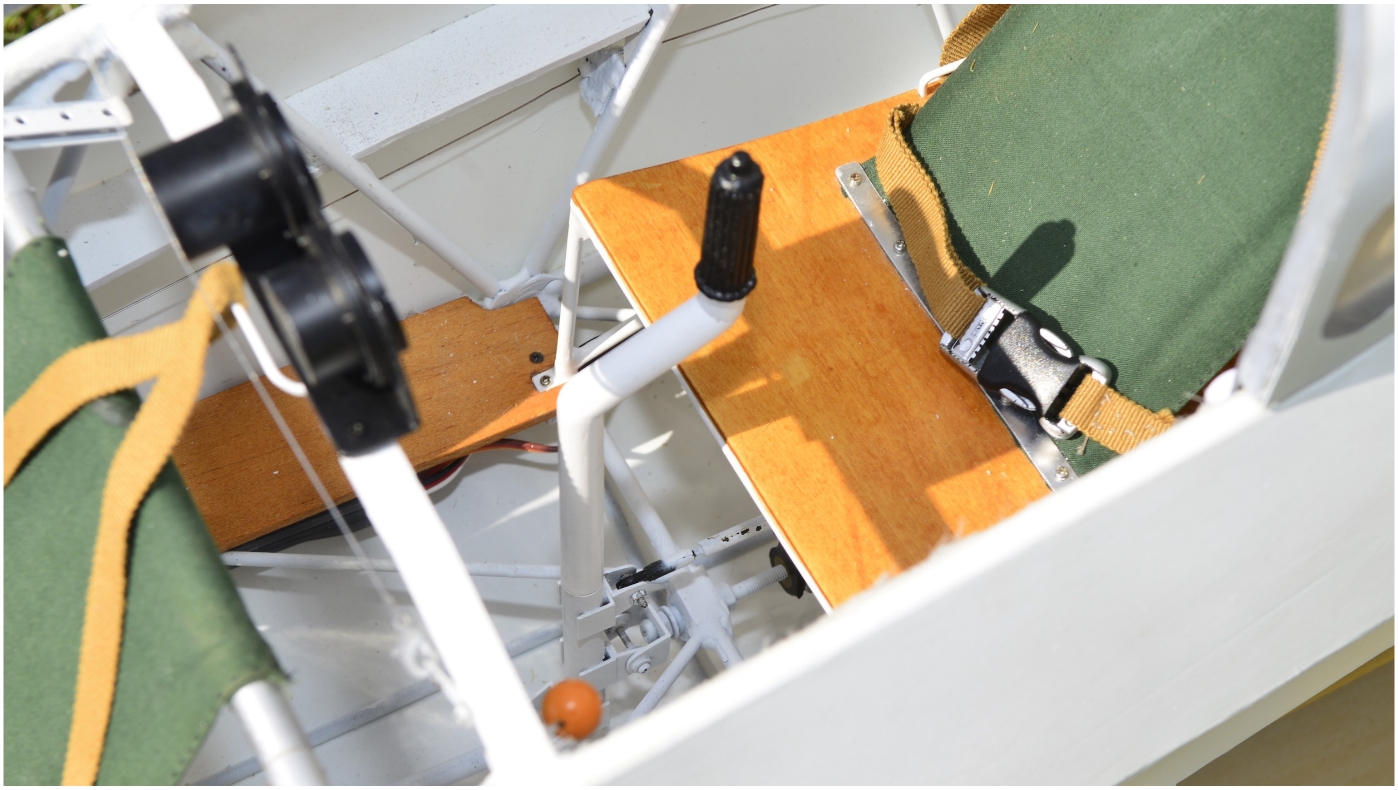
1/3rd Scale Mita Type 3 Production Notes

Norimichi Kawakami



You may want to read the third part of this series before proceeding to this article. Also if you prefer, you can read this article in its original Japanese.

Fabrication Part 11: Wingtip

Wingtip of the real aircraft

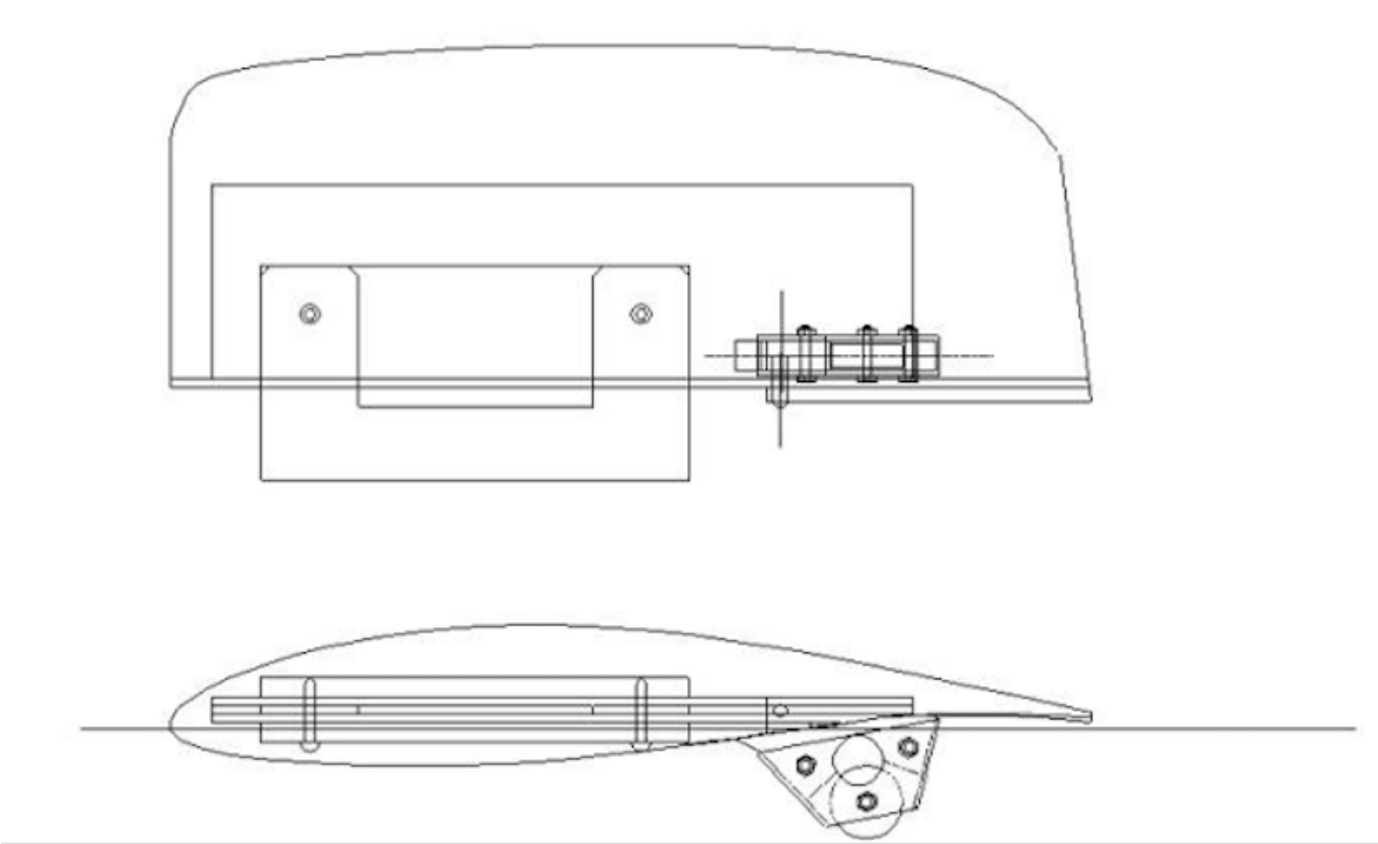
Since the main wheel of the real aircraft is single-wheeled, one of the left or right wingtips always touches the ground at low speed. Therefore, a small auxiliary wheel is attached to the wing tip:

Photo 58: Wingtip of the real aircraft.

I made this wingtip with a wheel in 1/3 scale.

Drawing

The first step is to make the drawing. The wingtips of the real model are not removable, but in the 1/3 model, the ailerons are fitted from the outside, so the wingtips are designed to be removable. Drawing 20 is what I made. A 2mm thick aluminum fitting attached to the outer wing is inserted into the wingtip and screwed tightly. The auxiliary wheel is a small one with a diameter of 15 mm. Its attachment mechanism is also designed to be similar to the actual one:



Drawing 20: Drawing of wingtip.

Parts Fabrication

Photo 59 shows the parts fabricated based on the drawing:

Photo 59: Wingtip parts (one side).

The part where aluminum fitting is inserted is constructed by sandwiching 2mm balsa between two sheets of 1.6mm plywood. For the part where the screws are to be fastened, 4mm-thick plywood is applied as a support. Several balsa sheets are overlapped to the thickness of the wing around them. I cut out quite a few sheets of balsa because the wing thickness is quite large even at the wing tip. If I had used thicker balsa, the number of sheets would have been less, but since I used scrap balsa, I ended up with more than 10 sheets for a wing. The parts in the photo above are for one wing tip. The part for attaching the auxiliary wheel is made of 5.5 mm thick plywood and sandwiched between two pieces of 0.5 mm thick brass to attach the wheel.

Rough Cut Wingtips

Balsa sheets were laminated together and rough-cutted to the shape of the wingtip, and the auxiliary wheel was temporarily attached:

Photo 60: Rough cut wingtips.

I finished sanding the wingtips while they were less than 1mm thicker than the final shape. This is because I plan to attach them to the outer wings when the planking are completed, and sand them together so that the whole shape is smoothly connected.

I had wanted a thicker rubber wheel, but I couldn't find a suitable one with a diameter of 15 mm, so I ended up with this one, but the shape of the wingtip is similar to the actual one.

Completion of Wingtips

The wingtips were shaped later when the outer wings were finished. After that, putty was applied to the recesses for final shaping, sanding sealer was applied, and after drying, fine sandpaper was used to clean the surface. After repeating this process twice, I sprayed the wingtips with 1000-grit surfacer and then painted them with red acrylic paint to complete the wingtips.

The weight of each wingtip was 58g including the screws for attaching to the outer wing.

Photo 61: Finished wingtips.

Change of Policy

In the Basic Concept №1, I had decided on the fuselage and wing division method, taking consideration of its transportation by my car, but after checking the actual loading with the completed fuselage so far, I decided to change the patition of the main wing.

Car Loading Check

Now that the skeleton of the main wing and the rear part of the fuselage were completed, I checked them by actually loading them into my car. First, the outer wings. As you can see in Photo 62, I confirmed that the wings can be installed without folding down the passenger seat:

Photo 62: Checking the installation of the outer wings in my car.

