1/3rd Scale Mita Type 3 Production Notes

The second part of a multi-part series.

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

Fabrication Part 2: Center wing rib assembly

Rib cutting and assembly jig fabrication

Following the spoiler fabrication, I started to fabricate the main body of the center wing. It seems that everyone has their own way of making wings, but I'll explain mine.

First, I printed out a full-size drawing to cut out the ribs. At this time, as shown in the photo below, the rib and the assembly jig, which is about 30mm high and touches the underside of the rib, are also drawn and printed together.

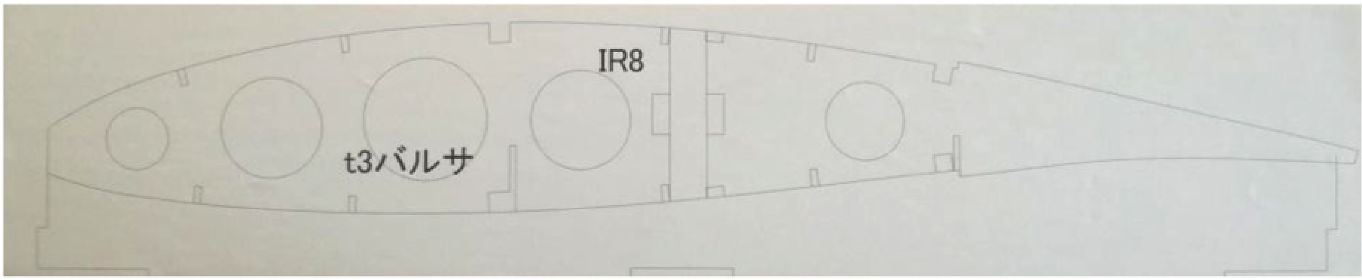


Photo 6: Printing the rib and assembly jig parts drawing.

The printed drawing is attached to the balsa sheet for the ribs with 3M removable glue spray, and then cut out along the lines with an OLFA 30° thin cutter.

Image 7: 3M removable glue spray and OLFA 30 degree thin cutter.

The drawing is printed with very fine lines of 0.09 to 0.13 mm, so if you carefully cut out along these lines, you can cut out with almost the same precision as a laser cutter. These are the rib and a component of the assembly jig after cutting out.

