

# Waterman Arrowbile

by Paolo Severin

[www.paoloseverin.it](http://www.paoloseverin.it)

# Waterman Arrowbile

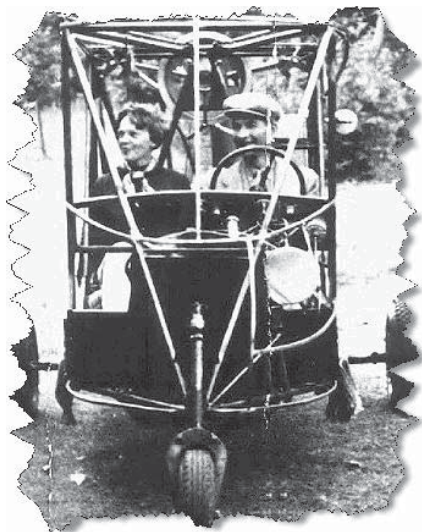
Publicato su Settimo Cielo 2009

When some friend of mine walks in my workshop and see what i am working at, usually asks me if i am crazy. In all honesty i have to admit that sometime i wonder if i am, but then i say that they are the crazy ones and i go on...



The above to point out that the Arrowbile project has been a very committing task, probably the most unique and ambitious that I have entertained so far.

I had indulged many times on the three view drawing of Paul Matt Arrowbile: everytime I got carried away with construction fantasies, but when I arrived to the power plant I was forced to hold off. As matter of fact the Arrowbile had a rear engine completely enclosed in the fuselage, it was impossible to cool it by air unless awkward air intakes would be used or having the engine heads



sticking out and I would never accept that. Probably the problem could have been solved using a modern and efficient electric motor, but unfortunately I can not accept such option either: the smell of fuel and the sound of the internal combustion engine fascinates me in a way that I can not still live without it.



So, when i put my hands on a MVVS 58cc engine, water cooled, with radiator and water pump, I did not hesitate a second and started to plan the reproduction of the Waldo Waterman Arrowbile.

Waldo D. Waterman was born in San Diego, California, in 1894. In 1909, at the age of 15, he began to be interested in the studies of Curtiss and Wright and built his first glider. During the following years he built other experimental airplanes and in 1912 he entered the university of California as a student of mechanical engineering. During one of his first experiments he incurred in a serious accident (he broke both legs) and the consequences mined his health for the rest of his life. Despite that, Waterman was the first American to make a true flying car. As matter of fact, for many years, he was involved in devenloping a convertible airplane, simple, safe and economical for the average pilot. Waterman believed that the solution was a project based on the flying wing concept. In 1932 he built an airplane that not only was



the first successful flying wing in the USA, but also the first step towards a plane that could be converted in a flying car.

The prototype in 1932, named "What-sit" for his unconventional design, open the way to the "Arrowbile" in 1935 designed and built for a contest announced by the US department of commerce. It was powered by a Menasco C-4 ,95 HP and in 1935 flew from Santa Monica to Washington D.C. and granted Waterman the contest prize. Having proven that his project was valid, Waterman decided to adapt it for ground use. The first Arrowbile was flown by Waterman himself on February 21st 1937 and proved to be stable , difficult to stall or spiral in and had all the manoevrability required for the normal flight. Equally important was the fact that the Arrowbile was complying with the road driving code so it could



Six Arrowbile were built, each one slightly different from the other, especially for the body work.

Picture on the left: Amelia Emerarth togheter with Waldo Waterman on the Arrowbile still under construction.

Other pictures: some versions of the Arrowbile in flight and on the road. Front page: The model airplane just finished.





be used on highways.

Some financial problems, the unstable health of Waterman, and the upcoming World War Two were the main causes of the interruption of the Arrowbile project, but a last version, called "Aerobile", appeared in 1957. It was a three seater powered by a water cooled Franklin engine and a single piece wing. The "Aerobile" remained a sole prototype and after having flown successfully many times joined the "Whatsit" in 1961 at the National Air and Space Museum. Let's get down to the project of the model. In order to fit the engine comfortably, i decided to go with a 30% scale which resulted in a 3,5mt. wingspan. I thought: "Same as my Fieseler...after all it's not that big". I wished! It's a 3,5mt, true, but the a 64cm chord and a 25 degree sweep are a whole different thing. If had been one centimeter bigger i should have changed car to transport her. But let's go on

I thought that before building the wing and finishing the fuselage, I should have tested thoroughly the engine installation which did not look easy at all. Due to the c.g position I had to locate the engine as forward as possible, basically right behind the seat, and this required an extension of the shaft of about 30cm . I decided also to gear down the engine 2:1 .

