The Fokker FG-2

Bringing aviation history back to life at 1/5th scale.

Vincent de Bode

The Fokker FG-2 flying over the Atlantic at Retroplane 2017. (image: Retroplane 2017 Media)

The challenge for Retroplane 2017, which took place in Vauville (France), came at the exact moment I finished my 1/6th scale Nemere, built in ply. The challenge was to build a glider of which the prototype was built before 1925. It was possible to reserve a specific glider, but that naturally gave the moral obligation to build it.

I very much wanted to participate, so I started looking for a suitable glider. Rob, a friend modeller, nudged me in the direction of a Dutch glider and showed me some documentation of Fokker gliders. I saw the FG-1 and FG-2, FG is an abbreviation for Fokker Glijdvliegtuig (Fokker Glider), and I thought: “Well a biplane is something different, why not?” I guessed the simple straight wings should be no problem (that turned out somewhat different) and I decided to build the FG-2. My provisional registration for

Retroplane 2017 was accepted.

The Investigation

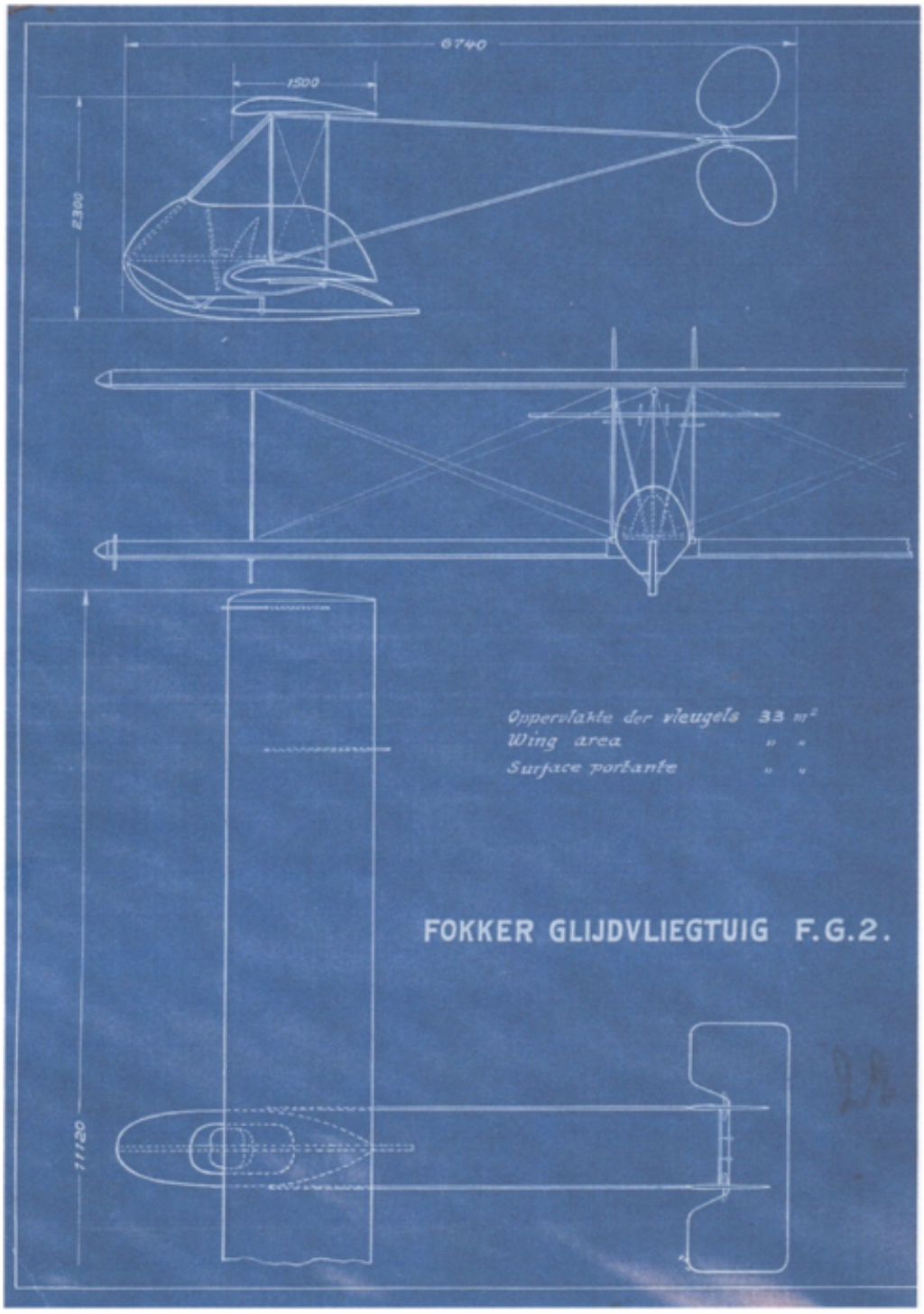
The FG-2 is mentioned in the German gliding museum with records as the first glider with a passenger at the Wasserkuppe and Ilford Hill.

This is the first conversion of the FG-2. Left on the photo someone is changing the rudders. Nice detail; the FG-2 stands on some wooden crates, its empty weight is just 93 kg. This picture gives a lot of info about the rudders, elevator and rudderhorns. Also visible is the internal cross bracing of the wing. (image: Hans Disma Collection)

I tried to gather information, which turned out to be quite limited. All the drawings I could find were different. Luckily there was some footage of the FG-1 (a very similar single seater) and FG-2 flying. The Aviodrome (a Dutch aviation museum) and Hans Disma provided me the original drawing and some nice photos, two of which were really sharp. Slowly I started to realise that this was a completely different plane from anything I had ever built. At

first I thought the FG-2 was built completely out of wood, but a lot of beams and struts were too thin in the photos to be made of wood, they had to be metal tube. Just recovering from that shock, I discovered that there was only one photo with ailerons and that on all the other photos and footage there wasn't an aileron to be seen! That meant this glider used wing-warping, a conclusion with great implications. This wasn't going to be a simple plane to build after all.

I started to read a lot about Anthony Fokker and watched a documentary about his life. A funny coincidence; he visited the same secondary school that I had in the sixties, I even recognised the physics classroom! At the Aviodrome I had a close look at the Spin (Dutch for 'spider', Fokker's first plane) to get an idea of how he worked with wood, steel, wires and canvas. Via the museum I came in contact with Hans Disma and the Historical Fokker Foundation. With all the gathered information I tried to reconstruct the development of the FG-2. In my view there have been 4 variants:



This plan is from the Aviodrome museum. I got it just after I finished my drawings, or rather sketches. It shows the long tail boom (but without a frame), the fuselage is the one I built. I assumed the overall dimensions are correct; span 11.12 m, length 6.74 m, empty weight 93 kg, fully loaded 260 kg. (image: The Aviodrome)

1. The original FG-2. The skin of the cocoon-shaped fuselage (nacelle) was attached to the skid. The fuselage extended until behind the trailing edge. The aircraft had a short tailboom, without internal bracing or frame.

2. First alteration, the left rudders were enlarged, with square extensions at the top and bottom.
3. It seems to me that it still didn't fly well and Fokker made a drastic change. A much longer tailboom was made, with a frame and internal crossbracing with wires. The rudders were changed back to original. The nacelle was also changed and the number of stringers (made from tube) reduced from 8 to 5 and the nacelle was shortened at the rear.
4. The wing-warping was replaced with ailerons. There is only one good photo of the FG-2 in this configuration, I couldn't find any documentation of it flying.