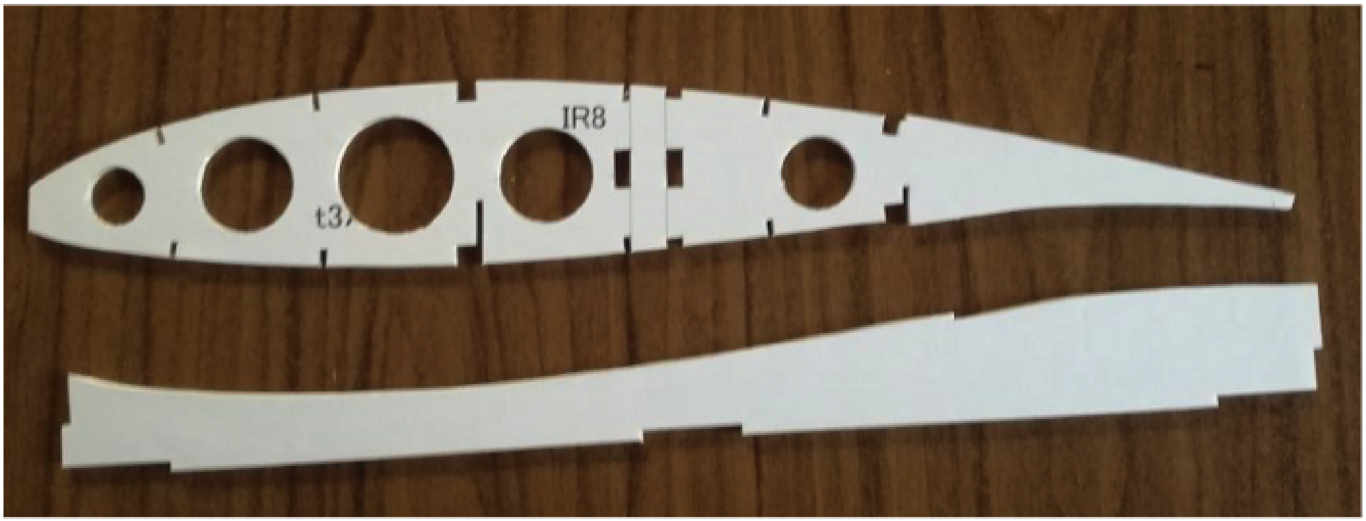


Image 8: Cut-out rib and assembly jig component

In addition to cutting out the ribs and assembly jig components, cut out the front and rear frames of the jig and the lower reinforcement part. After all the parts are cut out, the jig assembly was started. Since the center wing is 2 meters long, I decided to make it separately on the left and right sides for ease of handling during fabrication, and join them together at the end.

A full-scale printout of the drawing of the half central wing is laid out on a flat plate, and the jig parts are placed directly on top of it at the rib positions in the drawing. They are then supported by the front and rear frames and glued together with CA. The frames and parts have cutouts that interlock with each other for easy and accurate assembly. The drawing will stick to the jig due to the adhesives dripped during gluing, but don’t worry about it. In this way, the center wing assembly jig was completed as shown below.

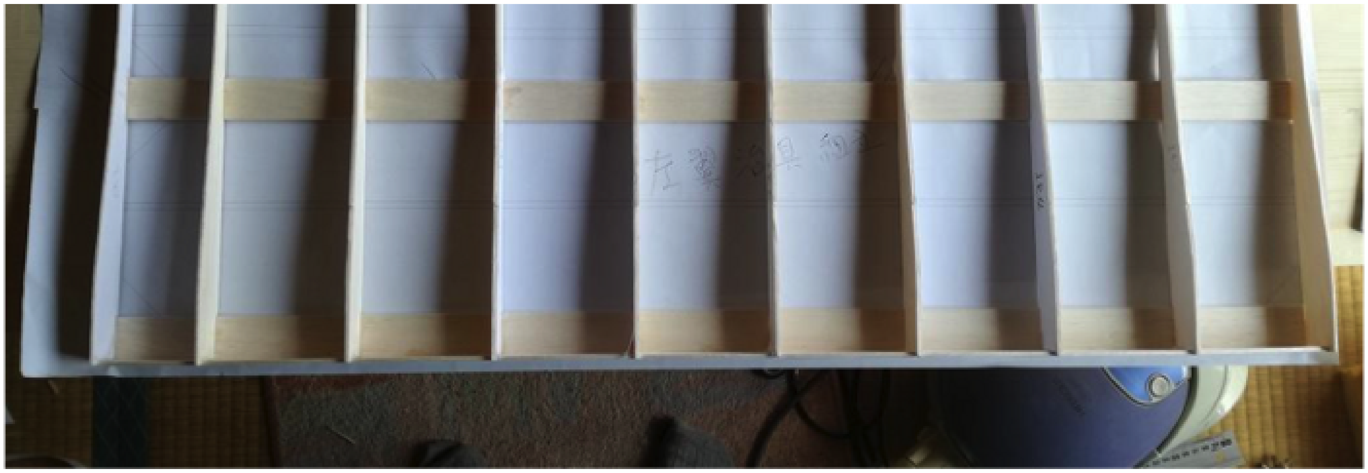


Photo 9: The center wing assembly jig completed

Assembling the center wing

Now that the ribs cutting and the assembly jigs are complete, it is time to assemble the main body of the center wing. Photo below shows the ribs for a half wing. The paper pattern is still attached.

Photo 10: Ribs for a half center wing.

The ribs were basically made of 3mm thick balsa, but 2mm thick was used for the ribs on the left and right sides that are planked to the trailing edge. The innermost ribs are sticked with 1.6 mm thick plywood, and the outermost ribs, which are in contact with the outer wing, are covered with 2 mm thick hard balsa as a protective board as explained before.

At first I thought I could leave the papers attached to the ribs, but I was surprised when I peeled them off and measured their weight. They weighed well enough to match a few ribs. Paper is heavy!.

Set these ribs in the appropriate positions on the assembly jig, and combine the spar flanges of carbon square pipe with the web cut from 1.6 mm thick plywood. In this state, the spoiler and the aluminum tube that will be used to support the carbon pipe to connect to the outer wing are also incorporated. After the assembly is complete, two or three heavy L-shaped steel bars are placed on top of the ribs as weights, and the ribs are aligned with the jig. The jig and ribs were originally made from a single piece of balsa, so they fit together perfectly.