I believed that gearing down the engine using a toothed belt would have made things simpler. Probably, splitting the transmission in two halves, I would have reduced the risk of vibrations compared to an extension made as a single piece with the crankshaft. I was never able to verify this because I could not start the engine using a reduction gear. If I mounted the engine on the test bench in a standard configuration, with the propeller on the crankshaft, the engine was as perfect as a clock. As soon as I modified the transmis-



sion system nothing would work, beside some occasional firing , there was no way to start the engine. I am sure that this was caused by the excessive sophistication of the electronic ignition of the engine. The MVVS is a very innovative engine: the

ignition module is controlled by a microprocessor which programs the advance timing and also controls a servo that adjust automatically the air valve.

Mounted in a standard configuration is marvelous, but changing the

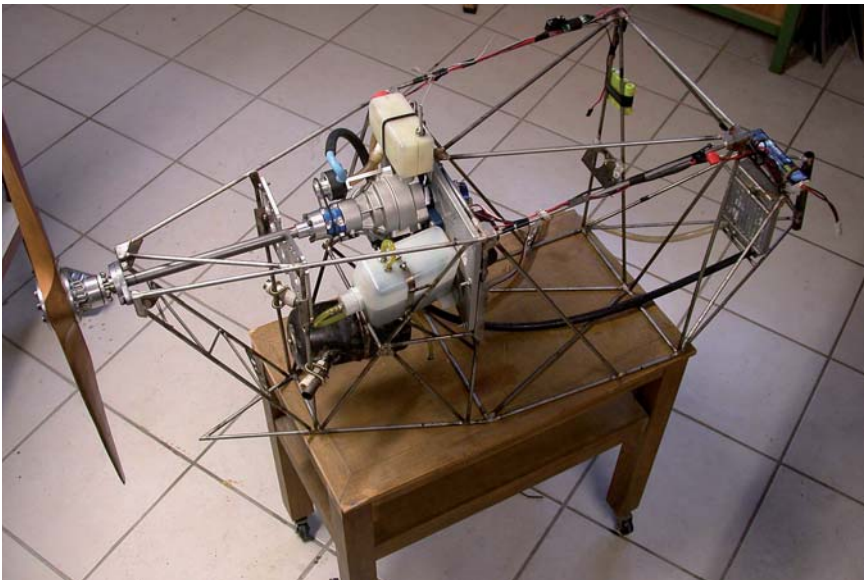
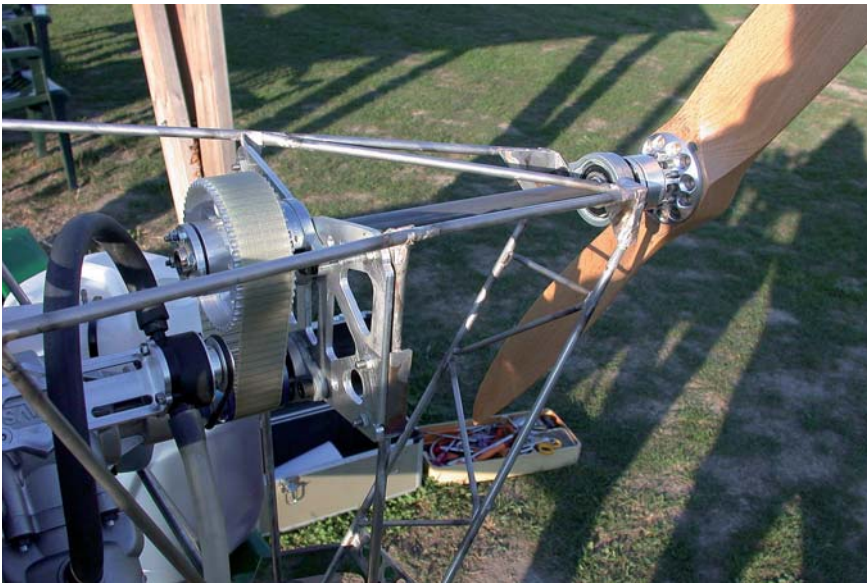


