Restoration of P51D Mustang

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Last edit 10 May 2020

This is a model built to Tony Nuijhuis' 1/7 scale plan and kit. It had been flown once and crashed. It had been generally well built but poorly shaped and finished, with little or no filler and coatings. It looked as though matt acrylic had been sprayed onto bare wood. This resulted in a rough, unprotected finish and splitting of the sheeting during storage. The repairs needed after the maiden flight were not so well done.

I intend to fit more powerful servos and all-metal arms and horns instead of the plastic ones already fitted. This will be quite a heavy and speedy model with fairly large control surfaces so I want solid control. I will reduce the thickness of the tail surfaces as they do not look to have been shaped enough. That will save weight. The motor is a barely used 4Max PO-5056-360. With a 6S battery this will produce more than enough power. I will decide later whether to use a two blade propeller or a less efficient, scale, three or four blader. Ground clearance should not a problem.

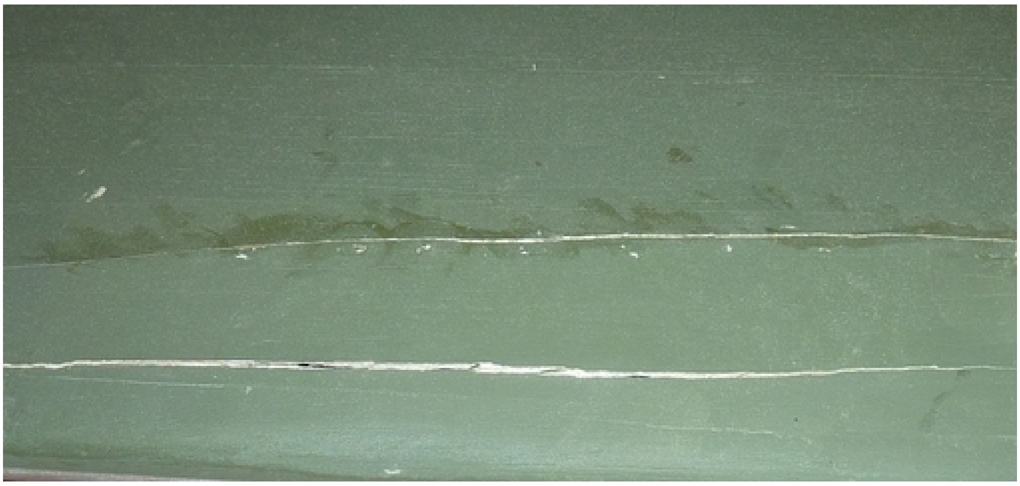
Wings

I started with the wing. I experimented with the left wing top surface first to decide how best to do the rest. I removed the aileron and flap. First I glued the sheets together where they had split apart. Then using a flat aluminium sanding block with adhesive 120 grit paper I sanded off all the green paint, and levelled bad joints, poorly shaped leading edges and general high spots. Then I used two coats of Eze-Kote to seal and harden the surface. I mixed a filler from Eze-Kote and balloons and filled the obvious dents and cracks. After more sanding and coating I got to a reasonable finish though there were still some high and low spots. I glued on thin pieces of balsa to raise the low spots and sanded then flat. I will use this method on the other wing surfaces then cover the whole wing with $48gm^{-2}$ glass cloth, again using Eze-Kote. This single part liquid from De Luxe Materials is light and easy to sand, and with the glass will strengthen the wing surface. To try it out I sanded and finished one side of the aileron and flap and applied the glass to them.

Right wing untreated

Left wing coated and sanded

The under surfaces of the wing are in much poorer condition and look strange. I am waiting for the plan to arrive from TN so I can judge the thickness of the sheeting. I might have to use a powered sander in some places and need to be sure how aggressive I can be. Or maybe I will hand sand.