Photo 11: Assembly of the center wing.

The balsa board standing on the leading edge of the ribs in the left photo is a jig that was inserted to make the ribs stand exactly vertically. In addition, a simple positioning jig as shown in the photo below was inserted because it is necessary to align the spar position precisely in order to join the left and right halves later.

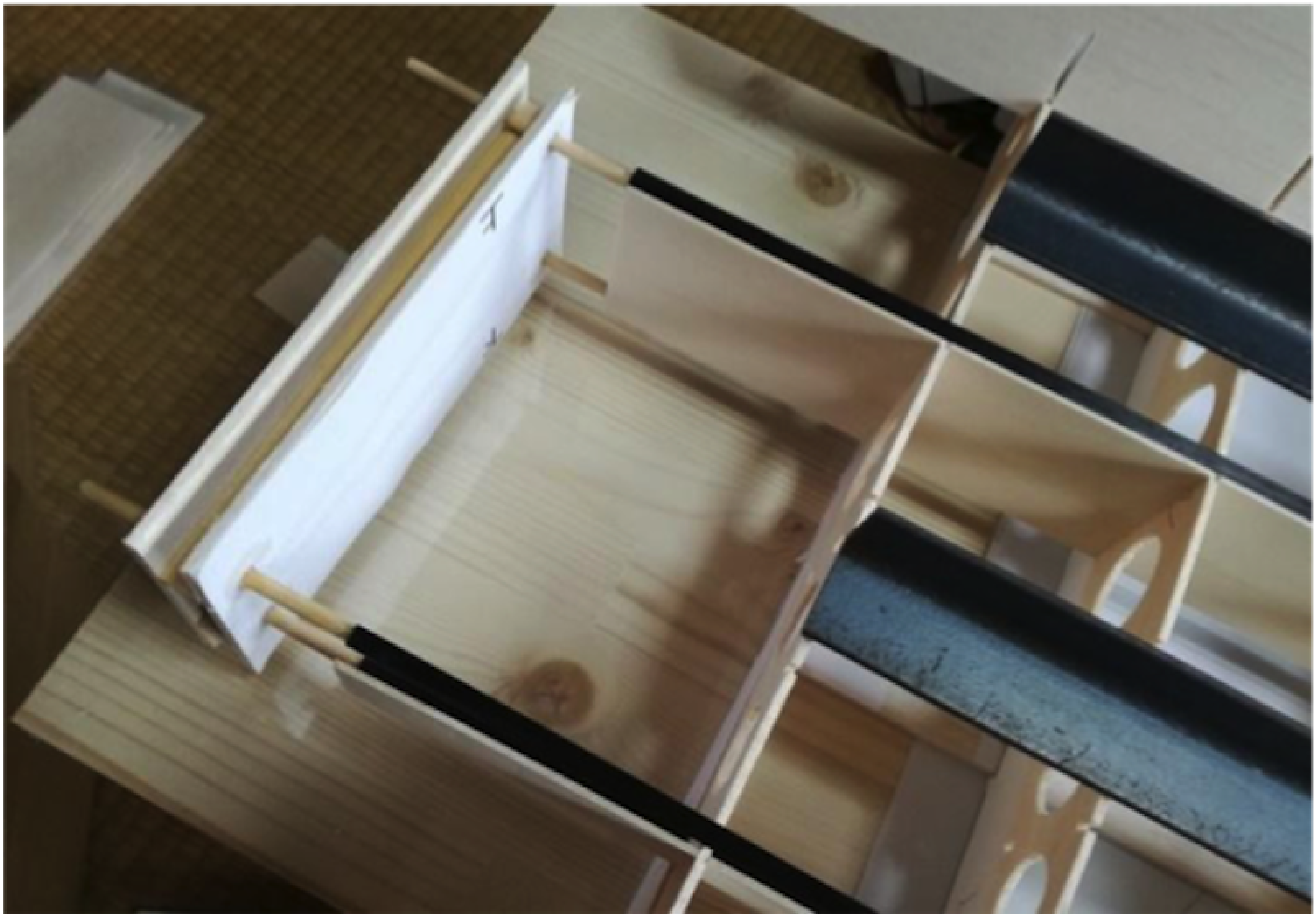


Photo 12: Spar positioning jig.