Next is the fuselage. Both horizontal and vertical tails can be removed from the fuselage. The rear fuselage is surprisingly thin, so it won't get in the way even if it jumps out between the driver and the front passenger seats. Then I actually loaded it in my car:

Photo 63: Fuselage mountability check in my car.

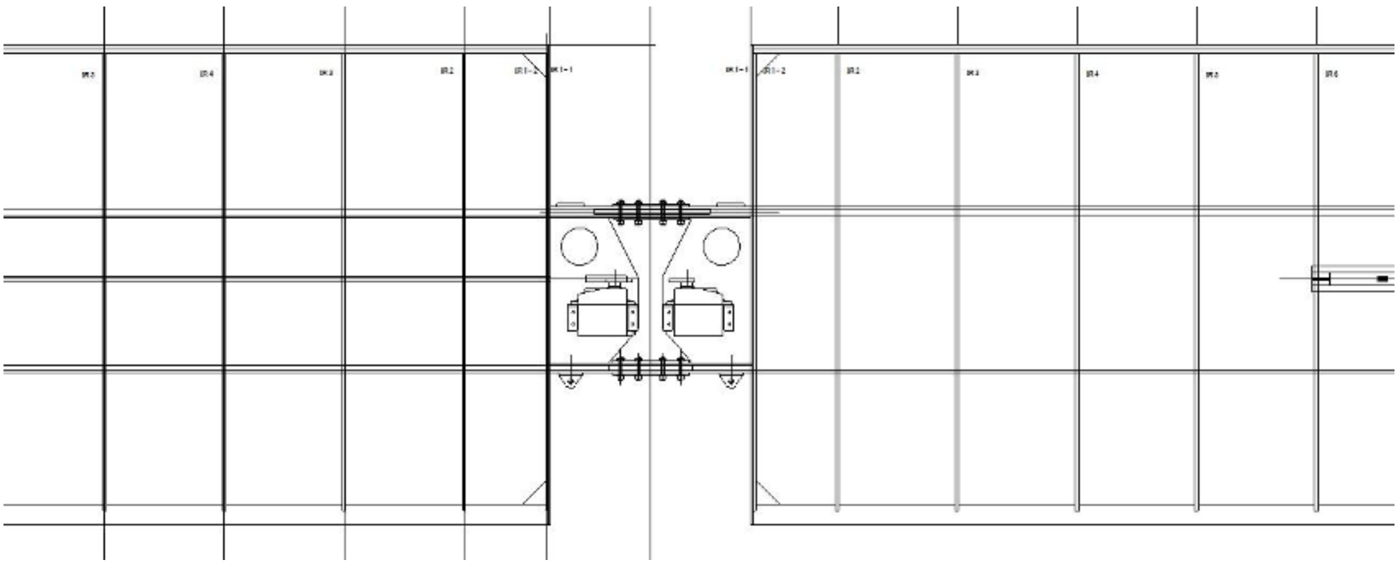
The rear fuselage is exactly half of the total length of the fuselage, so it is loaded in the luggage compartment of the car leaving a reasonable length. I confirmed that it is not a hindrance for driving, although it is a hindrance for accessing the cupholders and the radio.

Change Of the Main Wing Partition

The most troublesome part is the center wing which is 2m long. If I split it into two pieces, I can easily pack it into the luggage compartment of the car without folding the front passenger seat. Fortunately, the center wing was made in two pieces for the convenience of fabrication and has not been joined yet, so I decided to split it into two pieces. In other words, the main wing was divided into four parts, two center wings and the right and left outer wings.

Drawing of the split/joint parts

This is the drawing for a structure to split for transport and connect for flight:



Drawing 21: Dividing/connecting structure of the center wing.

The carbon flanges of both front and rear spars have 4mm inner diameter round holes, then 4mm pins are inserted into them for positioning. A 1.6t web of plywood extending in the wing span direction is originally attached to the rear surface of the upper and lower flanges, and the same plywood web is added to the front surface. The gap between the two webs is filled with thick plywood to create a solid structure. These are bonded together with epoxy adhesive. This solid spar is sandwiched between two 2mm thick aluminum plates and are fastened together with 3mm bolts.

This change affects the target weight. Originally one servo mounted at the wing center used to operate the left and right spoilers, but now two separate servos are required that will increase the weight. In addition, the weight of the joint structure must be added. The total delta weight will be about 120g.

This means that the target weight of the center wing will increase from 1,600g to 1,720g, and the target overall weight in normal flight will also increase from 7,600g to 7,720g.

Fabrication of the Joint Structure

I immediately made the joint structure of the center wing. Photo 64 shows the locating pins, which are 3mm carbon rods threaded through 4mm brass pipes:

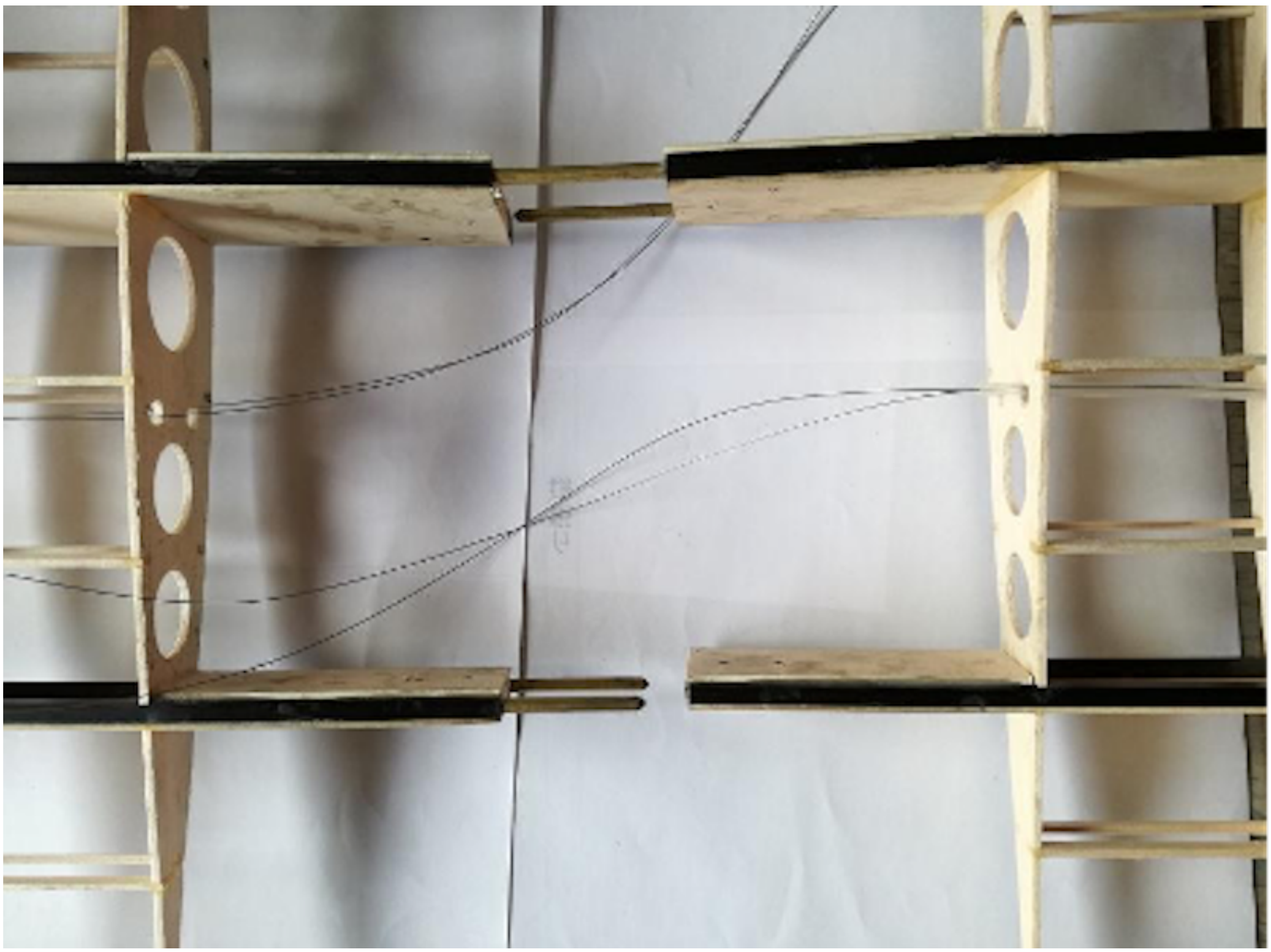


Photo 64 Positioning pins for center wing joint.

Photo 65 shows the left and right sides are connected for testing:

Photo 65: Testing the left and right connection.

Both sides could be joined quite tightly. Photo 66 shows the spoiler servo beds:

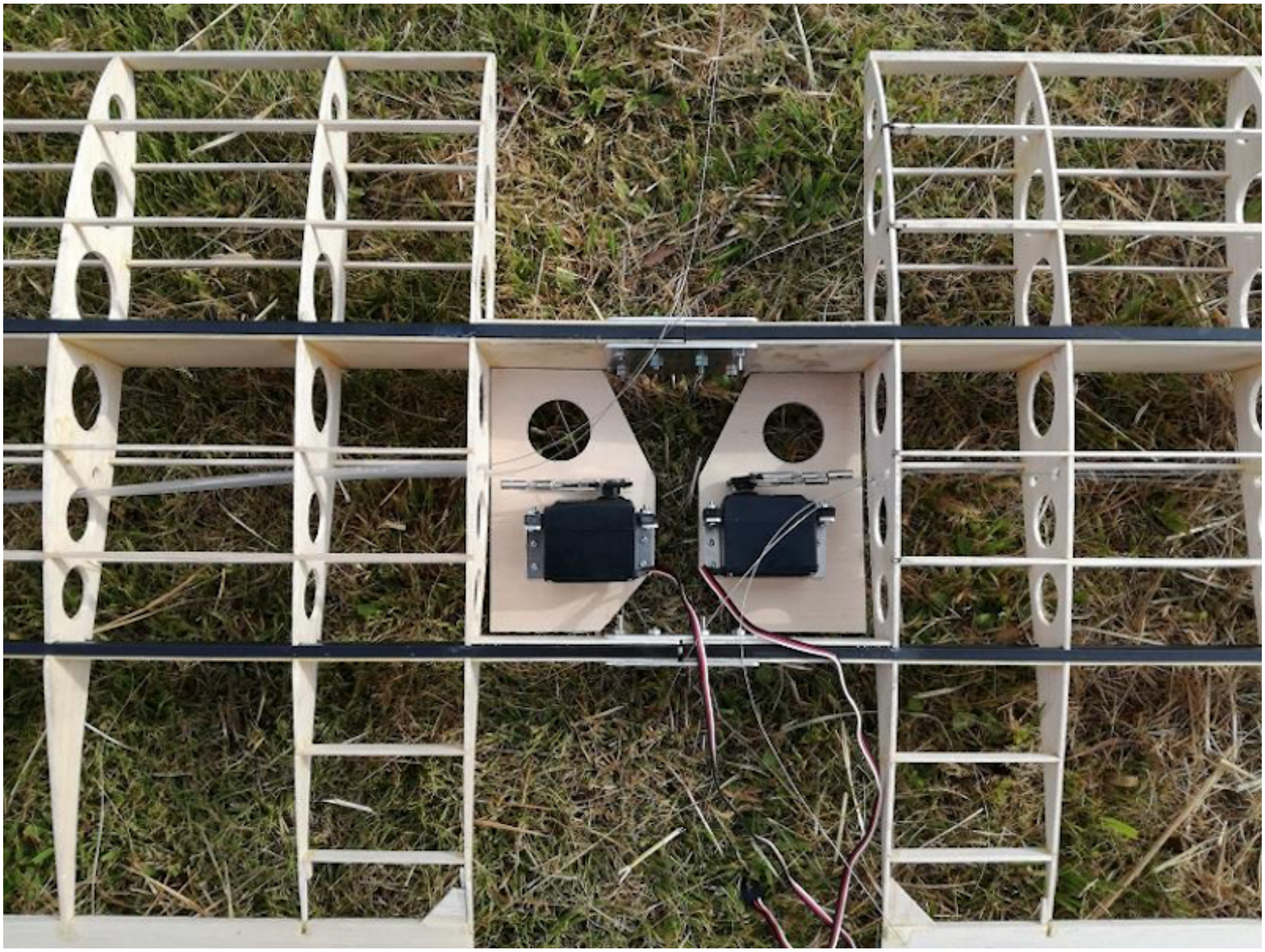


Photo 66: Spoiler servo beds.

Weight Check

Here, the weight of the center wing is actually measured to predict the finished weight. The weight measurement results were as follows.

Left center wing	400 g
Right center wing	398 g
Connecting brackets	53 g
Center/outer wing connecting tube	158 g
Spoiler servos	129 g
Total:	1,138 g

The estimated weights for the remaining items are:

Planking	400 g
Inner end rib reinforcement	20 g
Outer end rib reinforcement	10 g
Covering	190 g
Mounting brackets	50 g
Aileron servo extension cords	40 g
Painting and marking	30 g
Total	740 g

Therefore, the estimated completion weight of the center wing is 1,878g, which is 158g (9.2%) over the target weight of 1,720g.

I had weighed the wing when the framework was completed last time, and had expected it to be almost within the target weight. After that, a glass cloth was applied with a lot of epoxy resin to reinforce the connecting pipe supports and the connection pins to the outer wing and the measures to prevent the outer wing from slipping were added. Because of these works the weight increased significantly. I also forgot to count the weight of the aileron servo extension cords and underestimated the weight of the spoiler servo by 50g. The weight of the servo itself is 40g, but the weight of the servo bed and the spoiler cable length adjustment brackets turned out to be too much. As a result, the weight was 9.2% over the target, which was a bit embarrassing.

5th Calculation of Weight and Balance

Based on these data, the fifth estimation of weight and balance was checked in the chart below (the fourth was omitted):

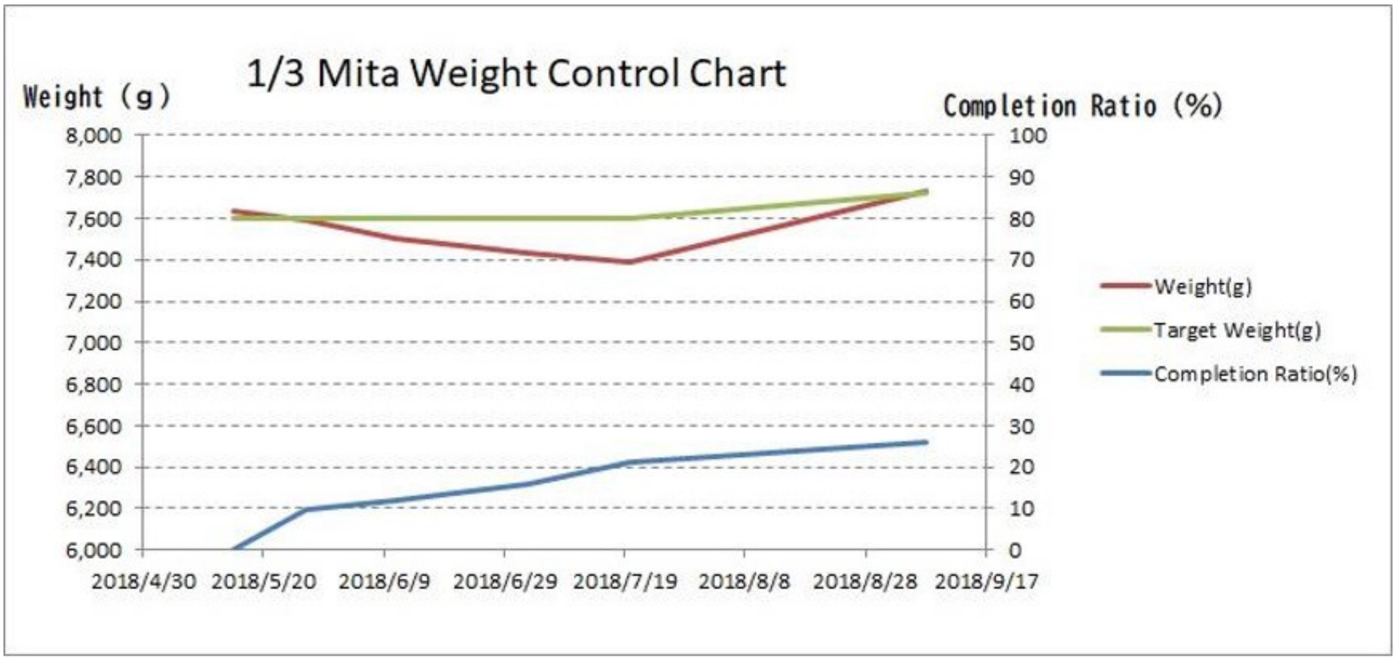


Table 5: 5th calculation of weight and balance.

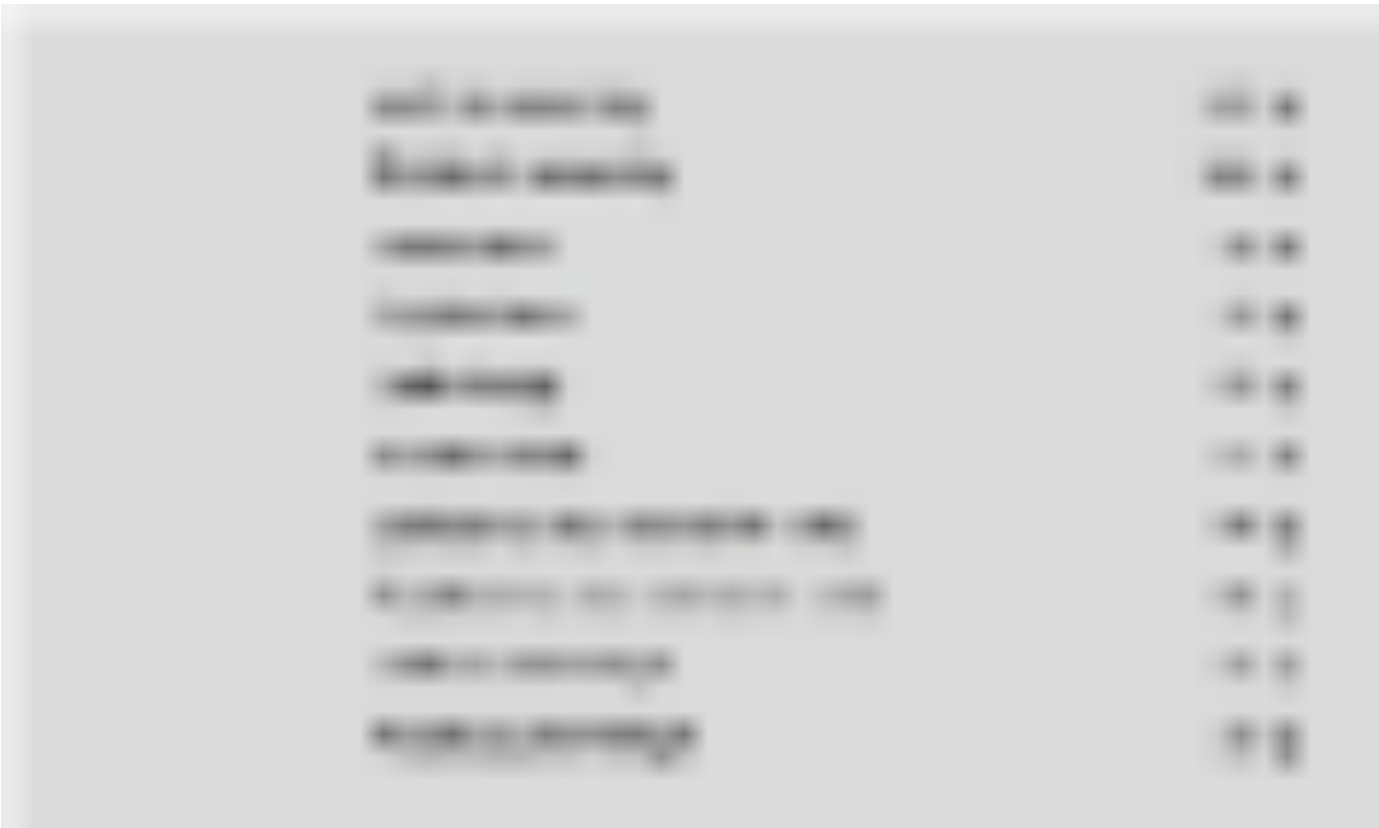
The total weight in normal flight condition seems to be 10g over the target value of 7,720g.

Significant Overweight Was Found After Measuring the Outer Wing Skeleton Weight

Because the outer wing components (rib assembly, aileron, wingtip, servo assembly and counterweight) were completed, I measured their weights. As a result, it was found that the weight far exceeded the target weight.

Weight Measurement and Finished Weight Prediction

The measured weights are as follows:



In total, the current weight of the left outer wing is 569g and the right is 563g. Table 6 shows a prediction of the finished weight of the outer wing from this state:

Table 6: Predicted weight of completed outer wing.

The weight of the outer wing is expected to exceed 1,000g per wing. The target weight was 700g per wing, so the weight of both wings will exceed 630g (45%). I may have overestimated the plank weight a little based on my experience of making tail wings, but I think I need to be prepared for 1 kg per wing.

