semering he reached his native town, Zagreb. It was the first car to be seen in Zagreb. Budicki was also the first to bring the first motorcycle to Zagreb in 1902, and to found the first driving school. The citizens of Zagreb got so excited about the first car that Ferdo decided to open a car shop where rich people could buy cars.



Figure 9: The first car drivers and founders of *The First Croatian Automobile Club*: Count Marko Bombelles, Ferdinand Budicki, Count Miroslav Kulmer, Mihovil Merčep and Baron Dioniz Hellenbach.

In early 1906, several car drivers met in Zagreb and founded *The First Croatian Automobile Club* (*I. hrvatski automobilni klub*), which comprised 14 members. Count Rudolf Erdödy was appointed President and Budicki Secretary. They initiated the regulation of driving tests and the implementation of road traffic laws. In 1908, a trip to the Plitvice Lakes for the club members was organised, and in 1912, the first driving race from Zagreb via Podsused, Bistra, Sveti križ Začretje, Veternica, Lepoglava, Vidovec, Varaždin, Novi Marof, Sesvete and back to Zagreb took place. After 177 km, Vjekoslav Heinzl, later a mayor of Zagreb for many years, was the first over the finish line, having been driving at the average speed of 54 km/h. In 1913, the club had 55 members and at the end of that year there were 269 cars, 22 buses and 69 motorcycles in Croatia.

However, it was not easy for women to get hold of the steering wheel. The first lady to have the privilege was a noblewoman, Alma Bailey. In 1914, she passed her driving test in front of the State Commission examining car drivers. At that time the regulations did not specify that a woman could take a driving test. Therefore, a meeting of the Commission with only that item on the agenda was called. After a marathon and heated debate reason prevailed. It was decided that Mrs. Bailey could drive her Opel, 8/14 HP model.

The First World War interrupted the club activities temporarily. The first meeting after the War was held in 1919. Five years later, in 1924, *The Automobile Club of the Kingdom of Serbs, Croats and Slovenes* was founded on the initiative of the *Slovene Automobile Club* (*Kranjski avtomobilski klub*) from Ljubljana. *The First Croatian Automobile Club* ceased to exist under its name and became a section of this newly founded club. This change was simply necessary as the international regulations specified that only one club from one state could become a member of the international automobile association *AIACR* and could be entitled to issue *Triptyque*, an international document allowing the driver to cross the state borders in his car.

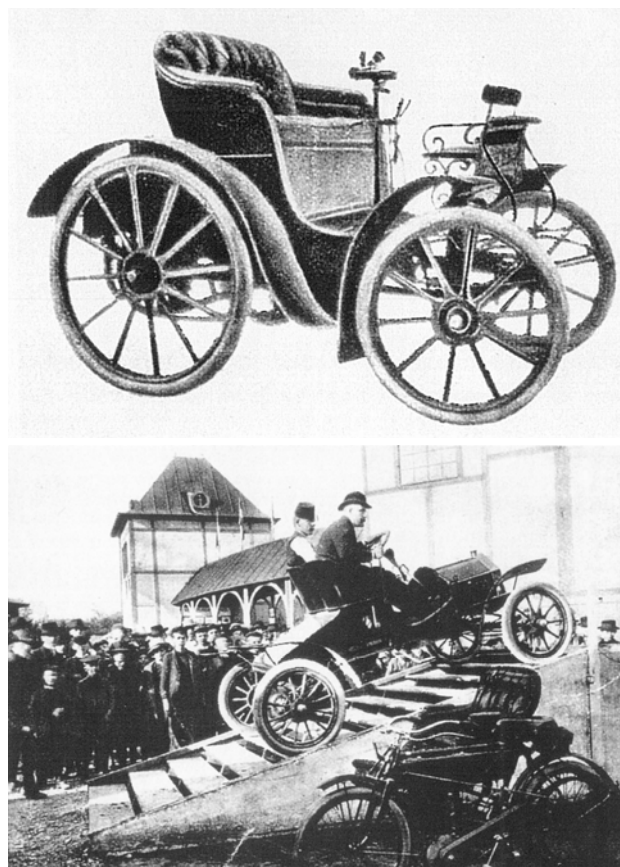


Figure 10: Enfant terrible Ferdinand Budicki: his first car (Opel) in which he drove to Zagreb in 1901 (above) and one of his famous foolhardy drive up the stairs at the *Zagreb Fair* in 1904 (below).