It is claimed that the FG-2 is the first glider ever to take a passenger, which by the way, was also filmed flying. Fokker (as a pilot) experimented also flying along the slope instead of flying directly into the valley. There are two duration records with his name. One was a flight of 37 minutes at Ilford Hill, which was later beaten by captain Ottley at the same location.

This is the glider I built, long tail boom with a frame, internal cross-bracing, normal

rudders, altered fuselage with two tubes per side and the fuselage covering free from the skid.

I got the impression that the FG-2 was made as an easy to (dis)assemble and transport glider. There is footage of the FG-1 and FG-2 in a kind of cradle on a small open truck. The tail consisted of four steel tubes (the original tail-boom) and the wings could be separated from the fuselage. It looks like Fokker designed the FG to get a very low wingload to get a low sink rate, with the glide slope ratio being less important. This was a common design philosophy at the time. I couldn't find anything about more FG-2s being produced.

After all this research I decided to build the third variant and I started to make some sketches. Some dimensions were known, but the wingspan for example was 12 m in some drawings, and 11.12 m in others. Luckily I got the original drawing, indicating 11.12 m. A major issue in building this variant was the wing-warping. This principle was already used by the Wright Brothers and also by Fokker. But how much wing deflection was needed? Luckily a colleague Retroplaneur built a Willy Farner and I learned a lot reading his building story, albeit in French.

The principal dimensions of the model (scale 1:5) would be a wingspan of 222.4 cm, length 135 cm, height 48 cm. The wing struts, tailboom, empennage and stringers of the fuselage should be made of steel tube. The skid and support of the chairs are wood with metal fasteners, like the Fokker Spin.

Building

Because I only had a vague idea of how the front of the fuselage was made I started with the wings. I couldn't find a drawing or other documentation about how the wing was built, only the distance between the two spars (55 cm) and the chord (150 cm). The transparancy of the wings is very characteristic on the photos. Normal ribs don't have this effect, I guess. On

the Retroplane forum lots of old gliders are built with ribs made from thin battens — in French “nervure aux baguettes” (sounds wonderful) — strong and light. So I decided to have a go for it! Luckily all the ribs were the same, so that’s good news. When I was half way making the ribs I found out I miscalculated the amount of ribs. This had something to do with two wings, of course.

Wing rib production at full speed. In the foreground the milled jigs from Delrin. Behind that the gusset plates, about 2000in all ! All the wooden battens have been cut to size. (image:)

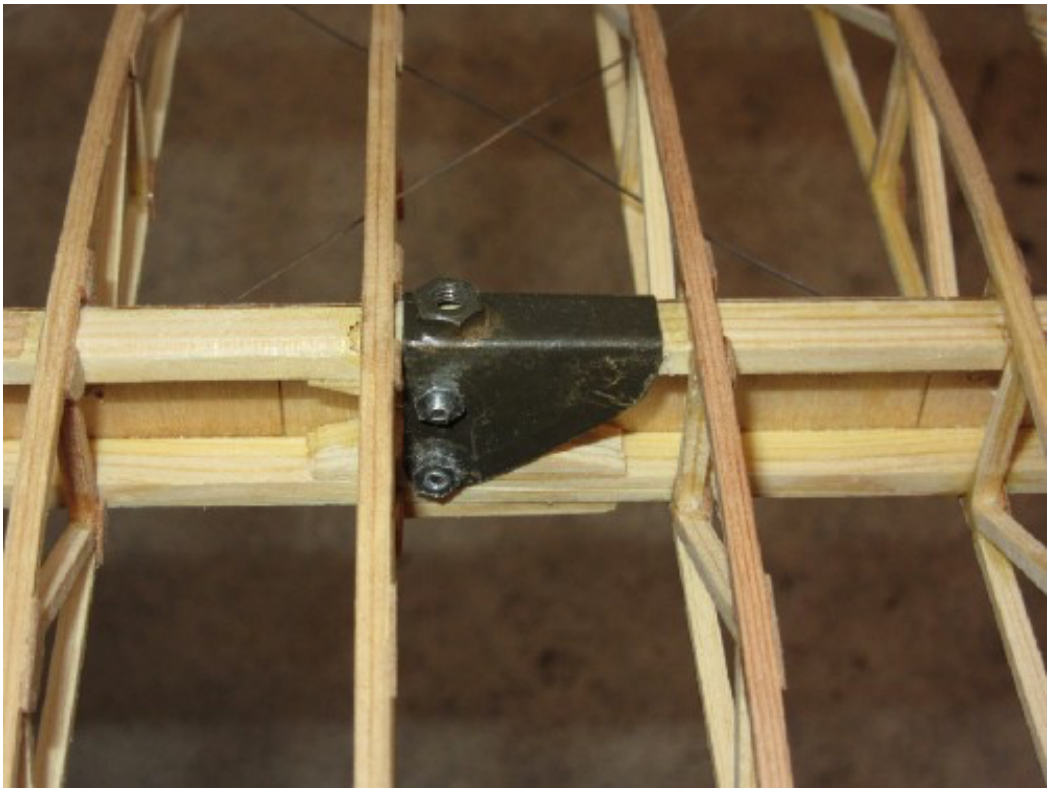
My friend Adri milled rib templates from Delrin (later I found out that Paolo Severin has already been using Delrin for a long time, beautiful website by the way). Lots of spruce battens from 2x3 mm were used. Also lots and lots of webbing plates, thanks to Adri who did all the milling! Just before my summer holiday I had 140 ribs finished.

Returning from the holiday I started building the wings. Originally in one piece, but Rob came with the idea to divide the wings in three parts, a small middle section fixed to the fuselage with two outer detachable sections. I wanted to keep this connection as invisible as possible, so the joining

construction should be as thick as the spars itself.

All the components for the wings. The wing joiners are kept within the spar profile. The filler pieces are needed for the strut fittings. (image:)

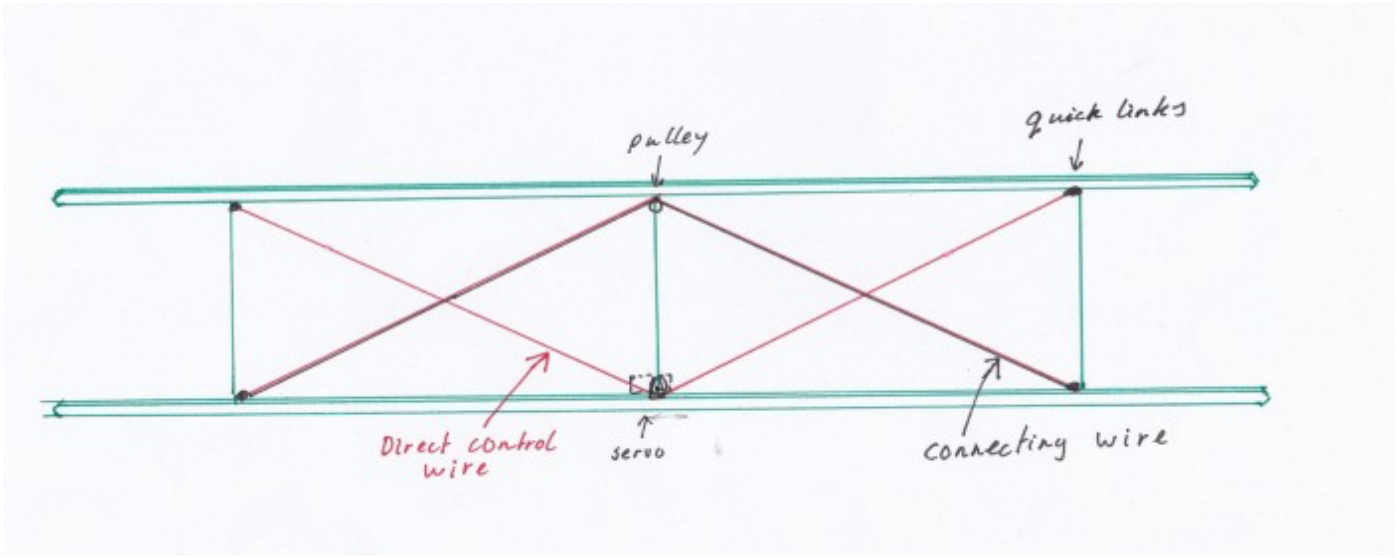
I made the spars from 8x4 mm spruce at top and bottom, connected with 0.6 mm plywood as webbing plate. Not a boxbeam, the wing should not be stiff in torsion, that was a strange thing for me! For the wing joiner in the front spar I used a steel strip of 1x10 mm, in the rear spar 3 mm round steel, both in brass profiles. These profiles are glued in the spars with thickened epoxy. The M4 nuts and bolts for the struts just fitted in. Thanks to the beautiful photo from Hans Disma I could figure out how all the ribs were placed. I started with the central wing parts, the rest followed quickly.