> ***Mistake №7****: Outer wing weight greatly exceeds the target*

Causes of Overweight and Reflection

Initially, I was surprised and disappointed by this reality, but when I became calm and tried to find the cause, I found out the reason. The reason is that there is a big difference between the way the outer wing is actually made and the way that was implicitly assumed when the target weight was set.

The target weight was set by multiplying the weight by the square of the scale ratio based on the weight data of the 1/5 model. Initially, I was going to multiply the weight by the third power, but since the thickness of the main components such as the plank material and the covering of Oracova is almost the same, I decided to multiply it by the second power.

This implicitly assumes that the 1/3 model will be made in the same way as the 1/5 model. However, the 1/3 model is quite different from the 1/5 model in order to make it look more realistic and to ensure strength. For example:

1. Single spar in 1/5 model, but double spars in 1/3 model.
2. Spar webs are changed from balsa to plywood.
3. 2.5 mm (or 3 mm in some cases) thick ribs are used in 1/3, while 2 mm in 1/5.
4. The aileron of 1/5 is a simple type, but 1/3 has a frise type.
5. Hinges are also changed from seat type to removable pin type.
6. Wingtip auxiliary wheels and aileron counterweights are installed, which are not found on the 1/5.

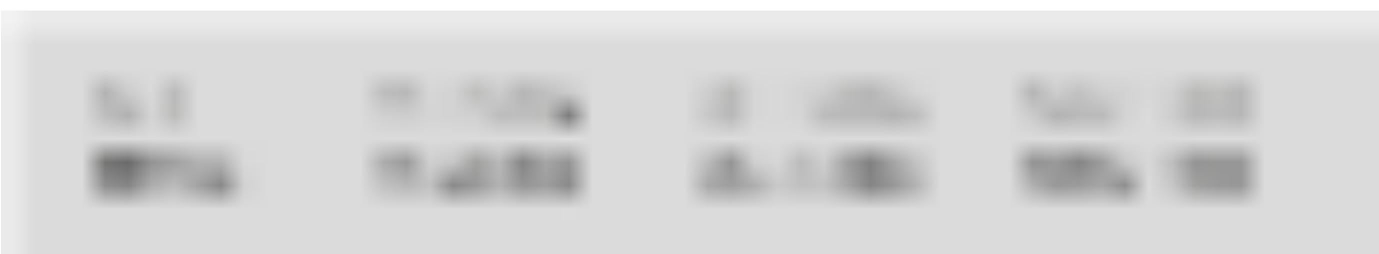
These are all factors that increase weight. In other words, the target weight that was set without considering these factors of weight increase was unreasonable.

6th Calculation of Weight and Balance

Based on this data, I immediately calculated the sixth weight and center of gravity (Table 7). The weight in normal flight condition is expected to be 8,377g, which is close to the expected maximum full weight of 8,700g. The fact that the target weight is unreasonable will again apply to the front fuselage that I am going to make next. In the 1/5 model, the landing gear is attached simply to the fuselage with a short carbon rod, while the 1/3 model has the elaborately built rubber shock absorbers just like the actual model. In addition, as the control mechanisms and seats are planned to be incorporated in the 1/3 model, the target weight of the front fuselage estimated from the 1/5 model without them is sure to be underestimated.

It seems that the assumed maximum overall weight will be the weight in normal flight condition. Since the strength study and the selection of the power unit are based on the maximum overall weight, flight is possible, but I am wondering how much it will affect the glide performance. I will confirm this point later by calculating the performance.

By the way, the weight of the Ka-8 and Minimoa sold by Thermal Studio in 1/5 scale and 1/3 scale, according to the data on the website, are as follows:



I took the median for the weights, which varied depending on the production. If I use this ratio to predict the weight of 1/3 from the 1/5 Mita, the weight of 1/5 is 2,765g, so the ratio 3.33 results in 9,210g, and 3.90 results in 10,800g. These 1/3 scale models from Thermal Studio also do not have a cockpit control system, and the landing gears are simple. Considering these factors, it is expected to be difficult to complete the model with the maximum overall weight of 8,700g. I regret that I should have made such a wide consideration when setting the target weight.

> ***Lessons Learned №4:*** *When setting target weights, pay close attention to the differences in construction methods and equipments from the base aircraft.*

6th Weight & Balance	**2018/9/15**	Completion Ratio		38.15 %			
	Predicted Weight	STA	Moment	Actual Weight	Estimated Remain Weight	Target Weight	Predicted-Target
Outer Wing Left	**1,020**	860	877,200	569	451	700	320
Outer Wing Right	**1,014**	860	872,040	563	451	700	314
Center Wing	**1,878**	890	1,671,420	1,138	740	1,720	158
Forward Fuselage	1,600	630	1,008,000	0		1,600	0
Aft Fuselage	**540**	1,550	837,000	350	190	560	-20
Vertical Tail	**212**	2,450	519,400	162	50	240	-28
Horizontal Tail	**378**	2,270	858,060	268	110	400	-22
Motor	361	100	36,100	0		361	0
Propeller & Hub	50	-10	-500	0		50	0
Battery for Radio	155	200	31,000	0		155	0
LiPo	600	340	204,000	0		600	0
Others	186	600	111,600	0		634	-448
Total	**7,994**	**879**	7,025,320	**3,050**		**7,720**	274
Target CG		**846**					
Weight	383	160	61,200			0	383
Normal Flight Condition	**8,377**	846	7,086,520			**7,720**	657

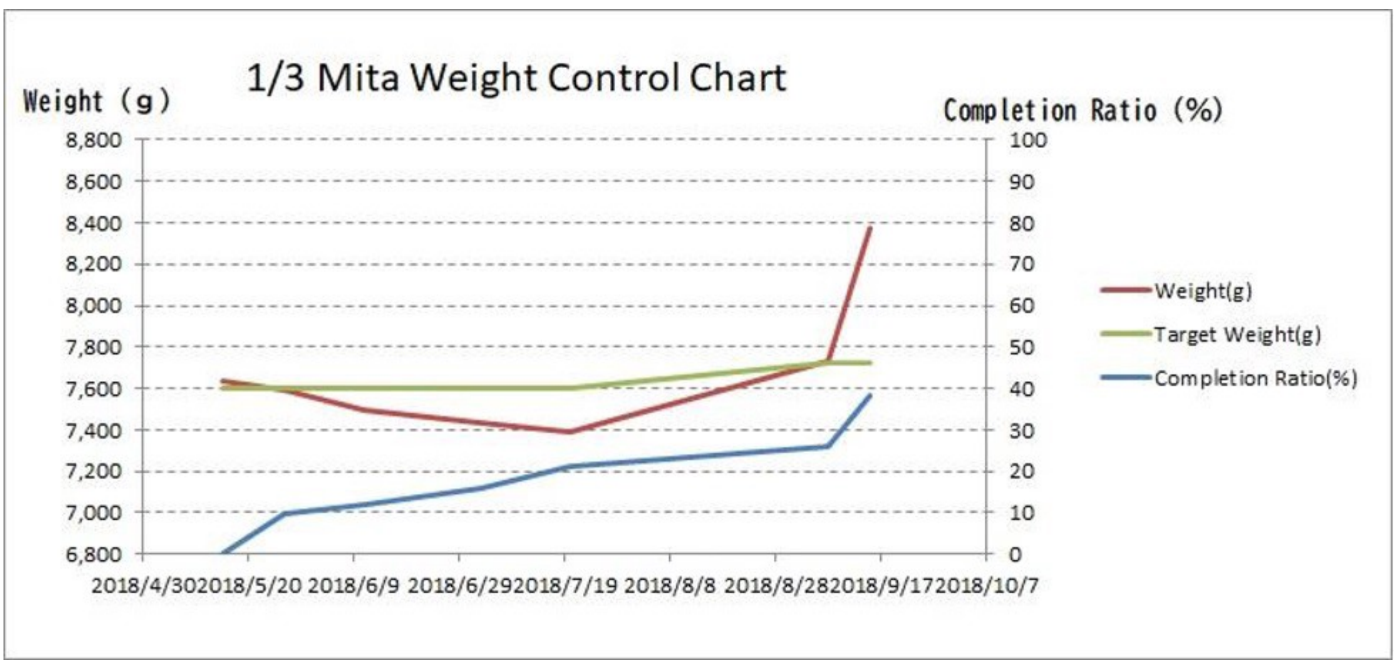


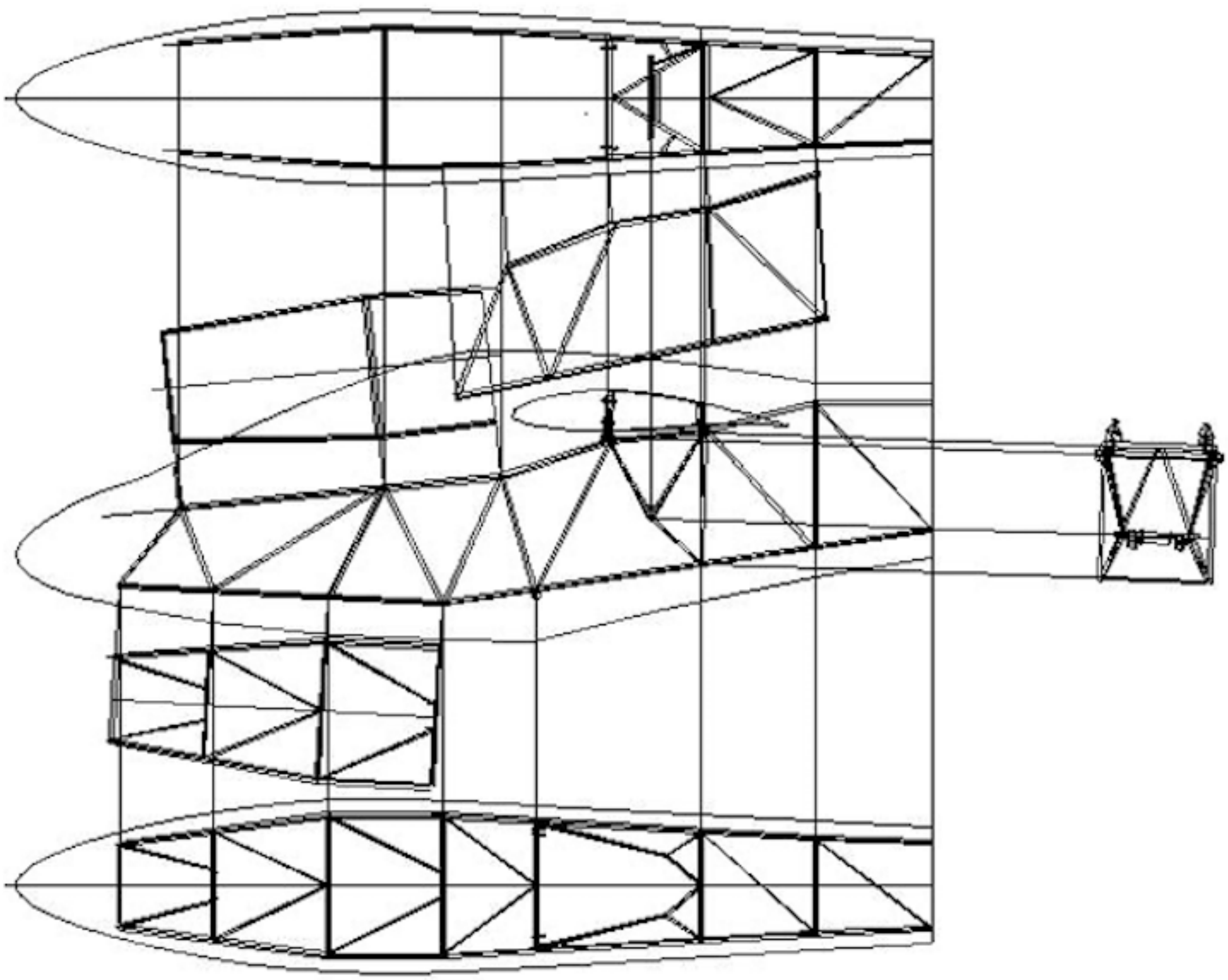
Table 7: 6th weight and center of gravity calculation.