Soon after Varaždin and Zagreb, Dalmatia also witnessed the arrival of the first cars. In 1902, Stjepan Cernić from Sinj used to drive on excursions to Split, Livno and other places. At that time Split was a cultural, economic and sports centre of Dalmatia. A club named *Adriatic Automobile Club* (*Primorski auto klub*) was founded in Split approximately at the same time as *The First Croatian Automobile Club* in Zagreb. All car and motorcycle drivers gathered in the club. The first president was a dentist, Nikola Gjurović. The car-fever gradually spread to other regions as well, the clubs in Vinkovci (*Sremac*, 1926), Osijek (*Slavonac*, 1926), Slavonski Brod (*Moto biciklistički športski klub Brod na Savi*, 1927) and in Bjelovar (*Moto klub*, 1930) were founded.

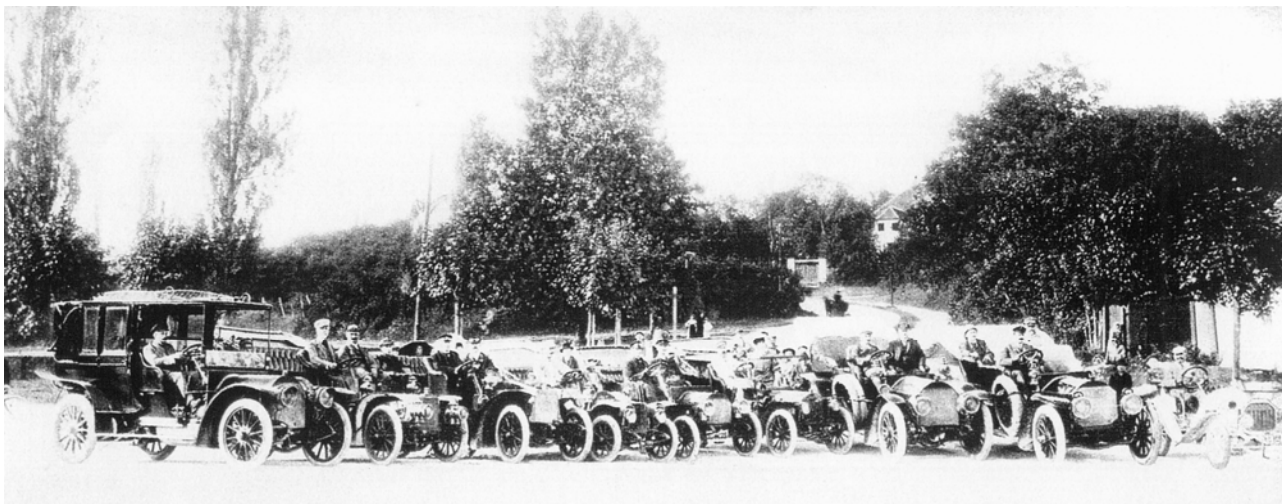


Figure 11: Members of *The First Croatian Automobile Club* on an excursion to the estate of Baron Hellenbach in 1910.