Right wing.
Upper split glued

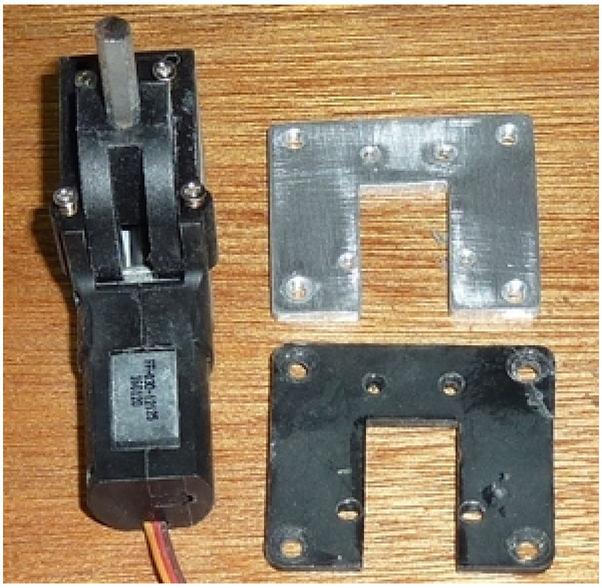
The underside of the wings took a lot of work. The builder had misunderstood the plan. Where TN had drawn an edge for a drawing cutaway the builder had thought this was extra sheeting. He had used a difficult to sand glue for the sheeting joints, and what I think is car filler for holes, so I had to use 80 grit on the sanding block. He had not kept the designed forward rake for the undercarriage. I had to grind away the hardwood bearers to increase the angle. This had the advantage of insetting the undercarriage so I could add ply hatch covers to the legs.

Left undercarriage mount

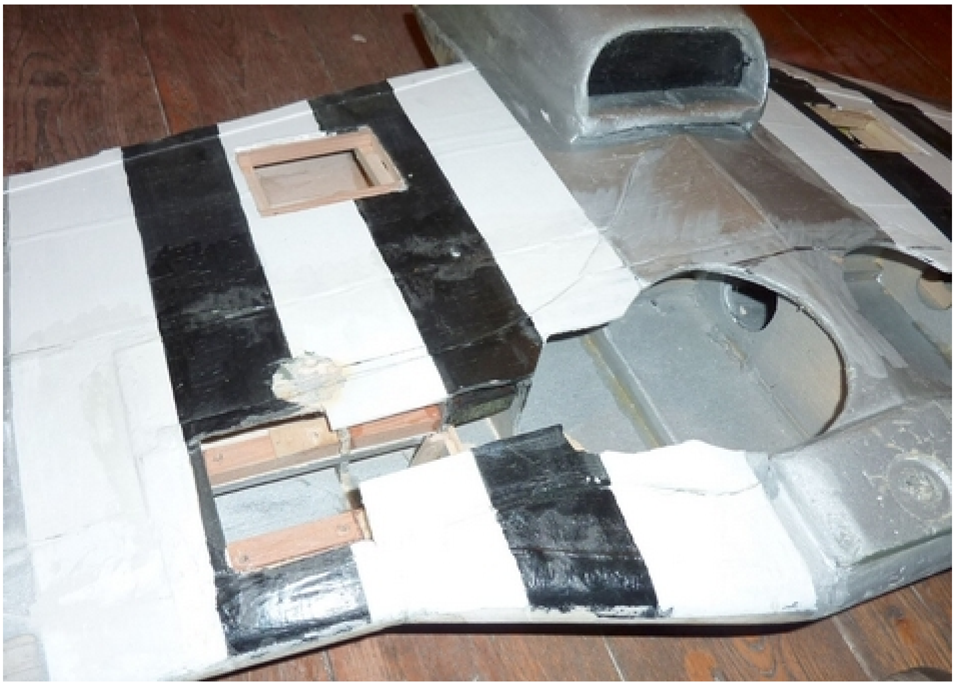
Right

However there is one further decision to make. Mark Jordan recommends Hobby King's 12kg retract mechanisms. He uses them on his similarly sized Mustang. However they are a little larger and heavier than those supplied by TN, 98g against 57g. Which to use? I decided to use the originals so I made a mounting plate out of 2.5mm aluminium to replace the plate that was broken in the crash. However the retract proved to be unreliable so I bought some of Hobby King's slightly lighter retracts. They proved to be identical to the originals.

New mounting plate



The central underside radiator pod was poorly shaped and lopsided. I sliced off the top, trimmed one side so it was equal to the other, then fixed on a new top. I will shape it all to have the thin curved edges and the front clearance from the fuselage as shown on the plan.