propeller flywheel effect by modifying the transmission it's the end: the ignition module does not receive the standard settings and can not control the ignition. Probably adding a flywheel to the crankshaft could have solved the problem, but after

many attempts I gave up and used a direct drive extension. It was not over yet. Even this way the running was irregular and the engine was not reliable. In the end I solved the problem adding a 500g. flywheel to the propeller plate. This way the

engine ran well but during an extended test the shaft, made out of a chrome-molibdenium tube, broke due to the expansion caused by the heat received from the engine. I made the mistake to lock tight the threaded bolts of the holding bearing , this did





not let the shaft to expand freely. After a pause of few months, during which i built a Bleriot to relax myself (!), I resumed work and I built a new shaft in titanium. After a short period of tests, during which-just to have fun- I burned out the electronic ignition module because of a wrong connection, and after rechecking several times the water cooling system trying out different solutions, specifically with regard to the location of the radiator which must be located as high as possible , I finally achieved a satisfying result and the engine ran well for a long time. I would like to point out that all the problems I had to solve are not related to defects of

the MVVS engine, which mounted in a standard configuration has always worked very reliably. At this stage I started building the wing. I used the airfoil NACA 23012 having a 4° offsetting (+5° at the connecting point, +1° to the end) same as the original one. I built the wing separating the ribs in two portions same as the full scale, I kept the center and the end portion of the rib parallel to the flying direction, while the rib nose enclosed in the D box is perpendicular to the longeron. The rib is made of obeche structure 4x4 mm and the noses, which are double of the ribs, are in poplar ply. The longerons are made of cedar , a very light wood

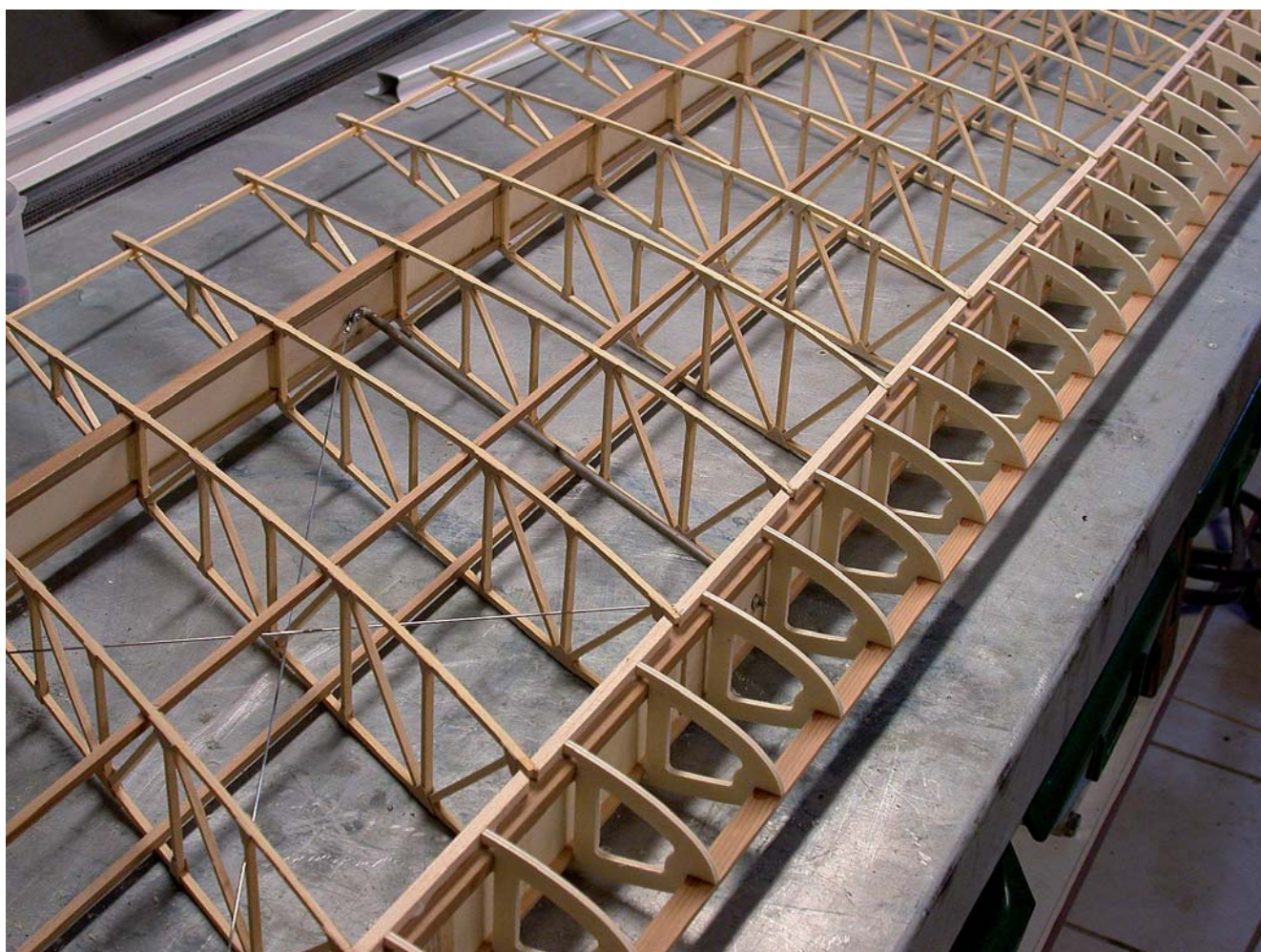
with a very regular vein direction. Because of the heavy sweep of 25° i deemed necessary to insert in the wing two anti-drag tying rods made of steel wire. The D box is covered with birch plywood of 0,8mm bent on a hot tube having an appropriate diameter. The two rudders located on the wing ends are built on a 3mm poplar base cut on the CNC pantograph. The outer edges are made with two laminated balsa listels+ one cedar listel of 2mm .