Homemade U-profile with an M4 nut soldered on it, attached with two M3 bolts to the spars. (image:)

The fastening of the struts required some headscratching. I planned to let a short piece of M4 bolt protrude out of the wing, over which I could put the strut (6x0, 5 mm stainless steel tube), secured with a 1 mm steel wire clip through the tube and an oversize hole in the bolt, to give some room for movement. Because a 4 mm hole in an 8x4 mm spruce batten weakens the wood too much, I made a U profile from 0.5 mm metal sheet, silver soldered a M4 nut on top, in which I could put a short piece of M4 bolt later. This U profile was fastened with a M3 bolt through a filler piece in the spar.

Wing-Warping

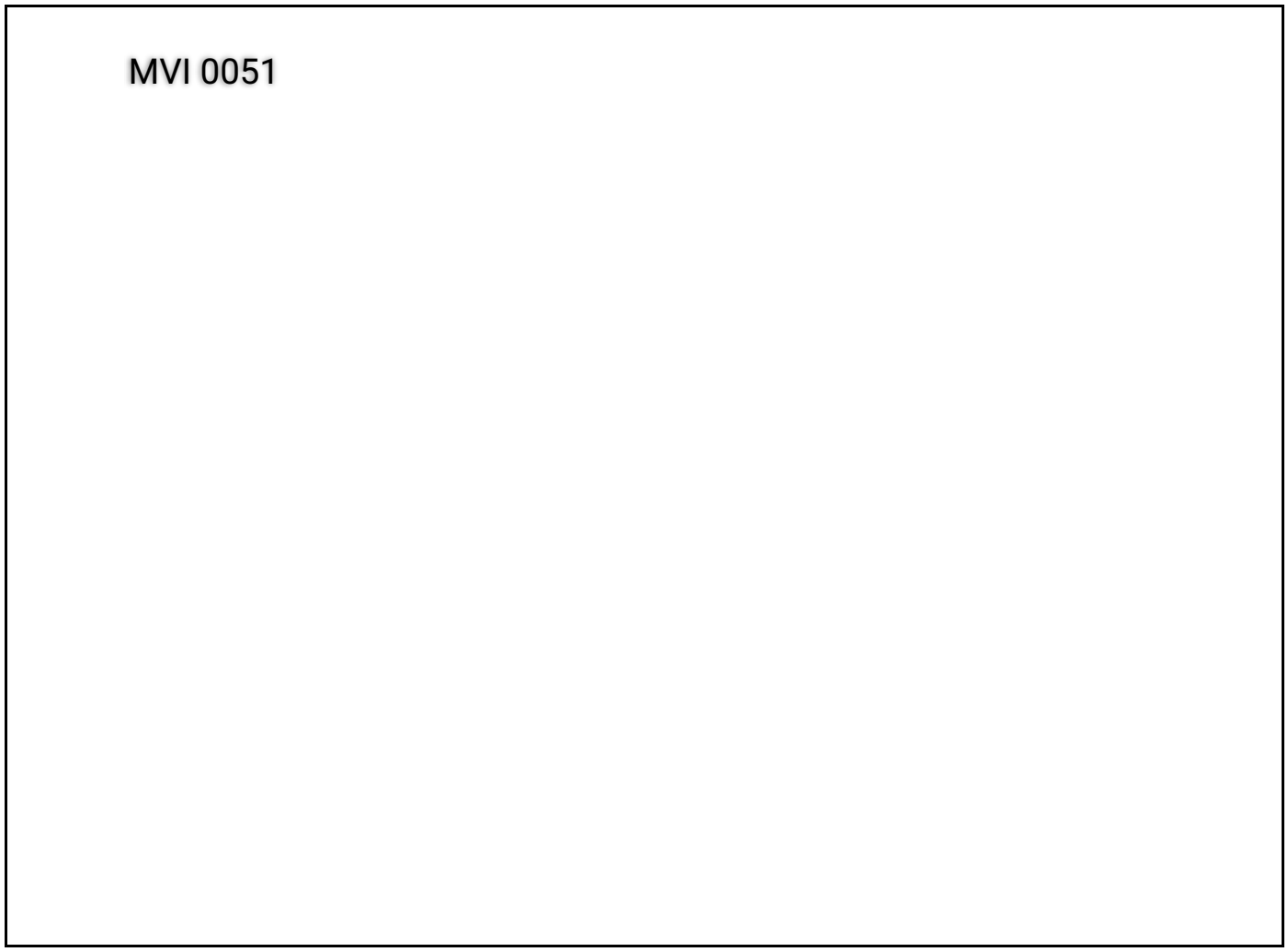


A sketch to explain the wing-warping principle. (image:)

Slowly I started to understand how I would construct the wing-warping. At the bottom of the rear central strut is the operating device. In the model it's a big servo, in the real airplane it was a sector plate which was connected with the control stick via a torsion tube under the wing.

Detail of the modified servo sector plate. The quicklink is drilled out and is connected with an M3 bolt through a bush. This is a vital and heavy loaded part of the controls . At full throw the servo consumes 2A, at half throw it's 0.7 Amps. The servo is rated for 2.5 Amps. (image:)

The sector plate of the servo is connected with rigging wire to the topsides of the outboard rear struts. When the sector arm pulls a wire, the strut on that side will lower. With a second wire which runs over a pulley on the topside of the rear middle strut, the strut on the other will rise. Because the front struts are made rigid by means of crossbracing, the wings have to warp. Difficult to explain in words (especially in a foreign language) but very logical when you see it. The servo used has 14.5 kg/cm torque and draws max 2.5A. To my relief it functioned well, the servo consuming 1.7A at maximum travel.