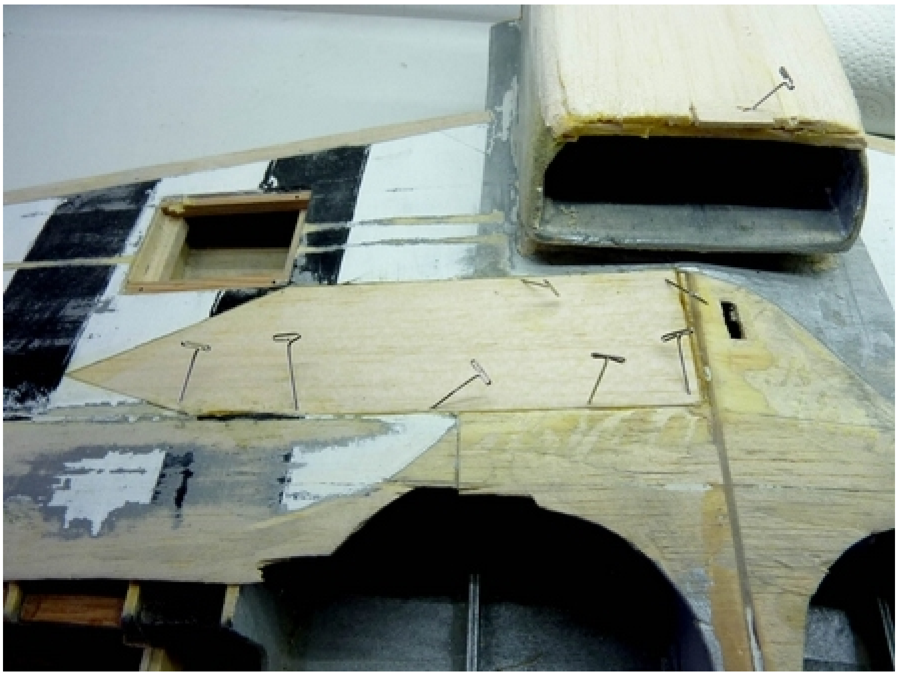


Strangely the leading edges of the two ailerons were different and neither was the shape shown on the plan. Easily corrected of course. The builder had glued thin balsa strips on the top and bottom of the wing trailing edges to butt up against the flaps and ailerons instead of the strips being flush with the wing surfaces. I replaced these with spruce strips.

Note the clumsy lump of balsa in the centre front. This was incorrect so I cut it off and replaced it with a curved fairing as shown on the original aircraft.

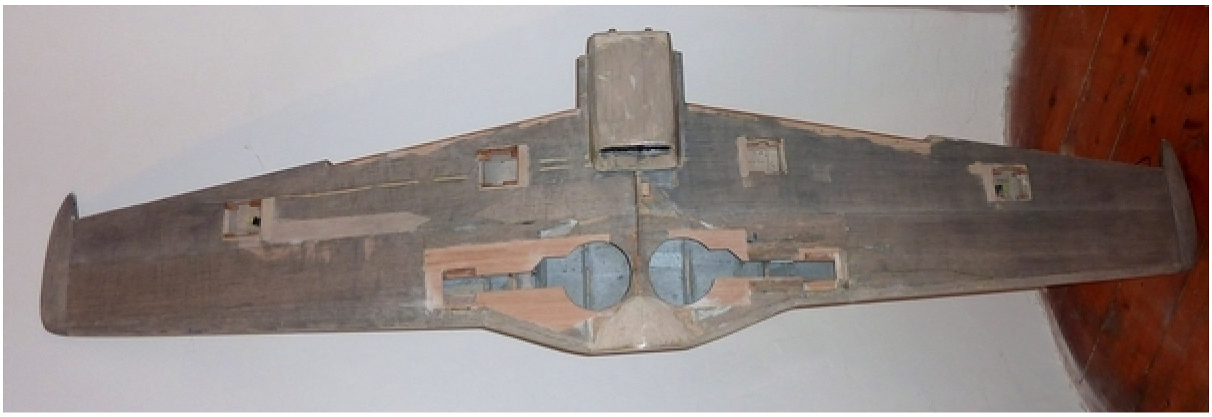
During the work I switched from normal Evostik white PVA to Titebond. I have found this as easy and clean to use as PVA. It dries more quickly and sands easily. Sanding flush is a problem with PVA.The underside was flimsy in places so I had to add some new sheet as you see later.

Here I have cut away the top of the scoop to give the correct gap. I found details of the grill on the web. I bought some punched aluminium sheet. Details later.



Then, as before, it was a cycle of sand, fill, sand then Eze-Kote. Repeat until happy, then glass with Eze-Kote. I will complete the repair of the wings before doing the fuselage. I will stop the finishing when I have sprayed on the coats of primer. I'll spray the colours when all is finished. The wings will be an experiment that will help me with the fuselage, and with the finishing of my Tony Nijhuis Mosquito. The latter is a longer term project that I consider more important than the Mustang. I will make my mistakes on the Mustang.

These pictures show the patching that I had to do. These are the wings just before glassing.



Flaps

The large flaps seal on the top surface so they present a smooth upper wing surface. Balsa was not hard enough to form the edges of this seal. On the flaps I added a spruce insert as shown here. The joins were filled and sanded flat.

This butts up against the trailing edge also made of spruce.