In this state, low-viscosity CA are dripped on the joints, and the aluminum tubes are glued to the surrounding spar webs with plenty of epoxy adhesives. Photo 13 shows the center wing rib assembly after gluing is completed. The red-colored part is the spoiler, and the aluminum tube is also visible.

Photo 13: Center wing rib assembly after gluing is completed.

Thanks to the assembly jig, accurate rib assembly was easy to produce. The jig is also very useful for the planking work after this. The left half weighed 355g and the right 344g, for a total weight of 700g. The weight difference between the left and right is a bit large.

Since a large amount of balsa powder will be generated during the planking process, I decided to stop making the center wing after the weather cooled down.

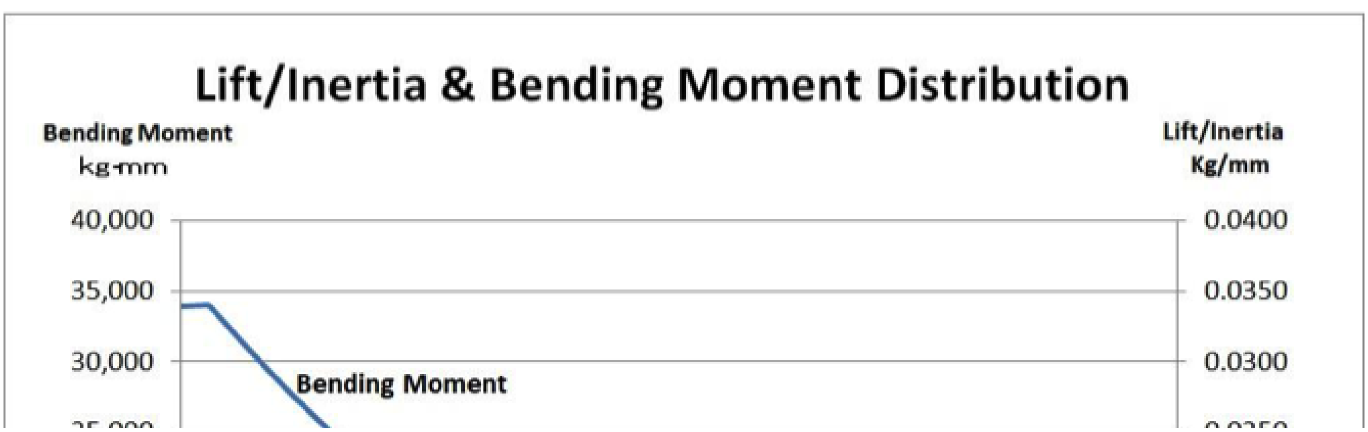
Structural Analysis of the Main Wing

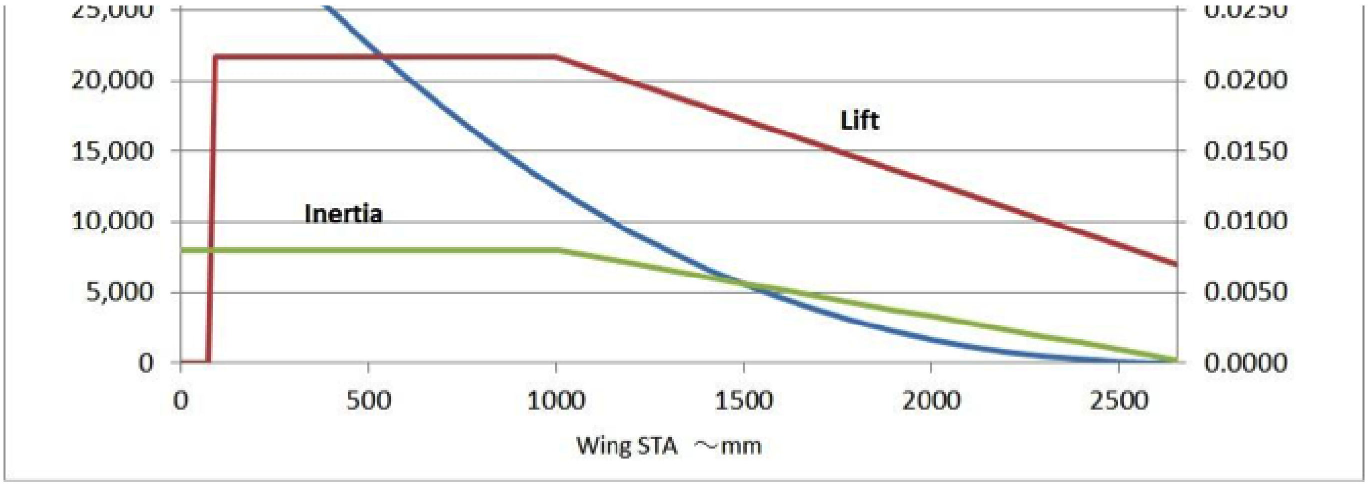
Since this is a large aircraft and heavy, I have conducted a structural analysis of the main wing.