MOTORCYCLES

In 1948, due to the act of insubordination to Stalin, Yugoslavia was condemned and rejected by the communist countries. After that the Yugoslav leadership decided to move away from the Western European countries and, consequently, the country found itself politically isolated. The political leaders believed that the country should not depend on foreign industries and decided to start all kinds of manufacturing industries, in most cases without any realistic foundation. Many of the attempts proved a failure for good reasons, like cameras produced by *Fotokemika* factory in Zagreb, other fell victim to political decisions or inherent weaknesses. Expertise was strongly influenced by politics. Every prominent politician had to have "his own" factory: in the early 1950s the Diesel engine factory in Rijeka producing *Aran* engines was named *Aleksandar Ranković* after a politician, the engine factory in Karlovac was named *Edvard Kardelj* after another politician, the plant in Bregana was named *Vladimir Bakarić*, etc. The Yugoslav economy was a planned one, which meant that in Zagreb, for example, only the production of bulbs up to 60W and above 150W was allowed. Bulbs between 60W and 150W were produced in a factory in Pančevo. Another example: Croatia has a sea, so the shipbuilding industry was to be developed here, but not car industry. In spite of that, an engine factory named *TMZ* was founded in the industrial zone of Zagreb, Žitnjak, in 1950. Thanks to the enthusiasm and persistence of Zagreb engineers, the factory had evolved from a small prototype workshop established in 1948 as a part of the *Manufacture and Design Office of the Ministry of Industries of the National Republic of Croatia*. It ended as a victim of political decisions and partitions.

Immediately after the Second World War an idea to start a production of motorcycles was born. It all started in 1947 with copying a BMW 500 cc model - the next year a prototype was finished in that prototype workshop. After such somewhat romantic ideas, the production of heavyweight one-cylinder, air-cooled, two-stroke Otto engines named *Savica* was initiated. The entire design was by TMZ, and in co-operation with local manufacturers TMZ produced all components apart from ball bearings and electric devices, which were to be imported. The

engine had the swept volume of 285 cc and the power of 4.5 kW at 3,000 min⁻¹, and it was used to drive farming machinery and fire pumps. Subsequently, two versions of 175 cc and 3kW were developed. In the meantime, the factory launched the production of motorcycle prototypes of 350 cc and 500 cc - the plan was to start a mass production in 1954. The plan proved unrealistic but in 1957, mass production of mopeds 50 SL under licence by the Austrian factory HMW started. As production lots were rather small, it was not feasible to start the manufacture of Al-die castings and large sheet-metal components, which were imported.

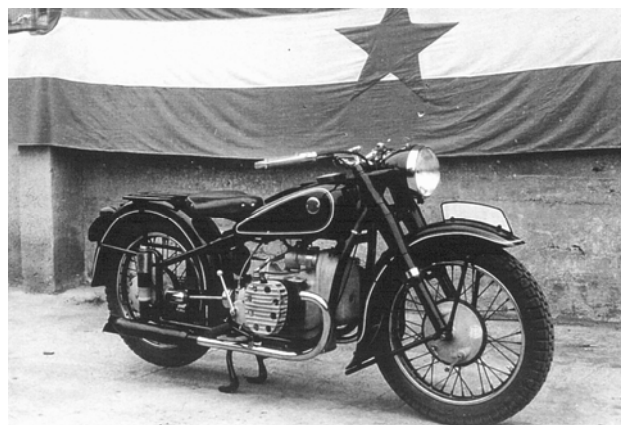


Figure 12: The first motorcycle prototype with a four-stroke, 500 cc engine produced in Zagreb in the workshop in Bleiweis Street.

The *TMZ* experts wanted to construct their own motorcycle, so they designed scooter named *Švrčo* (Scamp). Although *Švrčo* was different in shape from the moped *SL 50*, and was much more comfortable, it was designed based on *SL 50*. Both models had many parts in common: engine, telescopic forks and trailing arm axle, handlebar, cable harnesses and front and rear drum brakes. *Švrčo* had a three-speed gearbox in distinction from *SL 50*, which had only a two-speed gearbox. Several prototypes were successfully presented at the national shows and fairs as early as 1958, when it was possible to launch the mass production in *TMZ*. However, for lack of budgeting the beginning of the mass production was repeatedly postponed, first until 1959, then until 1960. In 1960, the production capacity was 2,700 mopeds and scooters, 3,000 stationary engines, 900 motor-driven pumps and 500 small farming tractors. However, the factory was under great pressure of the planned economy of former Yugoslavia because it had never really fit into it;

the finances required for modernisation and expansion of the production line could simply not be obtained. Finally, the factory was closed down and in 1963 the machinery and the remaining components were moved to Mali Zvornik, Serbia. That was then a definite ending of the engine and motorcycle production in Zagreb. Consequently, the Zagreb factory, established due to the enthusiasm and persistence of Zagreb engineering experts, ended as a victim of political decisions and partitions.