Fabrication Part 12: Main Skeleton of the Front Fuselage

Next, the main skeleton of the front body was fabricated.

Drawing

Drawing 22 is the main skeleton of the front fuselage which is mainly made of carbon tubes:



Drawing 22: Main skeleton of the front fuselage.

If you look at the drawing carefully, you will notice that there are flat areas. These are the left and right panels of the wing attachment area, the cockpit floor and the canopy sill. First, these panel structures are fabricated on a flat board.

Fabrication of Panel Structures

Just as I did when I built the rear fuselage structure, the full-scale drawings of these panels are printed and placed on a flat board. The cypress bars were used to secure the longerons. The lower longeron is straight, so only one Φ7mm pipe is needed, but the upper one is bent twice, so three members are needed to be connected. These members are connected with a 4mm diameter aluminum pipe of 60mm length buried inside the longerons with epoxy adhesive.

Next, cut the 5mm diameter members that connect the upper and lower longitudinal members to the dimensions shown in the drawing, fit them in place, and fix them with CA. I used a diamond file to carefully make a radius at the connection part to match the roundness of the pipe.

Photo 67 shows the process of making the left and right panels of the main wing attachment area:

Photo 67: Making the left and right panels of the main wing attachment area.

The two thin sticks in the center are 1mm thick cypress sticks, which were laid down to ensure accurate stepping when gluing the Φ5mm vertical members to the Φ7mm longitudinal materials.

The cockpit floor panel and the canopy sill were made in the same way (Photo 68):

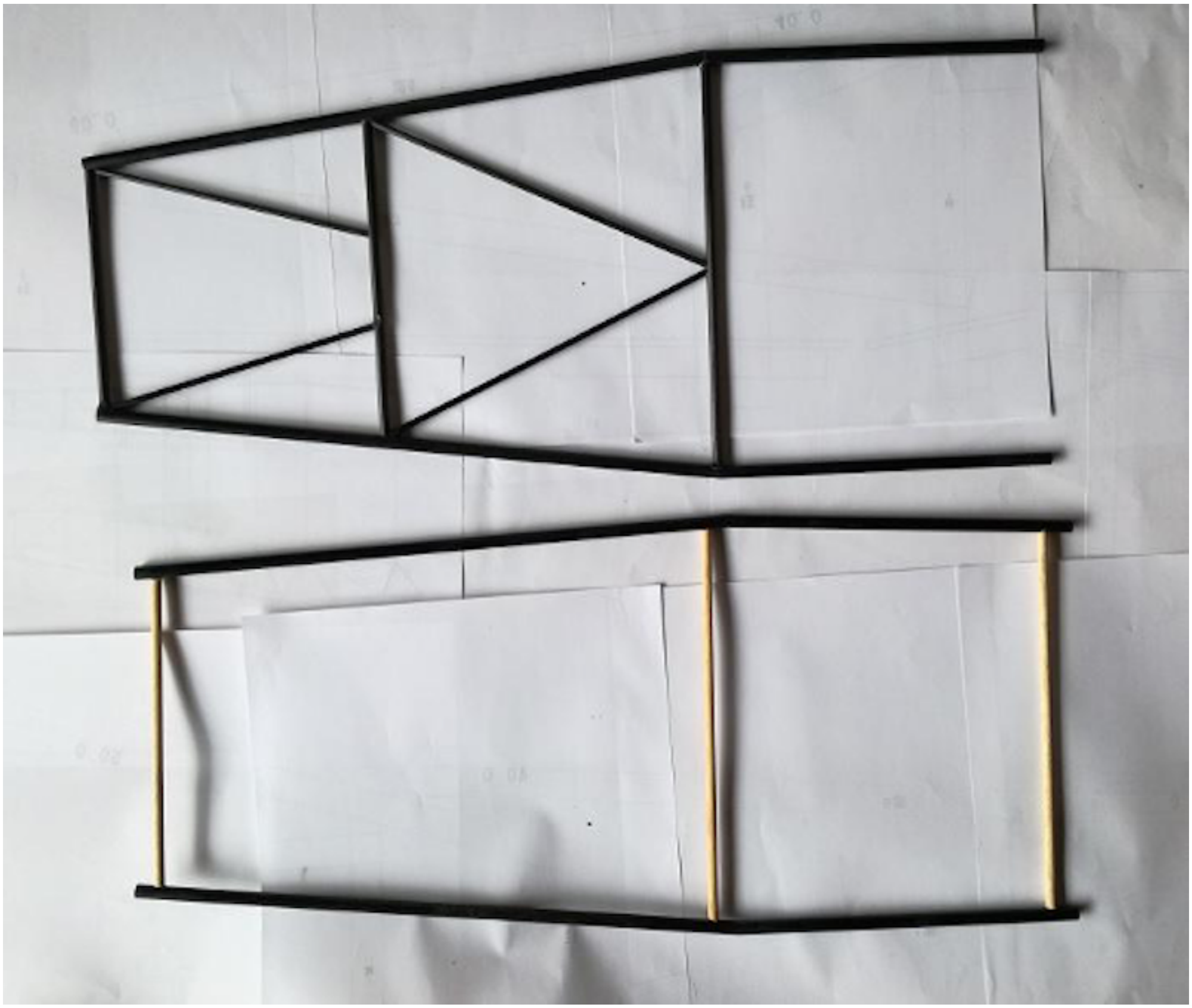


Photo 68: Cockpit floor structure (top) and canopy sill (bottom).

Since there are no parts to connect the left and right longitudinal members of the canopy sill, three temporary connecting members have been installed for the convenience of assembly. These will be removed after assembly is complete.

Making the Main Wing Attachment Section Crossbeams

Two cross beams are attached to the top of the right and left main wing attachment panels to connect them and to which the main wing attaches. These cross beams are made of 10 mm square carbon pipes, and their ends have extremely complicated cutouts to connect to the bent part of the Φ7 diameter longitudinal pipes. I had a hard time finding the right dimensions for this part, but I finally solved the problem as follows.

First, from the drawing of the joint between the crossbeams and the longitudinal pipes, the top, bottom, front and rear development views of the crossbeam are drawn and printed in actual size, then they were cutted out (Photo 69). Although it is not clearly visible in the picture, the development views of the cutout shape are printed on both ends.

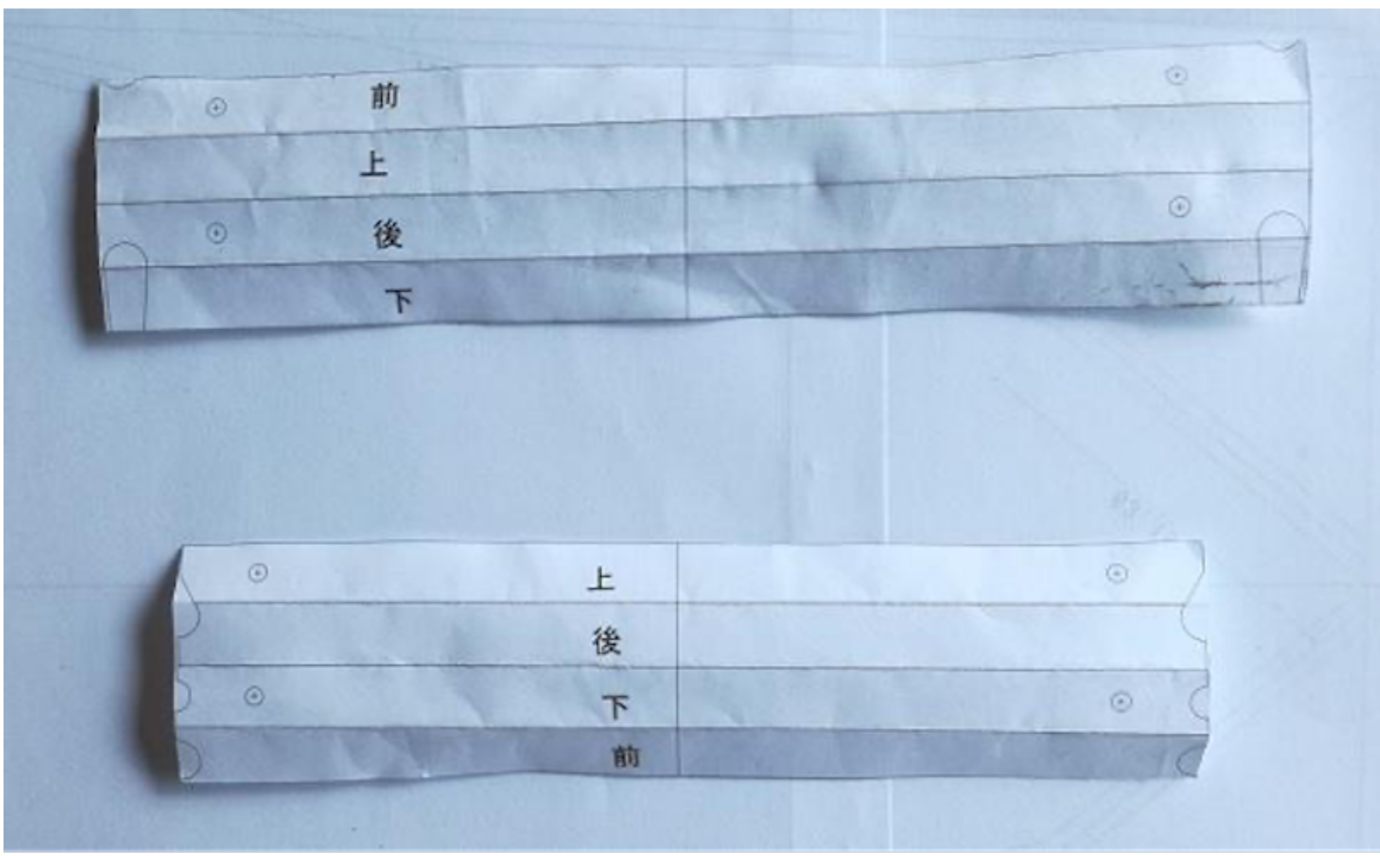


Photo 69: Development view drawings of the main wing attachment crossbeams cut out.