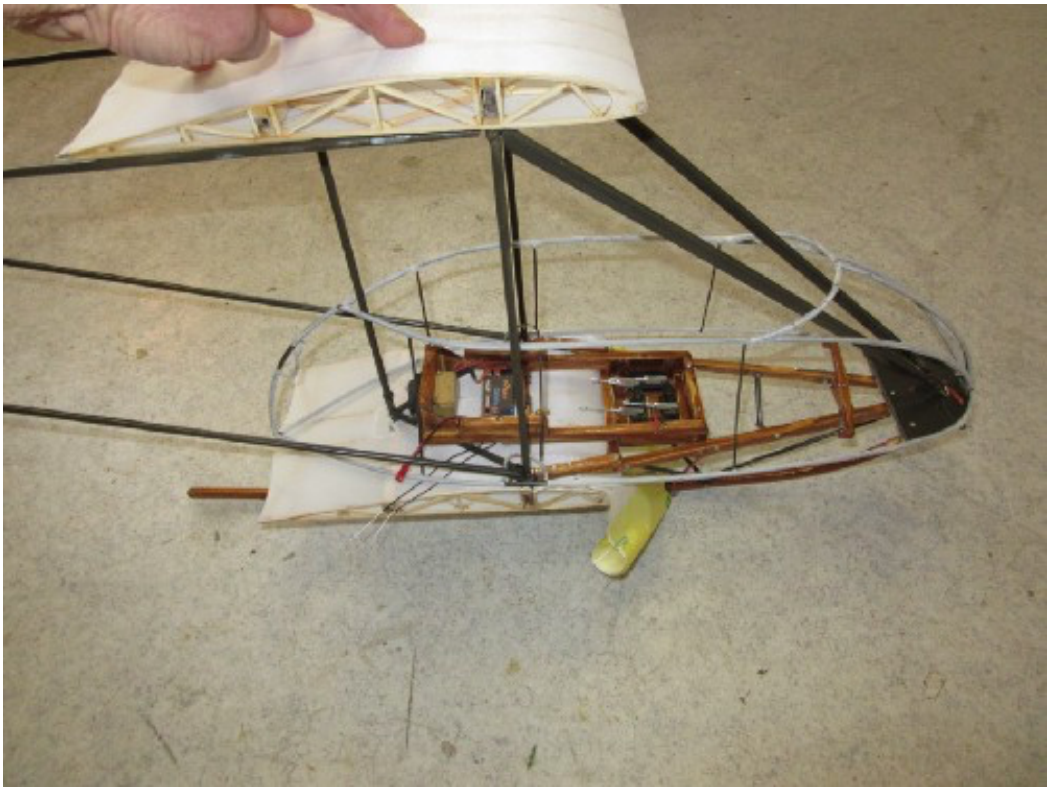


The wing-warping mechanism in action. (video:)

The Fuselage

First, some remarks about the metal tube used in this glider. Nowhere I could find any dimension, so I had to guess it, put it in place and compare it

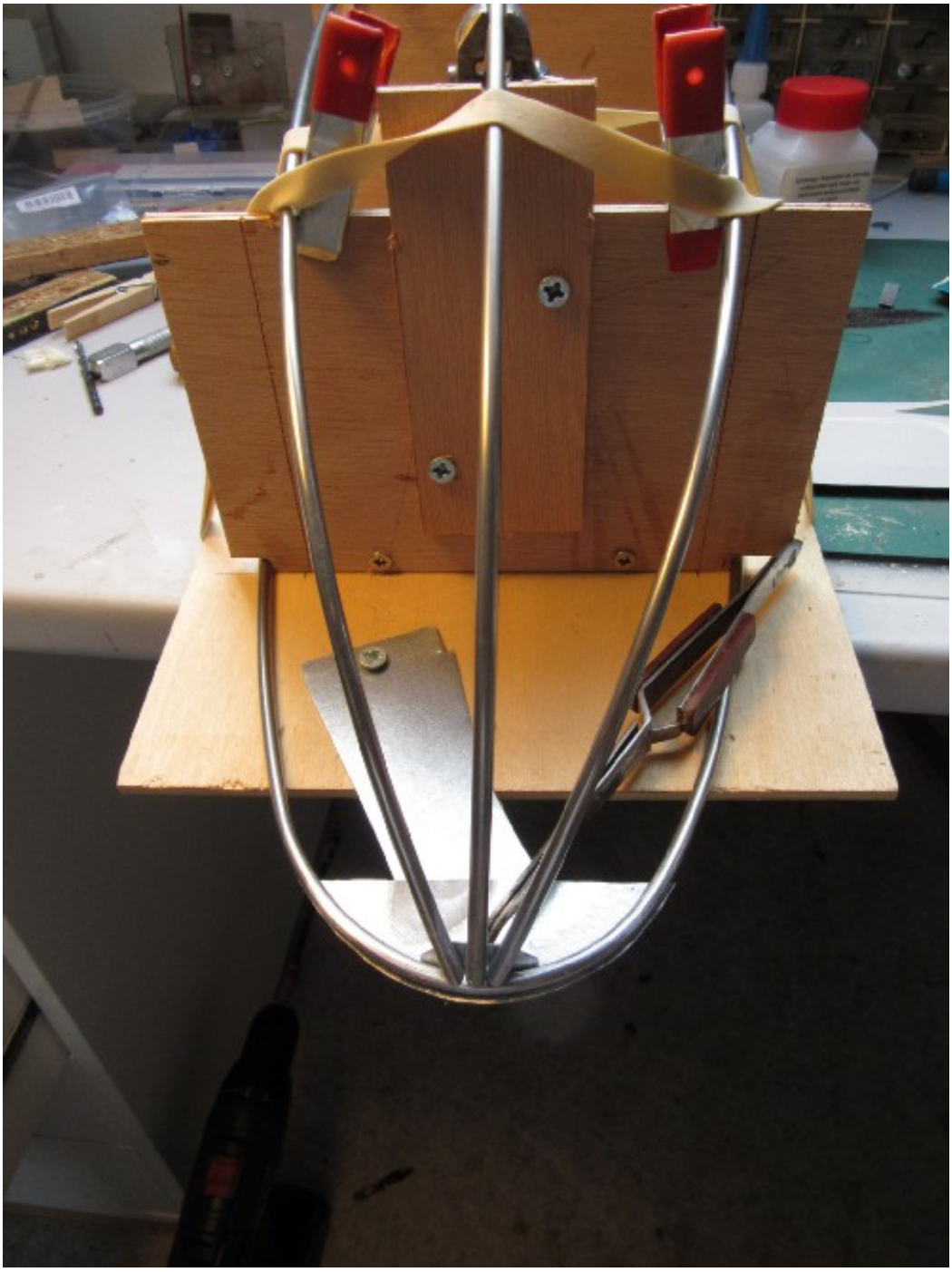
with photos. I also hesitated about the thickness, 0.5 mm or 0.25 mm. It happened quite often that I had to remake parts, just because they didn't look good. It is difficult to measure on photographs, they are often not very sharp. I ended up using 4x0.5 mm tubes. The tubes were bought at 'Tubos Capilares' in Spain, delivered in lengths of 2 meters. All the tubes were silver soldered for enough strength. I had to learn that, which took time! A lot of trial and error was involved. The tubes were bent with steel cable inside to prevent buckling.



An overview of the front of the fuselage. Almost everything is connected to the central front struts, the rear strut only determines the angle between the wing and the fuselage. The placement of the RC components and the servo for the wing-warping is visible. (image:)

From scrap ply I made a kind of jig to keep all the tubes in position. A small and a big torch were used for soldering, depending on the size of the joint. I used a lot of flux (looks like yogurt) to solder it. The solder likes to flow to the hottest place, so there is a way of 'steering'. It took time to learn and in the beginning I had to start over a number of times: clean everything up under the water tap and have a new go. Complex joints have to be soldered in one go which can be challenging, so you have to think well in advance!