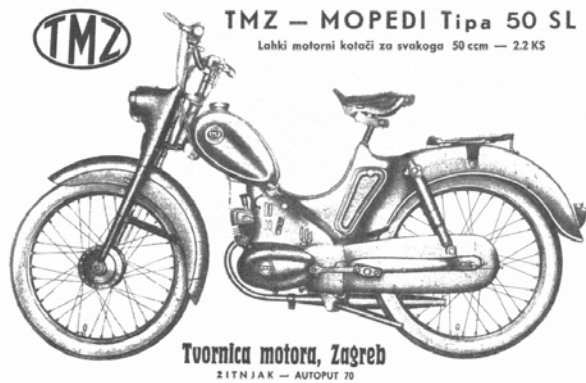


Figure 13: The TMZ SL moped, 50 cc, advertised by a slogan "No driving licence or number plate needed"



Figure 14: Production in the small, but very tidy TMZ factory.



Figure 15: Scooter Švrčo (Scamp) was an original design by TMZ - in spite of the fact that they had many parts in common, Švrčo's shape differed very much from the moped SL 50.

BUSES

The bus manufacture in Croatia was initiated towards the end of 1930s in the workshop *Juriša* in Zagreb. Its craftsmen, auto-wagon-makers, would mount a wooden frame for the passenger cabin on a ladder-type frame, and then would cover it with metal skin and make windows. The rounded parts of the skin on the front and the rear side were made of soft Al-sheet and they were hammered into shape on a specially shaped wooden block.

In 1948, the workshop named *Autokaroserija Zagreb* in Savska Street started the manufacture of buses with some thirty workers. It was still a workman like production and body structures were still made of wood. At the time of general post-war poverty, a variety of chassis frames, available at the time, were used: *Büssing*, *OM* and others. Often standing on a ladder or in a passage dug in the ground below the floor-level when the height of the room was inadequate, draughtsman would draw a bus in actual size on a big drawing board with dimensions of 3 m in height and 10 m in length. Subsequently, on the basis of technical drawings, templates for the bus manufacture would be made. Every morning workers would first agree on the plan for the day and then would get to work. The time limit for production was not set, so the work continued until it was done. In the early 1950s, steel supplanted wood in the building of body structure. Modestly started and almost unobserved, the bus manufacture seemed to be unattractive at that time because it could not produce a significant number of buses per year, so it was not too big a disturbance for centrally planned economy.



Figure 16: The bus produced in the workshop *Juriša* in Zagreb in 1940.



Figure 17: Building of the wooden bus body structure (in Zagreb, between 1942 and 1945).

In 1954, the factory was moved to its final location, the Zagreb-suburb Dubrava, and as soon as the following

year, specifications for the manufacture of a steel body and devices for making body structure were completed. Even before that, in 1950, *Autokaroserija* started its co-operation with the lorry assembly plant *FAP* from Priboj, as well as with the plant *FAMOS* from Sarajevo (manufacture of engines and gearboxes). *FAP* supplied the Zagreb-factory with chassis frames driven by *FAMOS*-engines, and *Autokaroserija* constructed bus bodies on them. At that time, rectangular steel tubes used for vertical pillars of bus sides were not available on the domestic market, so they were made from iron sheet by hand, first by bending on a press brake and in turn by welding along the open end. All other sheet sections, i. e. L-, C- or Ω -, were also made by bending. In order to increase stiffness of an Ω -sheet section, a wooden board would be inserted.