Paste the cut-out development plans around the square pipes. After that, I shaved the pipes with a file along the development drawing to complete the processing of both ends.

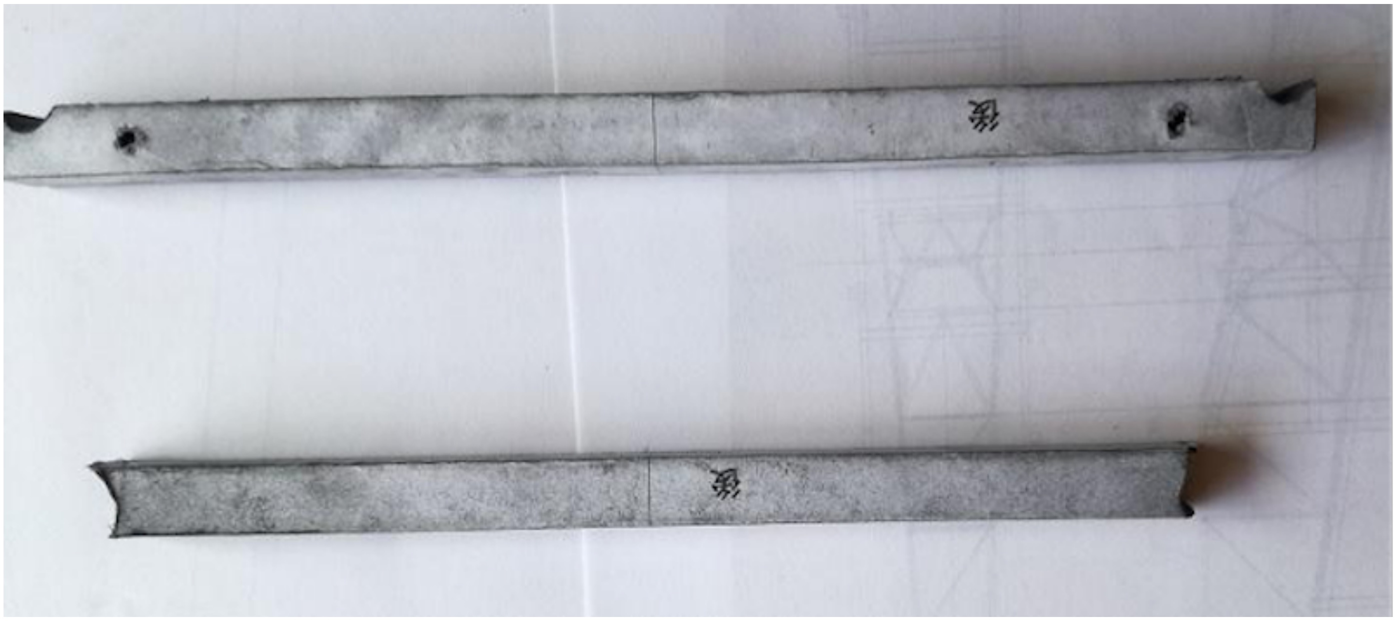
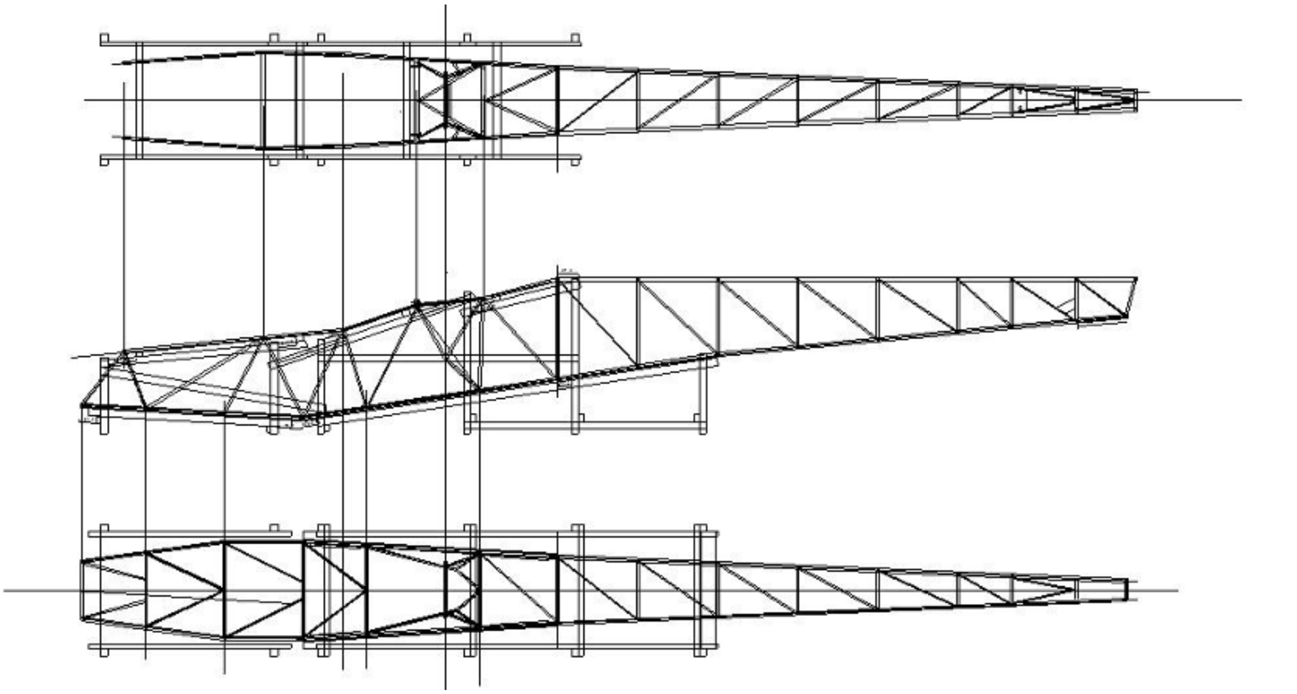


Photo 70: Processing the ends of the main wing attachment crossbeams.

Now that I have finished making the panels and the cross beams for attaching the main wing, the question is how to assemble them. The panels are connected to each other at complex angles, up and down, left and right, and also it is not easy to connect the assembled front fuselage to the already completed rear fuselage. An assembly jig is mandatory.

Drawing

Drawing 23 is for the assembly jig.



Drawing 23: Fuselage assembly jig.

I conceived of various types of jigs, but in the end, I settled on a type similar to the assembly jig used for real small aircraft. A number of relatively thick pillars are built and connected to each other by beams with the same angle as that of the fuselage to be assembled. The part in contact with the floor of the fuselage is covered with 4mm thick plywood boards and the actual size drawing is pasted on the board. Then thin cypress bars which hold the floor longerons are attached on the drawing for positioning accuracy.

The assembly jig for the actual machine is made by cutting and drilling with special precision machines and measuring the position accurately with laser measuring devices, so it is extremely accurate. This jig, however, is cut with a handheld saw and drilled with a hand drill, so accuracy is not expected to be as high. Therefore, the floor panel, which is a flat surface, is made first and then assembled the rest. This is the reason for this type of jig structure.

Assembled Jig

Photo 71 shows the completed fuselage assembly jig:

Photo 71: Completed fuselage assembly jig.

The pillars are made of 15x15 cypress sticks and the beams are made of 15x10 cypress sticks, which are assembled with screws. The actual size drawing is attached to the pillar to determine the exact position where the beam will be attached. When the beams were assembled according to the attached drawings, they were assembled with good accuracy.

I tried to place the completed rear body with front panels on this jig. It seems to work well:

Photo 72: Temporary mounting on the assembly jig.

Fabrication Part 14: Assembling the Main Structure of the Front Fuselage and Joining the Front and Rear Fuselages

Using the fuselage assembly jig, I assembled the front fuselage panels. Initially, I was going to assemble only the front fuselage and join the rear fuselage much later, but it turned out to be easier to assemble the front fuselage together with the rear fuselage.

This is the photo which shows how the assembly is being worked:

Photo 73: Front fuselage being assembled on the assembly jig.

Photo 74 shows the assembly of the trapezoidal truss structure to which the main landing gear will be attached. The assembly parts are held by passing the bamboo string through the holes drilled in the left and right beams of the jig:

Photo 74: Assembly of the truss structure for the main landing gear.

From another angle:

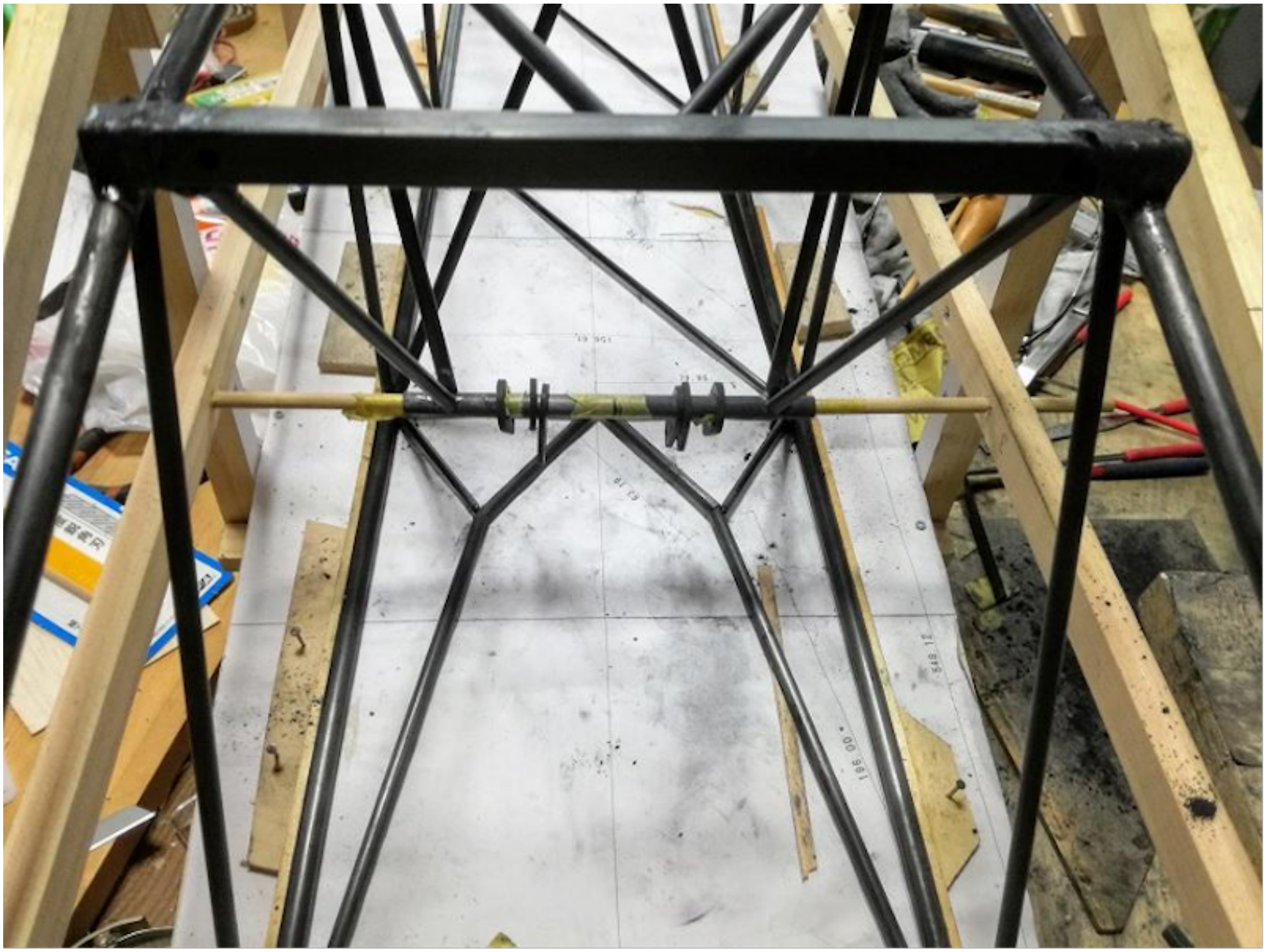


Photo 75: Assembling the truss structure for main landing gear attachment viewed from the front of the fuselage.

The two beams to which the main wing attaches are connected to the longerons at a delicate angle and the distance between the two must be exactly same with that of the front and rear spars of the wing, a simple positioning jig was made as shown in photo 76. This picture was taken after the work was completed, so the braces connecting the beams are in the way and the jig is not set in the correct position, but you can understand how it was.

Photo 76: Positioning jig for main wing attachment beams.

Completed Main Structure of the Fuselage

Fuselage is now assembled and unloaded from the jig. Photo 77 shows the completed main structure of the fuselage. It is made of carbon tubes so it is very light and weighs only 710g in this state:

Photo 77: Main structure of the completed fuselage.

This is the front part of the fuselage, where the cockpit is located:

Photo 78: Structure of the cockpit.

This is the center of the fuselage. The upper two cross beams are the main parts of main wing attachment:

Photo 79: Center of fuselage.

I temporarily attached the main landing gear:

Photo 80: Temporary installation of the main landing gear.

It looks pretty good. When I write this way, you may think that the assembly went smoothly, but in fact it was quite difficult, and some troubles occurred.

There are 165 parts in the truss structure, including the rear body. I had to cut them out from carbon pipes and cut the exact dimensions and process the end faces one by one with a diamond file. This is why my hands turned black for a long time.

The trapezoidal structure to which the main landing gear is attached was found to be slightly skewed only after the gear was attached. When I looked for the cause, I found that the holes drilled in the jig were slightly misaligned on the left and right sides, causing the bamboo string to be attached at an angle. The trapezoidal structure was disassembled, corrected, and reassembled.

The assembly is still in a temporary state using CA, so it will disassemble when subjected to impact. After reinforcing those areas that will be subjected to heavy loads and shocks, epoxy adhesive will be applied to each joint for final bonding.

Fabrication Part 15 — Gimbal Mechanism of Control Sticks

While applying epoxy adhesive to the main fuselage frame, I made the gimbal mechanisms of the control sticks.

Gimbal Mechanism of the Actual Aircraft

Since the Mita Type 3 Revision 1 is a tandem double-seater, there are control sticks in the front and rear seats. The ailerons are operated by tilting them left and right, and the elevator by pushing and pulling them. The control sticks of the front and rear seats are interlocked, and when one of them is operated, the other also moves. In order to make the control sticks move back and forth and left and right, there are gimbal mechanisms underneath. Photo 81 shows the gimbal mechanisms of the actual aircraft.

Photo 81: Gimbal mechanisms of the actual aircraft; left = front seat, right = rear seat.

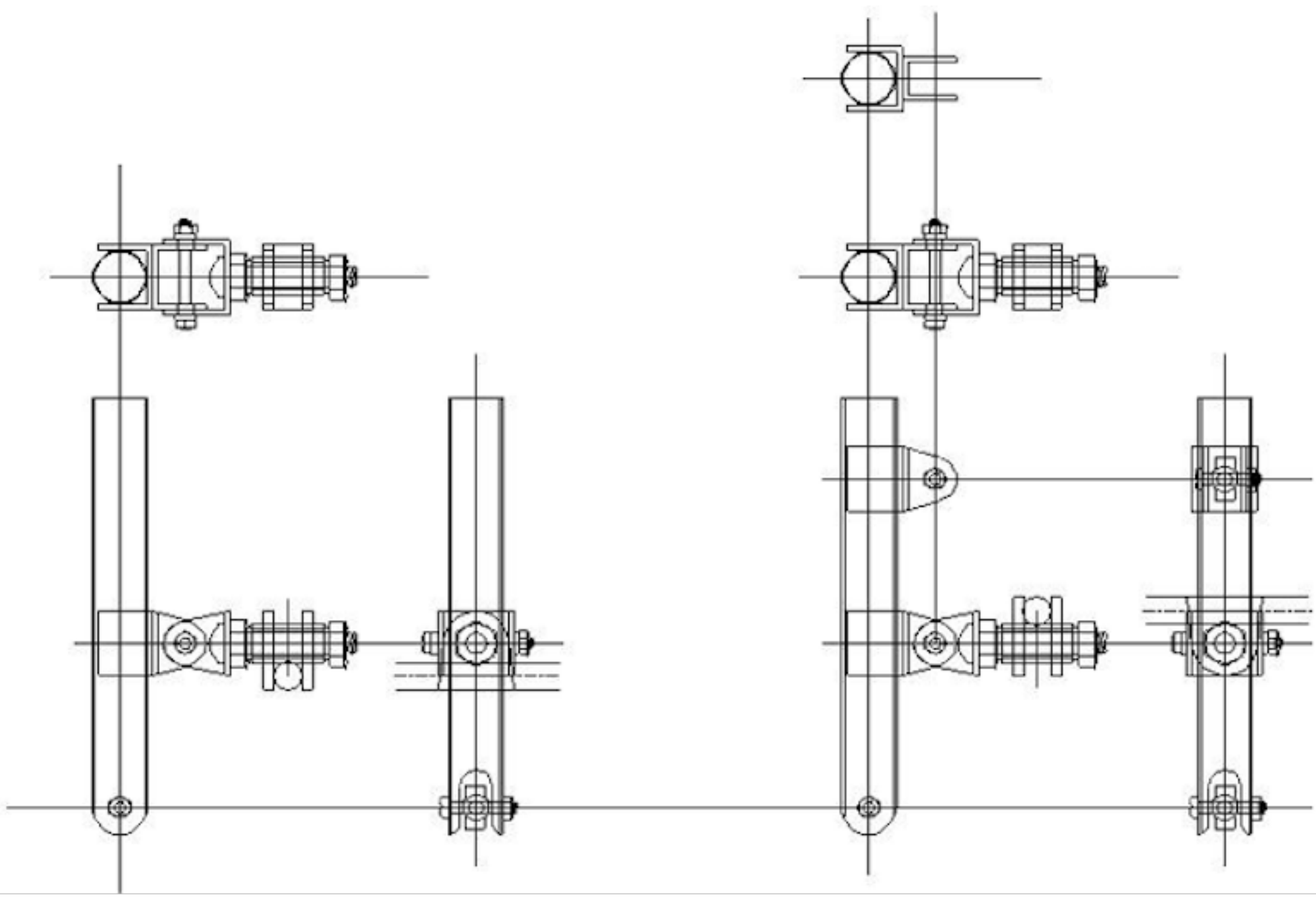
The front stick is mounted on the center of the lower fuselage crossbeam where the front seat is attached. The axle that rotates the control stick left and right for the aileron is attached to the crossbeam, and the axle that rotates the control stick back and forth for the elevator is attached in front of the airelon axle.

The rear stick is mounted under the center of the crossbeam where the rear seat is attached. In order to link the front and rear mechanisms, a connecting rod is attached to the bottom of the control sticks. There is also a link above the rear gimbal that passes under the rear seat and connects to the rear of the fuselage. This is the elevator control link.

Since the front stick is attached to the upper side of the crossbeam and the rear one is attached to the lower side, the connecting rod is attached at an angle. Therefore, the front and rear axles (for ailerons) are also inclined.

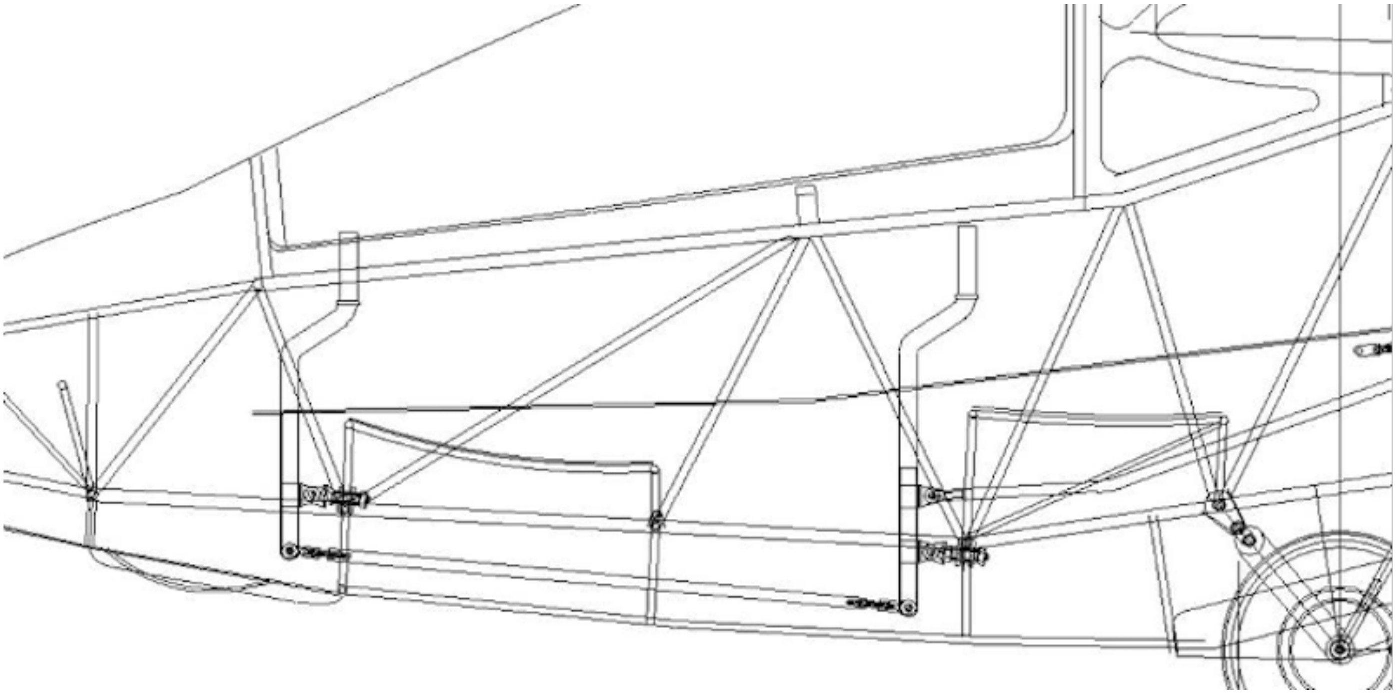
Drawing

This is the drawing of the gimbal mechanisms designed to mimic the mechanism of the actual aircraft:



Drawing 24: Control sticks gimbal mechanisms.