The structure is reinforced with balsa and cedar listels glued to the poplar ply base. The hinges are in 3mm fiber glass and are particularly long so to compensate aerodynamically the moving area.

I inserted two 7kg servos in the noses of the wing ends and I programmed them so to move the rudders only outwards. The elevons are controlled by big 24 kg. Hitec servos. The wing is attached to the fuselage with two 5mm centering dowels and two luggage rack elastic belts bought at the supermarket. The struts are made of stainless steel with two tubes, one inner tube measuring 6mm diameter 0,5mm tick and one outer tube drop shaped 0,25mm tick.

At this stage i have completed the fuselage. The front portion of the body is made of fiberglass carried out on a styrofoam mould, while the rear portion is of aluminum lithographic plate. All the panels can be removed to access all the internal parts. The radiator louver is made of a 3mm stainless steel round bar. It's a little heavy but I knew I had to add weight to the front so I did not worry about it. It's welded to the silver and simply polished with brushes mounted on the drill, it looks chrome plated. The other body louvers are in 2mm aluminium cut on the pantograph and polished carefully, they are very impressive. The doors are made of poplar ply , the hinges in fiberglass





and the handles in polished aluminium. I installed the radio (2,4 Ghz) behind the seat back. I did not use a power box connected directly to the servos without going through the receiver which could have caused problems with the high current drain of the giant scale servos. I installed also a working light retrieved from an old flashlight. The nose wheel steers and is shock absorbed, it's a 140mm regular wheel, the two rear wheels measure 210mm and have been perfectly constructed by a friend of mine. They are in machined aluminium and sponge mousse, unfortunately are covered by the wheel pants. The nose wheel does not have a pant because it rests against a heavy field box during the engine starting procedure. During this stage it's necessary to blow air on the radiator because it can not

be cooled by the airstream generated in flight. After I tried to install an onboard computer fan, which turned out to be inefficient, I decided to use a powerful fan mounted on the field box that blows air through a fabric sox fitted snugly to the radiator front. I had seen Burt Rutan using such system on his speed plane. I have also installed a thermometer on the cabin floor, this way I can read through the wind shield the water temperature and control the fan start. I performed an additional test and the engine ran for long time without overheating. I used a coloring scheme wich stands in between the original one and one of my fantasy but it resembles anyway the colouring of the time. I discovered in my workshop a can that I did not know I had, it was full of that green / light sky blue that I liked immediately. It reminds me of a Vespa I had when I was young and I