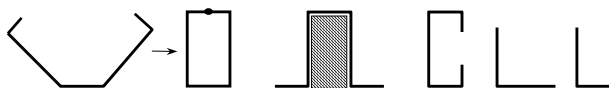


Figure 18: Steel sheet sections for construction of bus frames was sometimes made stiffer by the inserted wooden board (around 1950).



Figure 19: The buses *Raketa* produced by *Autokaroserija Zagreb* in 1958 in their original form (above) and in a new form (below) had contributed to the enhanced reputation of the factory by their success.

The year 1958 is the year of a big success, the bus *Raketa* (rocket). With its unusual, futuristic industrial design, and very comfortable and deluxe optional for those times, *Raketa* soon became a favourite means of transport of the then passengers, and one of the top-products on trade exhibitions all over the country.

In 1969 a joint-venture company *FAP-FAMOS* with its headquarters in Belgrade, the so-called *FFB*, was founded. The company was joined by *Autokaroserija Zagreb* and 11. *Oktomvri* from Skopje. In the same year,

the company bought license rights for production of lorries, buses and engines from the concern *Daimler-Benz*. And that was the start of *Daimler-Benz* bus production in Zagreb. At the beginning it was only a so-called CKD-assembling (complete knocked down). For the Zagreb factory it was at the same time a big chance to design its own chassis frame and thus to solve the key problem in the bus production. As all *Daimler-Benz* specifications were at the disposal of the factory engineering staff, they gradually started developing a production of components, starting with body structures, a logical step in the light of the wide experience already acquired. However, although the license rights meant a big step into the production improvement, it was that very segment of production that proved to pose problems which could not have been noticed at the first moment. Inadequate equipment with manufacturing machines and the production adapted to small lots resulted in the fact that it was too costly to start the production of the most complex elements of chassis frame. On the other hand, *Daimler-Benz* was carrying out some modifications and improvements of the design at such a speed and in such a wide range that the design and technical departments of *Autokaroserija* were under a constant, excessive work load, and consequently frustrated as they were forced to constantly adjust the adopted elements to the new, modified standards. Therefore, it was only in 1979 that the first 12-metre touring coach *Dubrava 14* was produced after a years-long, sometimes secret development.



Figure 20: The *Dubrava 14*, produced in 1979 in TAZ, was the first domestic bus in the former Yugoslavia with a chassis frame and air springs.

The body of the bus was constructed on the first domestic rigid frame with air spring, instead of on a ladder type chassis frame, and the glass panels were fixed by using adhesives, which was novelty for that time. The originator and designer of the chassis frame was Ivan Balog, enthusiastically interested in buses ever since his childhood. Compared to the *Daimler-Benz* body structure for the bus O 303 of the same size, it was much simpler to produce the body structure for *Dubrava 14* and it had the same rigidity and weight as the former. After Balog had left the project, elaboration of design details was completed under the guidance of Aleksej Aleksandrov, and the production was started. On that occasion, the factory changed its name into *Tvornica autobusa Zagreb - TAZ*, and its emblem featured prominently on the front of a bus for the first time¹. *Dubrava 14* was a full hit not only

¹ At the time when buses were constructed on *FAP* ladder-type chassis, *FAP* did not allow *Autokaroserija* to put their emblem on the front of the bus, so it made a shy appearance on the right side of the bus, in front of the front wheel. As *FAP* was delivering only some individual components for *Dubrava 14*, which

on the domestic market, but on the international as well. With constant improvements of design, technological process and equipment, *Dubrava* brought along an excellent position for his producer on the demanding and hard to please market in Finland.

In addition to *Dubrava 14*, its basic product, and *Daimler-Benz* buses, TAZ was also constructing buses on chassis produced by different producers (*FAP*, *TAM*, *Neoplan*, *Avia*, *Steyr* and *MAN*). TAZ was exporting buses to Saudi Arabia, Egypt, Algeria and other African countries, as well as to the Tcheck Republic, Great Britain, Denmark, Ireland and China. Furniture vans and different special-purpose vehicles were being produced for the home-market. During 1980s, at the time of its biggest rise, TAZ had some 1,200 people who were producing 500 to 600, and sometimes even 900 buses per year.