Glassing

I decided to cover with 24 g/m^2 glass cloth rather than 48. I changed my technique. Rather than coating the wood then laying the cloth on the wet surface, I put the glass cloth on dry then brushed a thick coat of Eze-Kote (EK) on, and through. I thought I'd take the opportunity to find out how much weight EK adds. In particular I wanted to know how much weight it loses as it dries. It is water-based after all. I weighed the pot of EK before and after coating. Each heavy coat on each wing half surface weighed 21 g of wet EK.

I carried out some tests on a 10 x 10 cm piece of balsa. I coated each side with three coats of EK and weighed it to find the wet and dry weights and how much weight was lost in sanding. The full results are in another document EzeKote Nov 19.doc. Summarised the results were:

- EK loses two-thirds of its weight as it dries after the first coat which loses half.
- The first coat on bare wood takes about double the amount of EK than later ones.
- The drop in weight on sanding is small.

Averages of two sides

	g/dm²	g/m²
First wet coat	0.98	97.5
Second wet coat	0.47	47
Third wet coat	0.36	36
First drop %	49	
Second drop %	68	
Third drop %	64	
First dry coat	0.50	50
Second dry coat	0.17	17
Third dry coat	0.13	13
Total of three	0.8	80

This means that the 21 g wet should drop to 7 g dry. A full wing coat will therefore weigh 28 g. So a rough guide is that one generous coat of dry, sanded EK weighs about 35 g/m^2. Later coats put on to nearly smooth surfaces took only 13 g for the whole upper or lower surface. This means a dry weight for both surfaces of just over 8 g or 10 g/m^2.

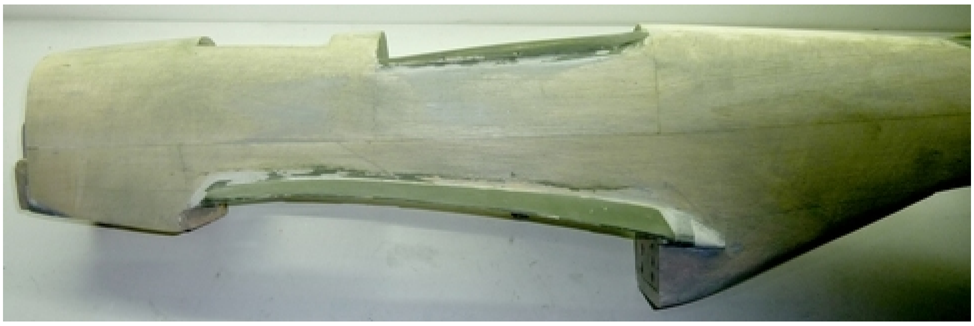
Because of the lightness of the EK, I was tempted to go on coating and sanding to a glass finish. However, despite my best efforts at filling, the underlying surface was never going to be perfect. It became a case of diminishing returns, so I stopped at ‘pretty good’.

Fuselage

The fuselage was a bit of a mess. The spinner did not line up with the flow of the body. The plastic underside cowling was not inset, so its edges stood out and could be seen. Block was not gouged internally to reduce thickness and weight and the motor mounting block was solid wood and heavy (60g). I replaced it with the usual four spacers. That will enable me to adjust thrust lines using washers. Right sidethrust is shown on the plan but no downthrust. Instead of a fairing under the centre leading edge the builder had glued on a huge lump of balsa through which the wing bolts went. I removed this and fitted a shaped fairing.

It was clear that the whole fuselage would have to be sanded to bare wood and treated with Eze-Kote and glass. These pictures show the poor state of some of the surfaces.

After sanding one side it looked like this. There are still dents and some poor profiles but it's on the mend. I had to be careful not to sand off too much from the 2mm balsa areas, though of course it will be glassed.



The builder opted to have the forward underpan removable and fixed on using woodscrews. This was unsightly and unnecessary. I fixed in a sloping battery plate and then glued the underpan and nose section into place and faired them in. The battery plate will also stiffen the nose further with very little weight gain.

There was one bad and inexplicable fault. Instead of running the fuselage side sheet in one piece from front to back the builder had cut it into three sections. This significantly reduced the strength. Fortunately I will be glassing it, which will restore most of that. Here you see the sheet is cut at the leading and edges of the wing fairing. The joints weren't even scarfed, only butted over the formers.

Fin fairing

The builder had added clumsy lumps of balsa on each side of the fin root. I cut and sanded these off then added vertical and horizontal 3mm sheet to allow the joins to be faired correctly to the plan. I used my usual filler made from Eze-Kote and microballoons.

Glass

I glassed the entire fuselage including fin, tailplane and control surfaces with 24 g/m^2 glass cloth and Eze-Kote. Lots of coating and sanding resulted in a reasonable finish as you see here.