*Above: The wing structure  
Front page: the 2:1 belt reduction gear which never worked and the second try with direct drive without the flywheel, but even this way.....nothing.  
The muffler made out of two camping gas cans welded togheter.*

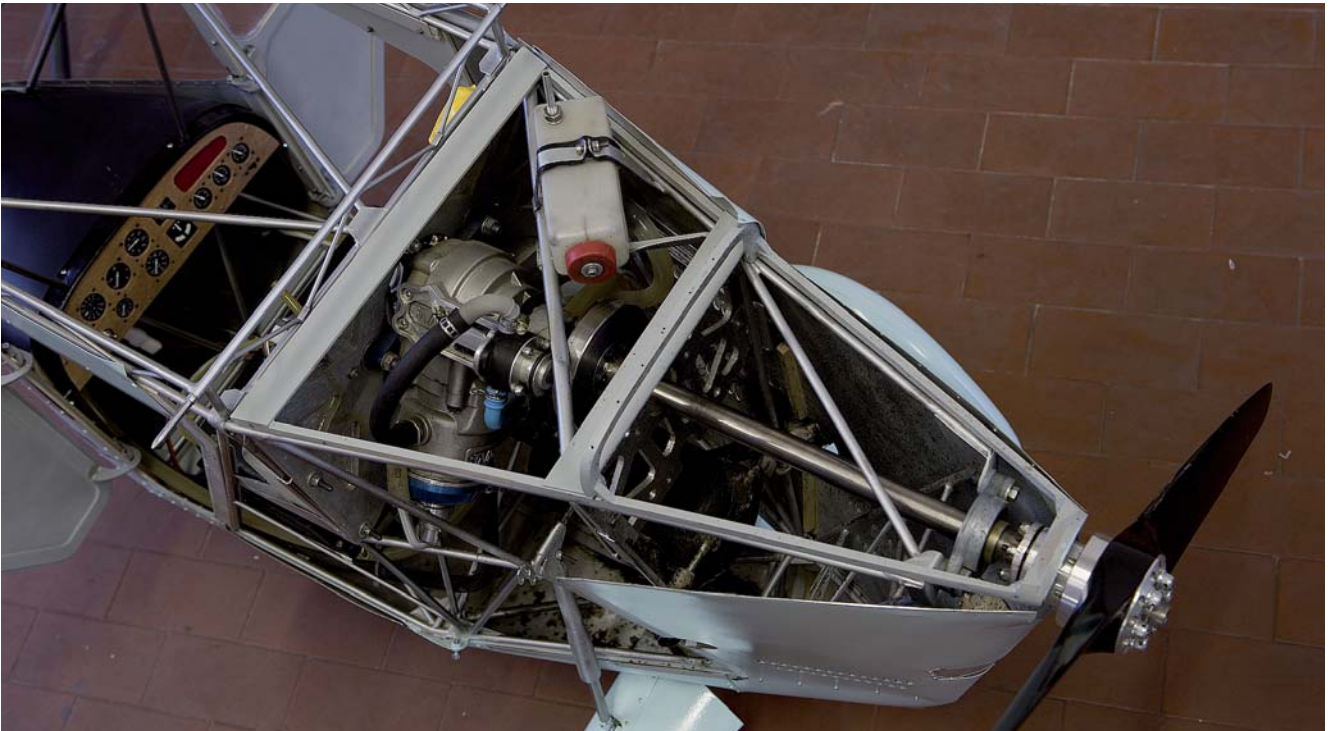
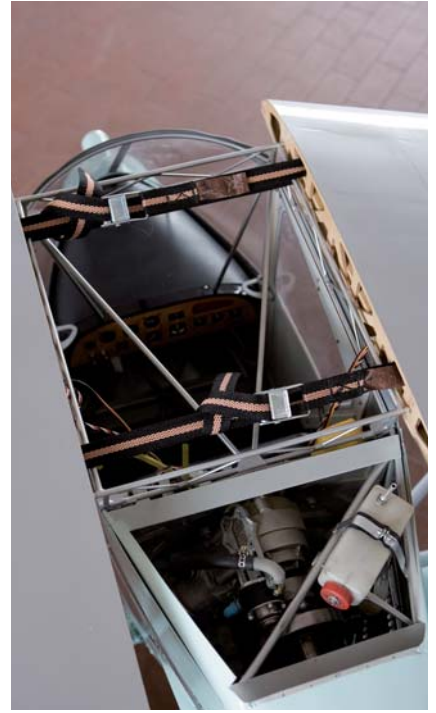