Design load

The strength calculation of an aircraft is a process of confirming the aircraft will not break under the ultimate load (design load), which is calculated by multiplying the aircraft's limit load factor (the maximum G allowed) by a safety margin of 1.5. At the time I started the design, I could not find the limit load factor for the actual Mita Type 3 rev.1, so I adopted the factor of 6.0, which is applied to fixed-wing Class A aircrafts that perform acrobatic flights. By multiplying this by a safety factor of 1.5, the ultimate load factor became 9.0, but I took a margin of safety and calculated the design load factor as 10.

Applying 10G to the model with a maximum overall weight of 8.7kg means that 87kg of lift force will be applied to the main wing. Since the main wing has mass, the inertia force of 10G acts in the opposite direction of the lift force. The difference between the lift and inertia produces the moment that bends the main wing upward. The figure below shows the result of the calculation using EXCEL spreadsheet.





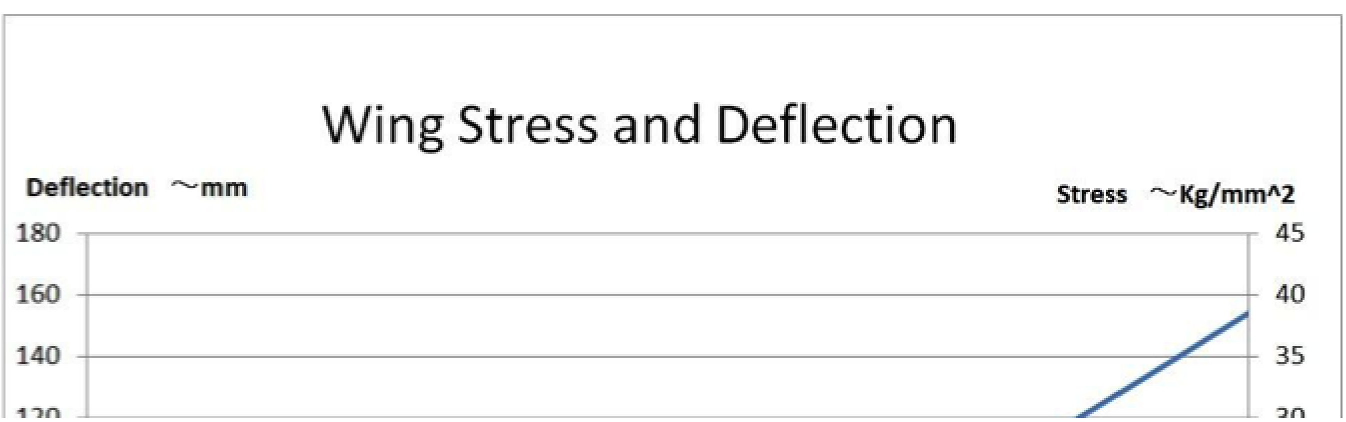
Graph 4: Design load of main wing.