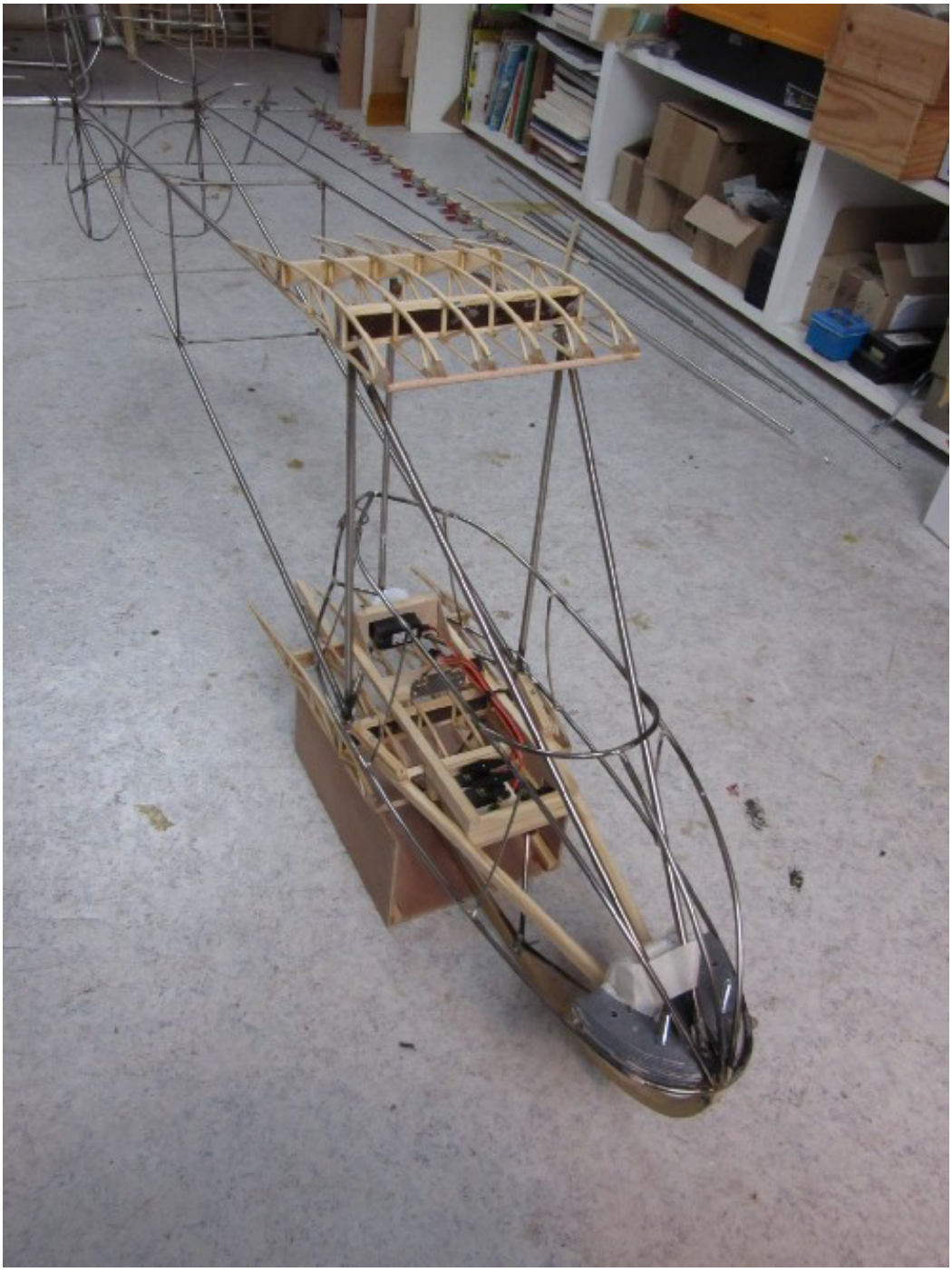
Now it was time to make the rear of the fuselage, which was completely uncharted terrain for me. The tail boom consisted of four stainless steel tubes 6 mm diameter. I started with a wall thickness of 0.5 mm, which was very heavy, so I replaced that with 0.25 mm thick tubes. The tail boom is attached to the two forward middle struts. These two struts are literally the centre of the glider, almost everything is attached to it: the tail boom, the rear central strut with spacers and crosswires, the nose section, both wings with the load bearing spars and the rigging. The central rear strut, cross braced to the two front central struts, only keeps the wing in the correct angle of incidence. My guess is that on the real airplane the tail and wings were removable. That probably changed with the third version, due to the extra frame in the tail boom. In my model I made the tail and two short middle wing sections fixed to the fuselage. On the real airplane the wings were in one piece.



Soldering aid for the front of the fuselage. It looks a bit disorganised, but with some notches, clamps etc. it all fits nicely together. (image:)

The nose section of the fuselage consist of a wooden A-frame, attached with two diagonal struts to the central middle struts. I made the wooden A-frame from 8x8 mm spruce, glued and on visible places connected with metal plates and M2 bolts and nuts. On Fokker's planes that seemed to be common practice. On this frame I made a demountable wooden rectangle for the seats on top and the servos and receiver underneath. Under this frame are supports for the control column. The column can be moved, but

it’s not connected to the servos — that was too big a challenge at that stage for me. On the front side of the A-frame are the rudder pedals, made of wood. I laminated the skid from 5 layers 8x2 mm spruce. I had to put the spruce in boiling water to get it in the right curve. All the wood was coloured with bister, an organic, water soluble colour powder for a nice antique tint. After that I laminated glass rovings with epoxy resin on the skid to make it stronger, which is almost invisible. The skid is attached with M2 bolts and nuts to the metalwork. The streamline body consists of several bended tubes, covered with Diacov.