think it's the right colour. Having no experience of flyingwings I asked a friend ,who had built many, for his recommendation. He confirmed what I had assumed , meaning that the center of gravity should be where the strut connects to the fuselage. It had to be this way since one or two people could fly on the real plane and the c.g had to meet the rear end of the people. I had

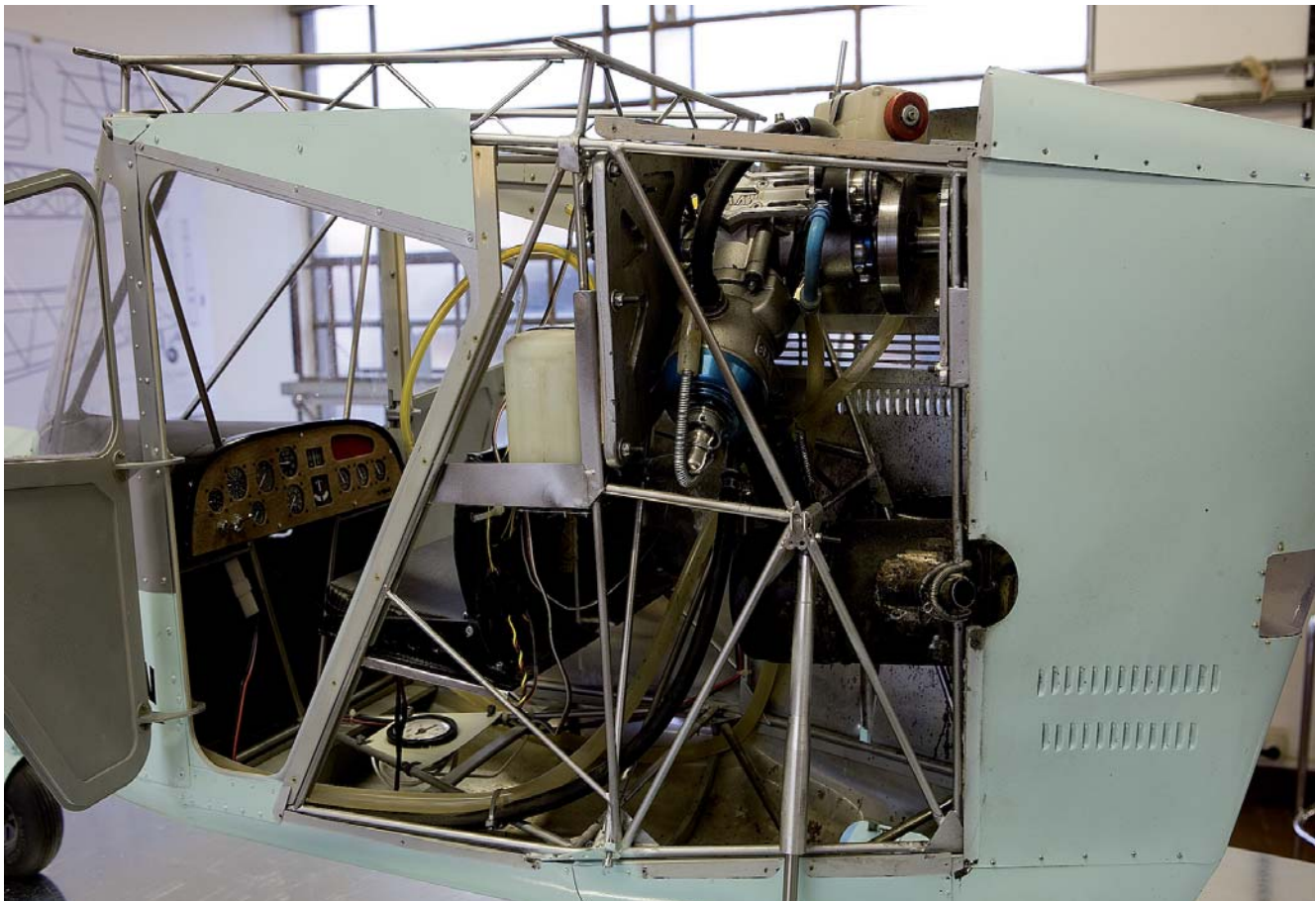
to add 1 kg. of lead attaching it right behind the radiator louver, but it was not over yet.....it resulted, from further tests, that the radiator , which is located on the nose same as the full scale and does not receive the propeller wind, is not sufficiently cooled by the airstream only , therefore I had to apply a small electric turbine behind the radiator same as it is on the car. To make a long story