Electrics and radio

The first owner opted for a 3.3Ah 6S battery. I am hoping that there will be room for the 5Ah 6S ones that I use. This should enable me to set the centre of gravity correctly which, coupled with too much elevator throw and too little expo, was the probable cause of the disastrous maiden flight. The propeller is probably too small. The builder opted for a 16 x 10 two blade. The 4Max specification for 6S voltage is for a 16 x 10 three blade or an 18 x 10 two blade. The motor was probably underloaded. I will experiment once the model is complete. I'll use a 60A Neuron ESC that will enable me to read RPM, power and current on the ground and in the air. With the right prop, the 25V from the battery and the 58A maximum current should give 1460W which is just under 2HP.

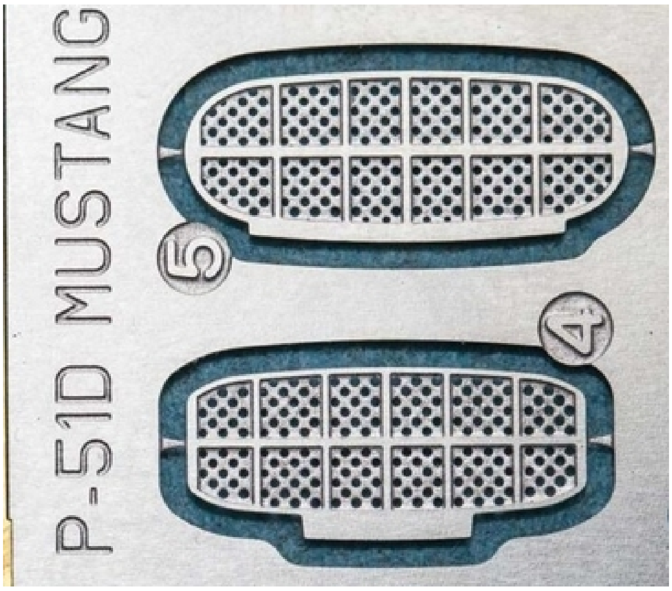
I also intend to fit a gyro stabiliser for the first few flights until I get the feel of the model. The ones I use, the Freewing E51, can be switched on and off in flight. Once I am happy about the trim and my skill I will remove it.

Where to put the receiver?

The builder had fitted the receiver on the top on the wing. This of course made wiring to the ailerons, flaps and retracts easy. It was clever idea that I will also use. I can position the gyro here as well. It means that the throttle, rudder and elevator servos will have to be connected on assembly. I will use a separate receiver battery and a switch. These will be in the fuselage so I have decided to try a 12 way connector and make a wiring harness. I did think about using S.BUS but decided that the reduction in response speed would not be wise. I might put the receiver on a power board but the servos are not high current ones so perhaps don't need to.

Oil cooler radiator

From: http://wingstracksguns.com/2017/02/tamiya-p-51d-build-report-4-radiator-oil-cooler/



The housing on the model is 100mm wide. There are 20 evenly spaced holes across the grid. As the holes are the same width as the spaces between this means that each hole must be 100 / 20 /2 mm, that is 2.5mm. I found some punched aluminium sheet with holes that were a little small but this isn't a perfect scale model. I might add some aluminium strips to simulate the cross bars.

Instrument panel

So far I have found two. One was from an advert selling a fullsize one. Both need printing at 35 to 40%. I have printed out a picture of the instrument panel and laminated it. I will add it to the cockpit when I fully decorate the model after a few successful flights.

Cockpit

Pilot position

As you see the pilot sat well forward

Meredith Principle

And now I learn more about the full size Mustang. The radiator housing is large so you would expect it to be a major drag inducer. It turns out that due to the Meredith Principle it actually added a modest amount of thrust. F. W. Meredith at Farnborough saw that the heat energy in the radiator could be added to the air compressed by the radiator grill and thus generate thrust. The hot, pressurised air then exits through the exhaust duct which is shaped to be convergent, i.e. to narrow towards the rear. This accelerates the air backwards and the reaction of this acceleration against the installation provides a small forward thrust. The air expands and decreases in temperature as it passes along the duct, before emerging to join the external air flow. In some ways this is similar to a ramjet. Meredith published his ideas in 1936, which were used in the Spitfire, the Hurricane and Mustang. Ethylene glycol was used as the coolant in the Mustang, which could be raised to a higher temperature than water, increasing the thrust. Perhaps the radiator airflow effect is what causes the Mustang whistle?

https://en.wikipedia.org/wiki/Meredith_effect