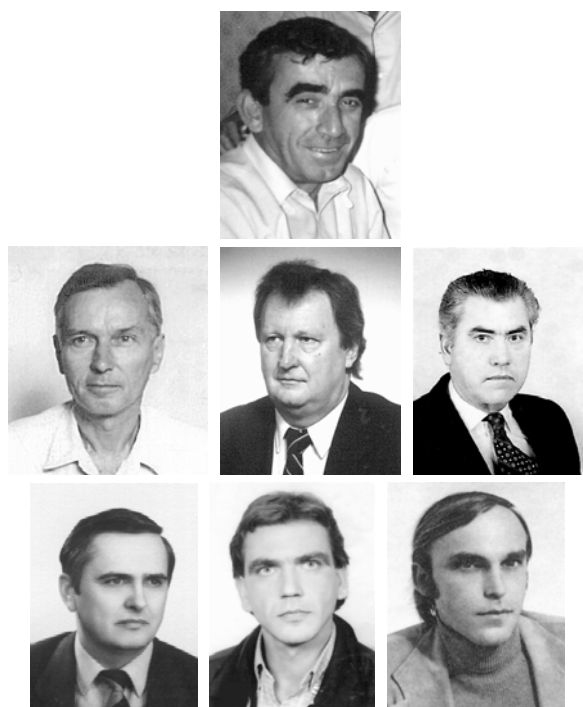


Figure 21: Outstanding experts who have grown out of the bus production in Croatia: Marijan Fočić, Zvonko Toplak, Branko Mokrović, Zeno Sokolić, Ivan Balog, Nebojša Buktenica and Aleksej Aleksandrov.

Among the people who contributed to the successful production, let us mention only those designers who left outstanding marks by their work in TAZ. In addition to the already mentioned ones, the recent history has recorded: Marijan Fočić, Zvonko Toplak, Branko Mokrović, Đuro Ožanić and Nebojša Buktenica. In the prototype workshop Sokolić Zeno should be pointed out as unsurpassed in his skills. Since 1990, the volume of production in *Tvornica autobusa Zagreb* had been progressively reduced over

represented only a small share of the complete vehicle, they were well aware of the fact that they could not forbid the Zagreb bus factory as a producer to put its emblem on the front of the vehicle. Nevertheless, *FAP* made their delivery conditional on putting the plain and ugly *FAP* emblem on the front of the vehicle together with the producer's. The Zagreb-factory solved the problem diplomatically, both to their and their customers' satisfaction, by delivering the *FAP* emblem unattached so that their customers could put it on the front of the vehicle according to their wish.

years to come, and eventually faded away.



Figure 22: Production line in the bus factory TAZ (Zagreb).

The year 1990 was also the year when the Zagreb-based company *Eurobus Ltd.*, was founded with the aim to design and produce buses. The company gathered the majority of the best Croatian experts in the field. Beyond any competition in the domestic industry, with a wide working experience gained in the production of thousands of buses, with a good knowledge of the market, and with a lower price of work than the one in the West, *Eurobus* started with almost ideal conditions. At the very beginning they managed to launch an excellent touring coach AV 120 on the chassis frames produced by *Volvo*. A good example of a modern industrial design, equipped with the best components to be found on the world market, conceived to be produced in small lots, conformed to customers' wishes to the greatest possible degree, the bus simply had to be a success. *Eurobus* had qualified and skilful designers who contributed to the production of the first bus in *TAM*, Maribor, by giving incentive for the production and by providing the design. They also completed one of their projects for the Austrian *Steyr*. *Eurobus* buses were well accepted on the Croatian market and arose a considerable interest on specialised trade fairs abroad. Special attention was paid to a deluxe touring double-decker AV 120 D, the first double-decker produced in Croatia. The product line also encompassed several subtypes derived from that basic model. In co-operation with *MAN*, a city bus and a special airport bus were produced, and short-distance buses were produced on *ÖAF*-chassis frame.