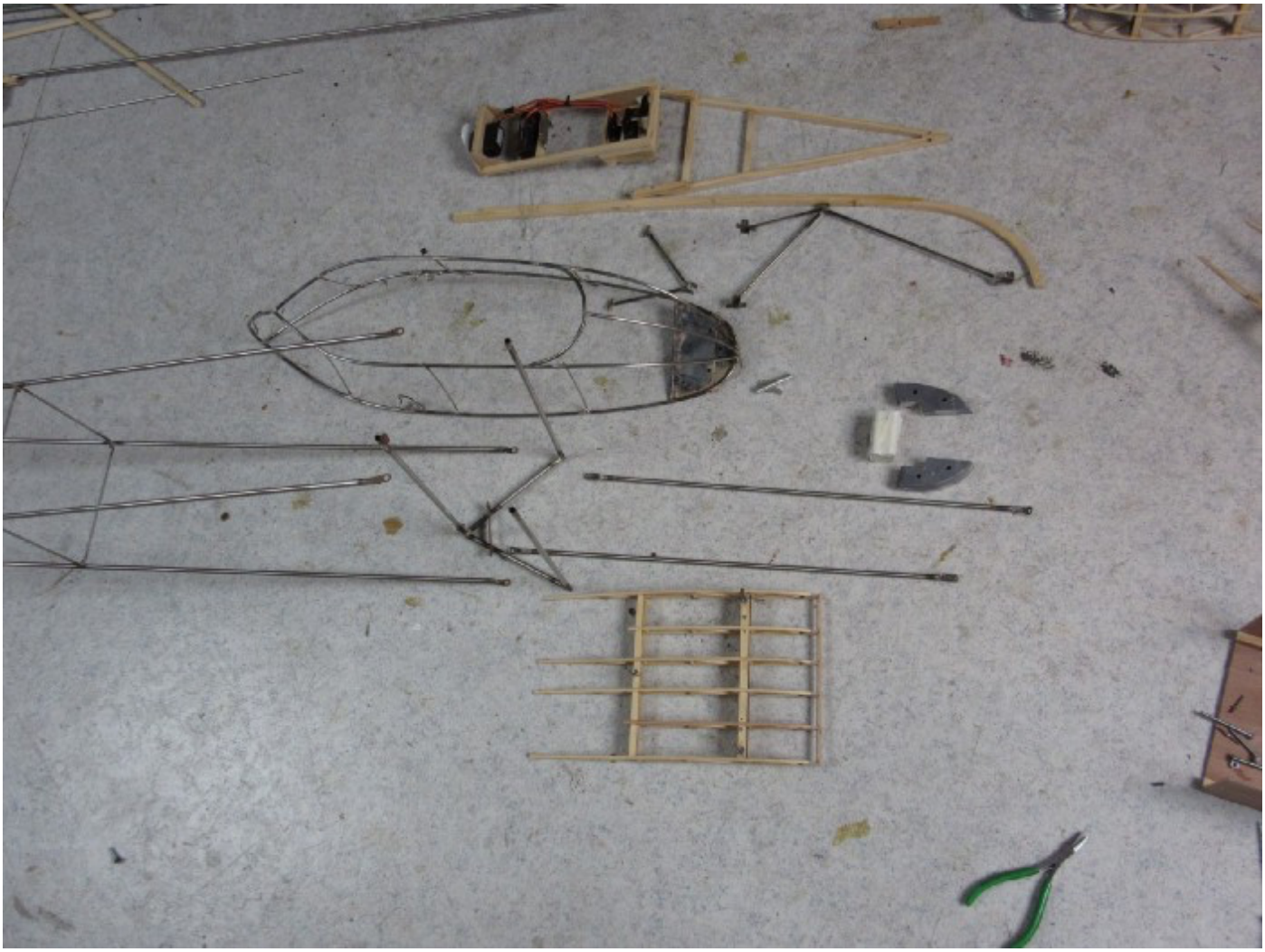


The fuselage in its early stages, a strange combination of wood and metal. Wood is certainly a part of the load bearing construction: the crew sits on it. When looking at the photos and some footage, I think I got that right. In the real airplane the fuselage was just a streamlined affair, in the model I used it as an integral part of the construction. (image:)

The connection with the middle, front struts at the lower wing is a complex construction. At each side an M4 bolt sticks out of the wing. Several parts come together here: the wooden A-frame (with a metal strip), the tailboom, the streamline body (with a gusset plate), a strip for the front crossbracing

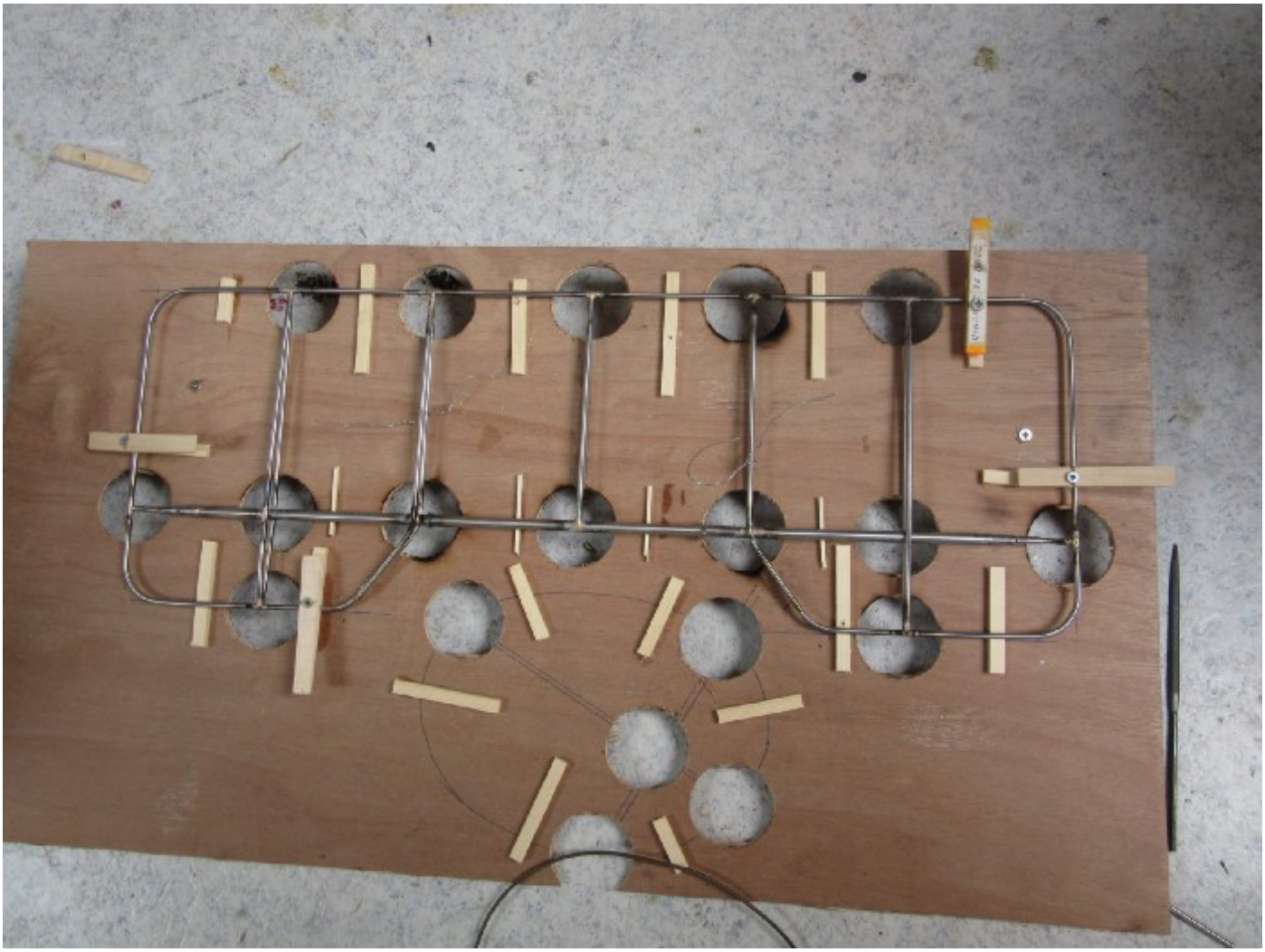
of the wing and finally the strut itself, all secured with a 1 mm clip through a hole in the M4 bolt.

The tailboom itself looked quite straightforward, but it had its challenges! The frame, all the thin tubes and gusset plates must be positioned in the correct position to solder it in one go. Regularly I was short of hands and when the metal isn't red anymore, it still can be hot. The tailboom ends in two short vertical tubes, connected with gusset plates for the rigging wires and horizontal stabilizer hinges. Through these vertical tubes I put thinner tubes to which the rudders are attached.