short when I solved a problem a new one would pop up, after a repetitive breakage of the crankshaft I was just about ready to give up.....In the end, after several modifications everything seemed to work, and one week before the Ozzano Radio Model Show, we went to that airport where we had the runway available to prepare the flight coordinates and have the maiden flight.



On the left: structure of the end rudder, wing connection system and the new titanium shaft with the flywheel made from a meat pounder machined on the lathe  
 On the right: the thermometer for the water temperature and side view of the model interior.

On Friday June 5th, myself, Alessandro Tosato and Oscar Cecchinato, the two trusty cooperators of the Paolo Severin srl- where as you already know I produce my kits- together with Sergio Filippini pilot and tester, leave early in the morning with a van full of airplanes. In addition to the Arrowbile, we had the Bucker and the Fieseler Storch because that day a film making crew that was shooting a documentary on model aviation would have come up from Rome. The weather was very bad, dark sky, wind and rain treat. We decided anyway to start filming the Bucker which flipped over at the first landing due to the fact that the wheels were too deflated and caused the breakage of a wheel pant. Good start.....



We would have liked to go on with the test of the Arrowbile but the wind had gotten stronger. "This wind is right for the Fieseler!" I said, and I performed several flights against the wind and the Storch flew almost

backwards. To be honest I am a very bad pilot, even other pilots of full scale planes that were present told me so when they saw me grazing for few centimetres an iron pole ..... In any case it went well and the



filming came out good. Unfortunately the weather got worse and we thought that would be better "to put our legs under the table". We had lunch all together at the restaurant "Voli e Sapori" which is right at the airport and as expected on a such exciting day there was plenty of food. When we came out of the restaurant the weather looked better even though was just about to rain. The fact is that we decided to try to make the flight lines with the Arrowbile. The engine started normally and the electric turbine kept the water tem-

perature under 60° C. Sergio taxied to the runway and started to taxi for take off while the first rain drops were falling. At this point Sergio gave full throttle and took off very determined... forget the flight lines! I have to admit that I would have done the same in those conditions.

The wind was very strong but fortunately was down the runway, after the first turn i asked- " How is going Sergio, does it need lot trim?" – "No,- he answered quickly- it's very balanced, it's even too stable, it's hard to turn....." The wind was getting stron-

ger so as soon as the plane made the second turn lining up against the wind I yelled –" Please Sergio, land, an hurricane is coming!" – To tell the truth he was already preparing for landing . Holding the breath, heart up my throat.... Perfect landing! Everybody screamed, clapped and ran under the airport firefighters tent to get a shelter from the rain. This has been the only flight of the Arrowbile before the Radio Model Show on Saturday June 12th, where after a beautiful flight, due to crosswind , it landed a little hard fortunately only with small damage to the







landing gear. Sergio says that she don't feel the side rudders that open only outwards. Probably he is right, after all a plane like this needs a further set up. In any case it flyes well , the engine runs without a problem, we'll see about the rest.

Paolo Severin

[www.paoloseverin.it](http://www.paoloseverin.it)