This drawing shows the connection of both gimbal mechanisms:



Drawing 25: Connection diagram of gimbal mechanism.

The aileron axle is made of a short carbon pipe of 7mm O.D. and 5mm I.D., with 4mm I.D. DURACON bushings attached to both ends, through which 4mm bolts pass. At the end of the bolt, a pair of hinges made from a piece of aluminum channel purchased at a home center is attached, and in front of the hinges is an aluminum pipe which was also purchased at a home center. The control stick will be made and inserted into this pipe later.

At the bottom of the aluminum pipe, a rod end with a bearing for the linkage of a large radio-controlled aircraft is attached, and a 6mm diameter carbon rod is used to connect the two gimbols. A 3mm thread is attached to the connecting rod to allow for length adjustment. A rod end is also attached to the top of the rear gimbal pipe and the linkage toward the elevator is attached here.

Fabrication

Here are the parts I made based on the drawing:

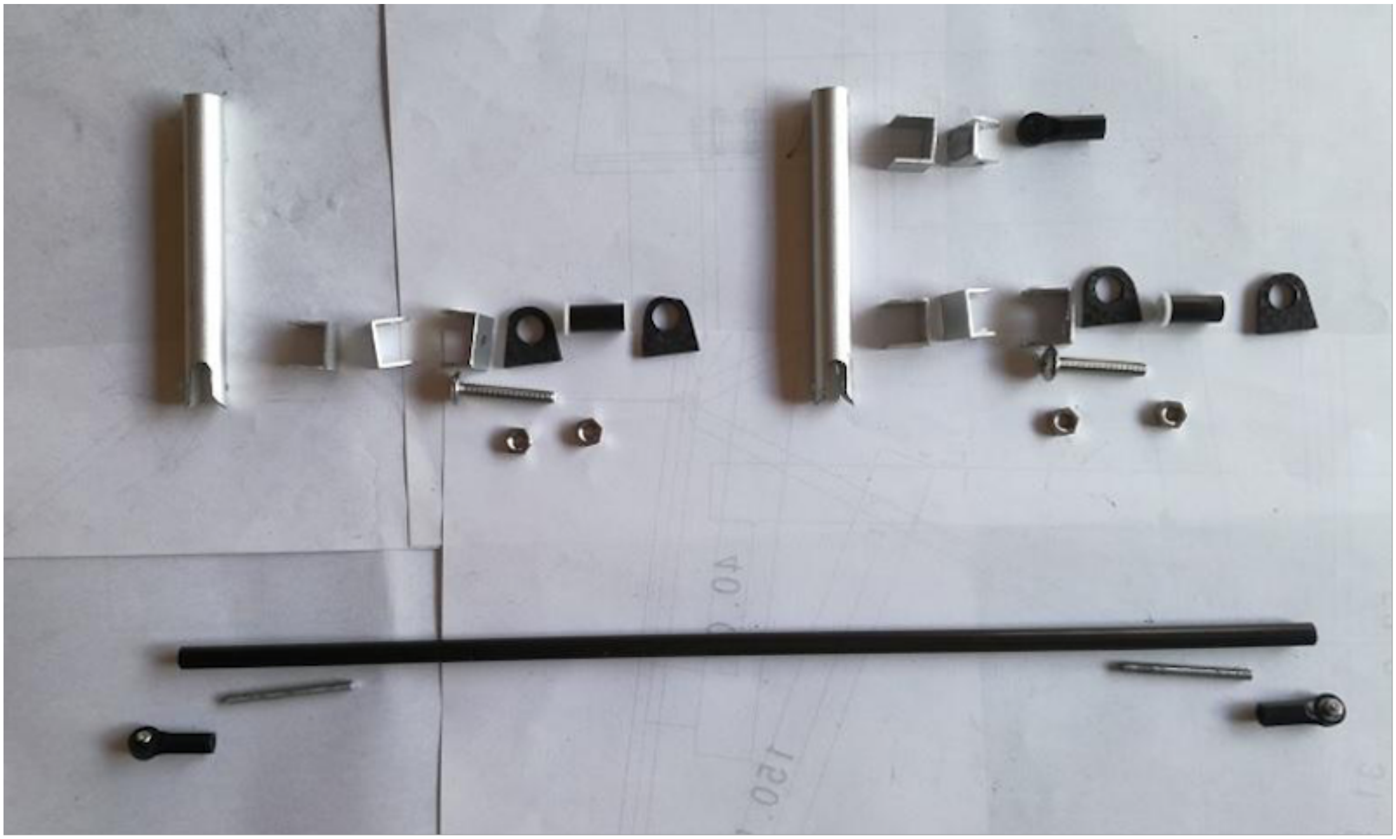


Photo 82: Parts of the gimbal mechanism.

The aileron axle pipes are inserted into two stays cut out of 2mm thick carbon board, and the two stays are attached to the crossbeam of the fuselage.

The Gimbal Parts Assembled

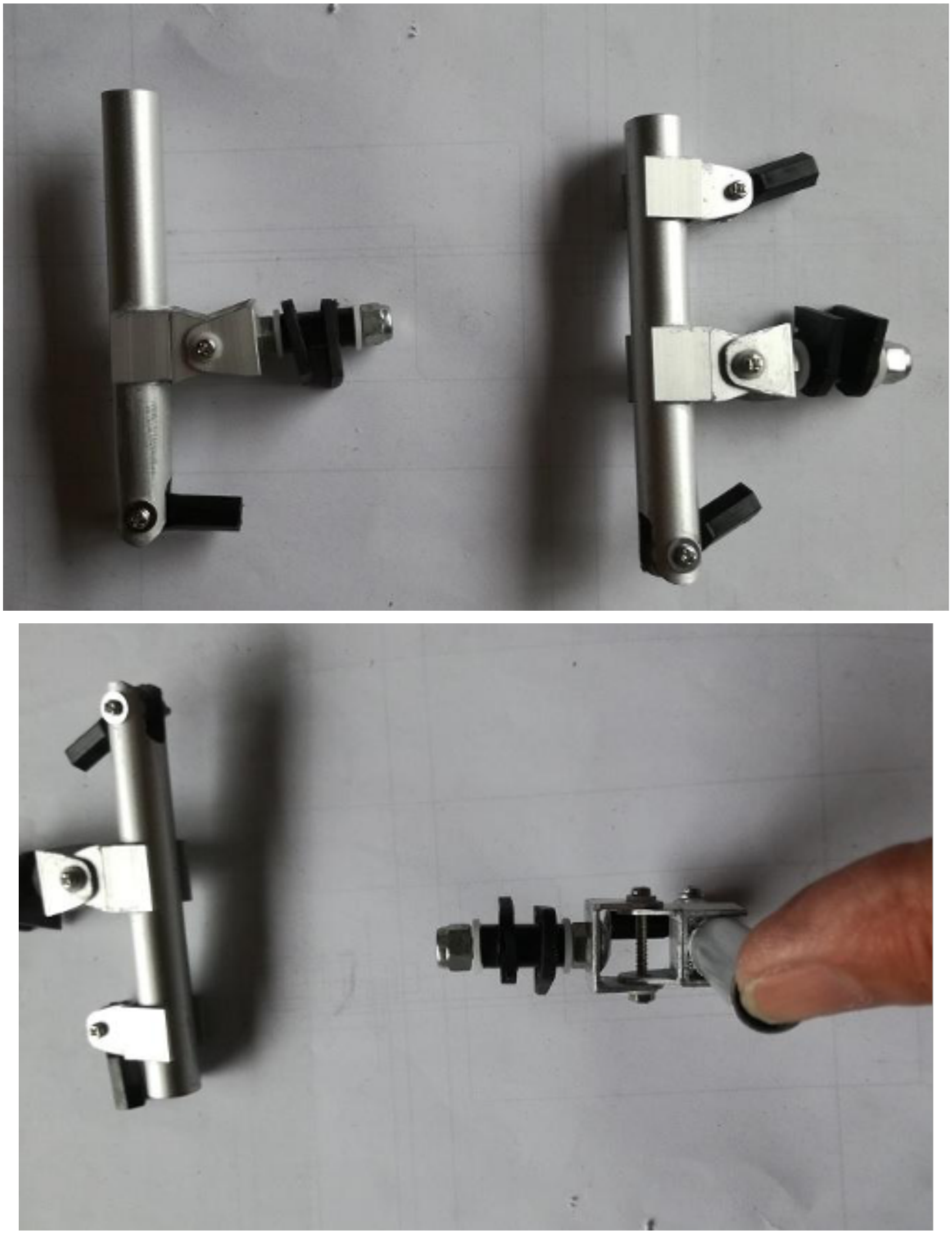


Photo 83: Assembled gimbal mechanism.

This photo shows how front and rear gimbals are connected with a connecting rod:

Photo 84: The connected gimbal mechanism.

Installation on the Fuselage

I immediately installed it on the aircraft.

Photo 85: Installation test of the gimbal mechanism.

Photo 86: Close-up view of the gimbal mechanism.

I was happy to have completed the gimbal mechanism as I had hoped, but I found an unexpected pitfall during the subsequent work on the elevator control system and was forced to modify it.

This is the fourth part in this series. Read the ***next article*** *in this issue, return to the* ***previous article*** *in this issue or go to the* ***table of contents****. A PDF version of this article, or the entire issue, is available* ***upon request****.*