Most of the components of the fuselage are displayed here. All is kept together with the two middle front struts (with the 1 mm steel clips). Fitting everything together like a puzzle was quite a headache. The wooden rectangle with all the RC components must stay demountable even in the finished model. (image:)

The Rudders and Horizontal Stabilizer



The soldering jig for the empennage. My guess is that Fokker chose to have top and bottom rudders to avoid torsion of the tail boom. The two sets are probably for ease of construction. I got the impression the glider was designed to be easily disassembled. The tail boom consisted of four tubes, wings in one piece and the fuselage looks demountable, as a dome tent long before its time. Apparently to improve its flying characteristics Fokker had to lengthen the fuselage. The FG-2 was intended as a floater, with low wingloading and low sink speed. (image:)

I built these in the same way as the original. Somewhere on the internet I found photos of the building of a replica Fokker fighter, which gave me a good idea of how they were constructed from metal tube. From a scrap piece of ply I made a jig with big holes in it, so I could solder with a flame (bucket of water at hand!). Stainless steel tubes of 3, 4, 5 and 6 mm with a wall thickness of 0.25 mm were used. Very quickly I had a stabilizer! To cut all the tubes I used a diamond cutting disc on a Dremel, more expensive than the thin carborundum discs, but they don’t break.

A rudder under construction. Because of the thin walled tube, one covered rudder weighs only about 30 gram. (image:)

The rudders are made in a similar way. The central tube is 6x0.25 mm in which a 5 mm tube is soldered, this 5 mm tube goes through the 6x0.25 mm vertical tubes of the tailboom and the bottom rudder slides over it, secured with a 1.5 mm steel pin. One rudder weighs about 30 grams. The actuation of the rudders is exactly the same as in the real airplane. The rudder horns were made of 0.7 mm metal sheet (a side panel of an old PC), soldered to the central tube of the rudders. They are connected with steel wires (strength 40kg) to the servo horns which are located under the pilot seat.

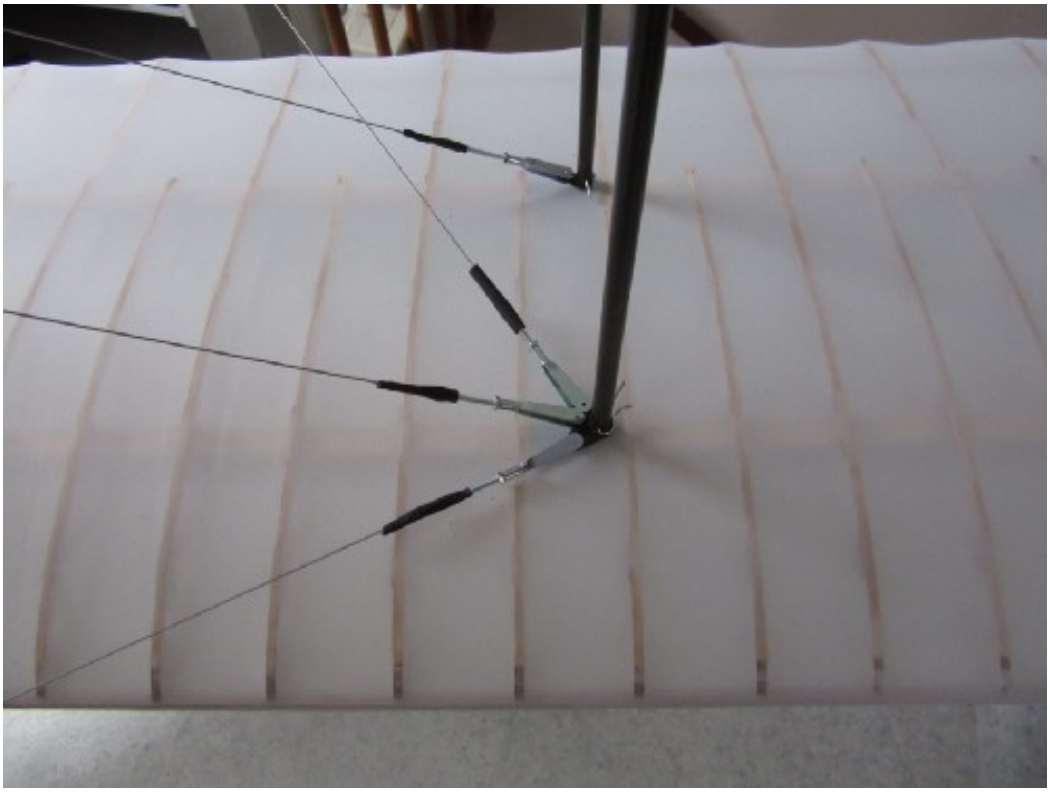
Covering

Before covering, the metal had to be painted. After counselling with some Fokker connaisseurs I went for a specific dark green. The local paint shop filled a spraycan with a primer/paint in that custom colour. The nasty thing with spraying all those tubes is that more than 90% of the paint will not reach the tubes. I have a kind of spraybooth, but somehow a lot of green

paint ended up outside the booth. For covering I chose Diacov, which looks like fabric. The width of the material was sufficient to cover the wing in one go. Because the trailing edge was a steel wire of 0.6 mm I had to fold the Diacov about 5 mm around the trailing edge. Covering the fuselage was a little more complicated, lots of small corners and gaps to cover. To make it less transparent I doubled the Diacov. The underside of the fuselage was even more daunting. I guess the real plane had a steel wire from the top of the main spar over the LE to the bottom of the mainspar running through a seam in the cloth. I can't model that, so I made a wooden replacement for that. I laminated this part on which the cloth is ironed. There were no wrinkles and it's obvious the cloth isn't directly attached to the wing, just as on the real airplane.

The Rigging

Now that everything was covered it was time to make the rigging. I had no experience with functional rigging and encountered several problems. For the static rigging in the fuselage I used 0.6 mm massive steel wire, for all the other rigging and control cables I used stranded steel wire, max strength 40 kg, with clamping bushes.



Detail of the demountable struts. I soldered metal plates on the ends of the tube with holes for the quicklinks. With a 1 mm steel wire clip it is secured (with oversize holes to allow movement) to a short section of an M4 bolt, which is screwed in the nut in the wing. (image:)

The loads on the wires are substantial and as the whole structure is very stiff, the peak loads on the wires during hard landings are very high. This caused the wires to slip through the clamps. I put an extra loop through the bushes and that solved the problem. Another problem was the opening of the wing-warping quicklinks under high loads. I modified the quicklinks by replacing the quicklink pins with M3 bolts, nuts and spacers and I am confident that it's strong enough now. The other quicklinks are now secured with a home made spiral spring which I can slide over the quicklink. During transport it takes a lot of effort to keep all the wiring tidy, but the wires are a vital part of the looks of this glider.

The Crew

The crew is very visible in this aircraft, so the pilots had to look as good as I could make them. They also had to be quite flexible, otherwise it's impossible to get them in. It's very cramped in the Fokker! I made the

figures from balsa with knee and elbow joints made of Robart hinges. The hip and shoulder joints are made of elastic band (same stuff as used in clothing). The heads have a 6 mm peg, which fits in the bodies. I made the heads from Super Sculpey. This clay-like material hardens at 140C, simply in the kitchen oven. I found some wonderful tutorials which show how to do the sculpting. The heads stay detachable, it's then so much easier to put the clothes on. My sister Hans had a good look at some photos of Fokker and his passenger and she made great clothes for the pilots. She added a big shawl which flaps in the wind, which looks very dynamic.