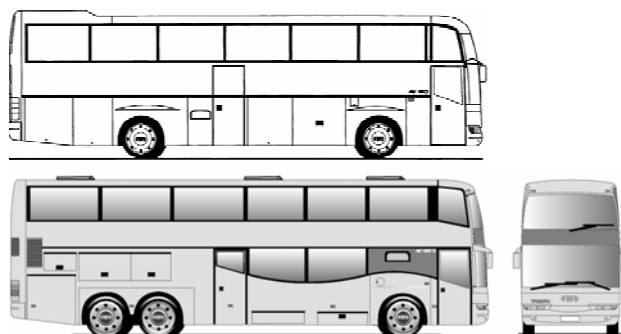


Figure 23: Deluxe touring coaches: AV 120 and a double-decker AV 120 D produced by *Eurobus*.

After a brilliant start, production figures in 1993 reached approximately 40 buses, which was an excellent result. In 1997, *Eurobus* and the *Department for Motors and Motor Vehicles* at the *Faculty of Mechanical Engineering and Naval Architecture*, together with the

Ministry of Science and Technology started a joint project with the aim to introduce modern computing methods in the process of bus design and construction. The results achieved in the project completed in 2000 came too late to be applied. Hardships that weighed on the entire economy of Croatia had not spared *Eurobus*. Production had been gradually reduced and in the year 2000 not a single bus was produced.

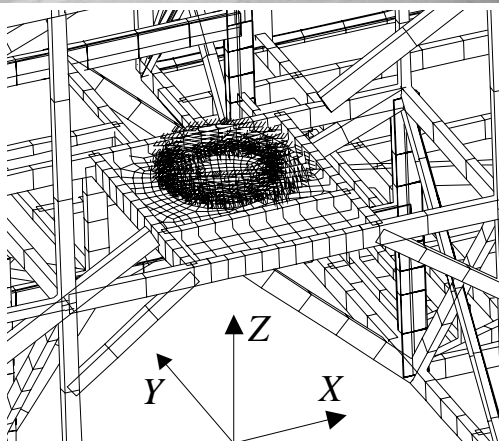


Figure 24: Eurobus' airport bus AE 141 A ($l \times w \times h = 14.1 \times 3.5 \times 3.05$ m, 13 t) and a detail of a computing model of the bus structure in the zone of an air spring, prepared for FEM-analysis.

are not only responsible for material goods, but their much bigger sin is that they have destroyed the roots of the most fragile and sensitive plant called knowledge. As productions of engines (*TMZ*, *Torpedo*), motorcycles (*TMZ*) and buses (*TAZ*) have faded away, the precious knowledge gathered in the period of more than half a century is irrecoverably lost for Croatia. Time is running short for preserving at least rudiments of that knowledge. Is there a chance of witnessing moments of inspiration, enthusiasm and elation favourable for the emergence of new sprouts in the near future?

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1 REQUIEM OR PHOENIX?

Major political changes in the last decade of the 20th century brought about the collapse of the socialistic economy, and the disintegration of the old and creation of new countries. Being unable to keep pace with the western industry with respect to modern developments and organisation, industry in former socialistic countries found itself suddenly exposed to the merciless world market and free enterprise, and above all to the foul dealing. Very few formerly successful companies survived the critical moments of that impact, even though, judging by their objective potential, a greater number of them could have been able to adjust to the new situation. Due to the massive increase in bankruptcy, millions of people have lost their jobs, and thousands of young experts can not find a job. All these misfortunes have not missed Croatia. The present situation is discouraging for the young people who are still studying, and the reduced revenue endangers the very system of education as well as the preservation of the current knowledge. If we lose knowledge, we are doomed to selling the bare manual work at the lowest prices. Crooks and political toadies who have stolen from and have ruined the home industry