Instruments

There are only two instruments onboard. On the left diagonal strut a woollen thread as a slip indicator, and on the right diagonal strut a "anemometre Wilhelm Morell" a kind of universal airspeed indicator from World War I. The latter is a very characteristic item, so it's vital that it look good. Luckily very good drawings are available. I was thinking about printing it in 3D, but lack the knowledge to do so. I counselled my friend Adri, he looked at the drawings and told me to have some patience. After a week he turned up with a beautifully crafted anemometer in 1/5th scale. Lathed, milled, pressed, glued and to my big surprise even functionally turning! My day couldn't be better! He also cut decals with number '4' and a small "Fokker" logo.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Left: The two intruments. The “anemometre Wilhelm Morell” rotates when the aircraft is flying! **Middle**: The

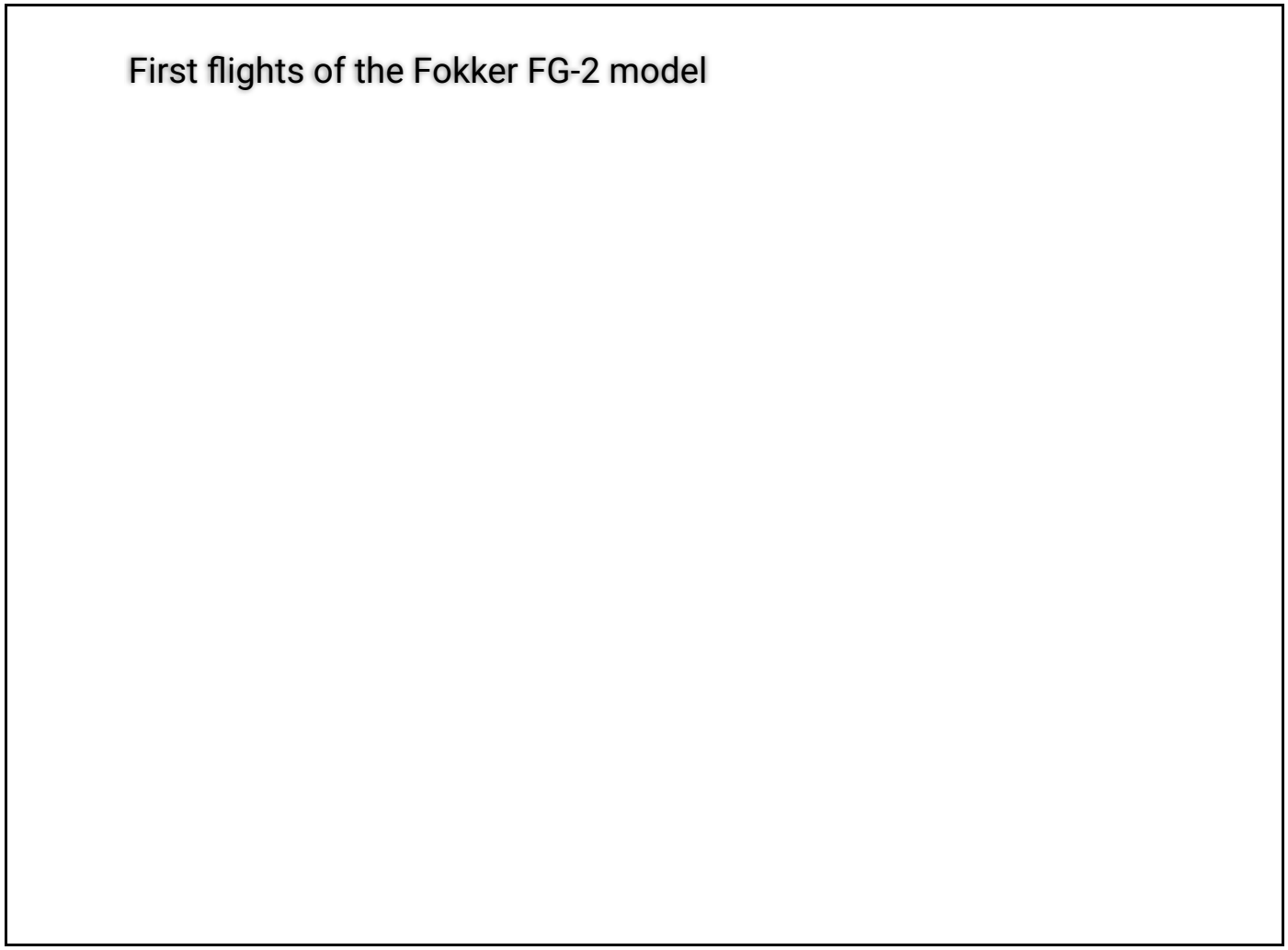
housing, two beautiful crafted pieces of brass. **Right**: The final result, later sprayed grey. (images: Ari Brand)

Flying at Last

Finally the FG-2 was finished and on a well cut meadow I put it together for a photo shoot. After the photos were taken, it was very tempting to make some hand tosses. They did not go that well. First of all it's an awkward plane to grab and secondly there was almost no wind. The Fokker responded weakly to the wing-warping. It had some hard landings with damage and the bushes in the wing rigging had slipped.

So back to work: I altered the rigging bushes and the wing-warping. The wing tip travel is now seven degrees up and down. We decided to make an aerotow start. I made a basic dolly and we went to our flying field. Rob has a Piper as tow plane, which we estimated to be just powerful enough. The tug started, scary, a lot of work and a lot of unknown variables. The Piper had to work hard, but it went well, the FG responded properly, just a bit sloppy on the 'ailerons'. It was a beautiful sight, the transparency of the wings with the shadow of the top wing over the bottom wing, wonderful!

It was a rewarding moment to see the Fokker flying after all the trouble to figure everything out. I saw a Fokker that looked very much the same as the one I saw on the old photos and footage. A piece of history which has come to life again. As expected the plane has a steep gliding angle, like a glider with the spoilers open, it's coming down at an amazing rate. Later it appeared the CG was a bit too much forward, so I took out 220 gr lead and it flew better.



First flights of the Fokker FG-2. (video: Raymond Esveldt)

Retroplane 2017

The launch over the Atlantic Coast at Normandy during Retroplane 2017. (images: Retroplane 2017 Media)

Finally we stood with all the participants of Retroplane 2017 on a hill, 150 meters high at the Atlantic coast in Normandy. A fantastic location suitable for SW through NW winds. A nice sloping hill with ample room for landings. When the wind should drop it was still possible to land 50 meters below the starting position. The wind was 20 knots plus and there was a lot of flying, but very few models of planes before 1925. I decided to have a go, the Fokker was a bit more than 4 kg. It was scary to launch this museum piece, but my flying mates Sjoerd and Claude provided me with some moral support. No guts no glory! Sjoerd is very good at tossing models, so it was his turn. It's an awkward model to handle, but the launch was OK. A quick correction and the Fokker flew beautifully. There was ample lift, the Fokker was in its element. It steered nicely and it was spectacular to see such a biplane soaring over the ocean. It was a rewarding moment.

Then I realised I had to land it. In flight this airplane is a bit like a normal glider with the airbrakes fully deployed, it's just impossible to pick up speed. I managed to land it, but I have to learn to master that better. I made some

more flights that Saturday and the Fokker handled quite nicely, it once dropped a wing (or should I say two wings?), but it was easy to recover. On Sunday the wind was less and it became sunny, good for the pictures. Sunday night the Fokker won the Challenge 1925 award, something of which I am very proud.

It was a very rewarding project, finding out how this plane was built, the building itself and the flying combined with all the feedback from the Retroplane forum.

Additional building details for my Fokker FG-2 can be found on the Retroplane Forum. Also, for those who are interested, here are some of the other entrants in Retroplane 2017.

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