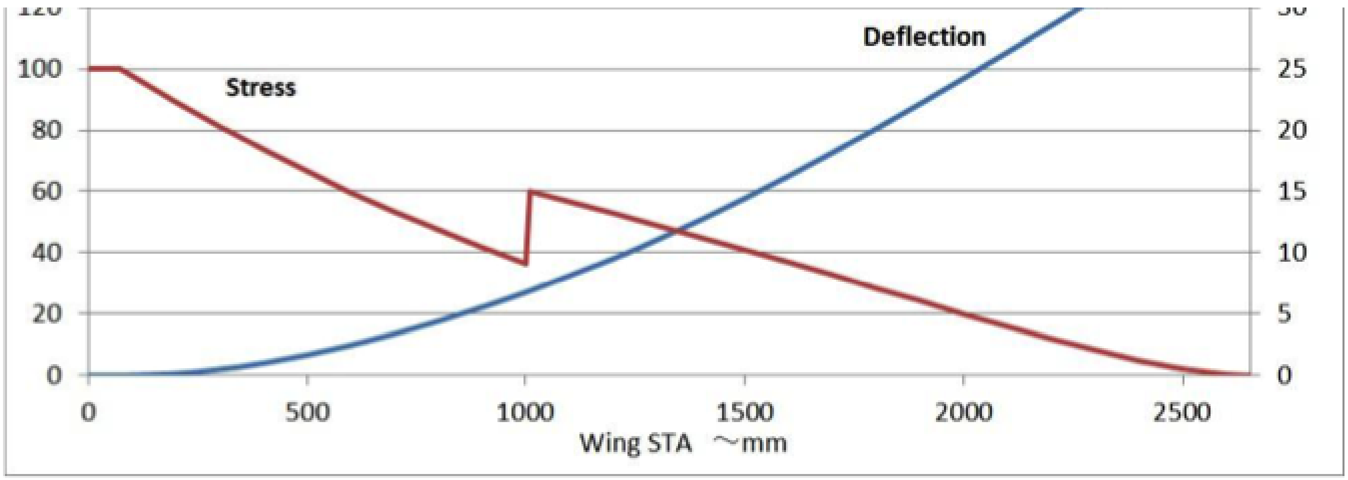
This is a graph of a half wing, with STA = 0 at the centerline of the fuselage and STA = 2655 at the wing tip. Both lift and inertia decrease as you move outward from STA = 1000, where the tapered outer wing is. The lift is zero inside the STA=100 because it is inside the fuselage.

The bending moment is zero at the wing tip and increases gradually toward the wing root, but it stops and remains constant near STA100 because the wing is connected to the fuselage at this point. The maximum bending moment is at this wing-fuselage connection, which is about 34,000 kg-mm = 34 kg-m.

Strength Calculation

The bending moment causes the wing to deflect upward, which in turn causes stress in the spar. The deflection and stress of the spar due to this moment load can be calculated using the beam theory of material mechanics. The detailed explanation is omitted, but the calculations were made using an EXCEL spreadsheet. The results are shown in the figure below.





Graph 5: Stress and deflection of main wing due to design load.

The deflection increases toward the wing tip and is expected to be about 154 mm at the wing tip. The stress is greatest at the wing root where the moment is large, and decreases toward the wing tip, but it increases again near STA1000 because the outer wing has a thinner spar flange from here. It can be seen that the maximum stress is about 25 kg/mm². This stress occurs in the flange of the carbon square pipe, but the allowable stress of carbon is about 70 kg/mm², so it is clear that the wing is strong enough.

The center wing is connected to the outer wing by a carbon pipe with an outer diameter of 20 mm and an inner diameter of 16 mm, and the STA1000 uses this pipe alone to transmit the moment. The stress generated at the outer edge of the pipe is calculated to be 26.8 kg/mm²,which is more than enough.

Later, I learned from a former instructor of the glider club of Tokai University that the limit load factor of the actual aircraft is 5. Also, the finished weight increased to about 10 kg. The design load under these conditions is 10 x 5 x 1.5 = 75 kg, so I was able to confirm that the design load of 87 kg mentioned above is on the safe side.

Selection of power system

It sounds somewhat strange to select a power system for a glider, but my RC club is located in a flat area and I don't have a winch for my glider, so all of my RC gliders are equipped with a motor and a foldable propeller for self-takeoff. The 1/3 model will also have a motor and foldable propeller like the others, so I need to select a power system consisting of a motor, power battery (LiPo), and motor controller (ESC).

Selecting a motor

First, I need to decide the size of the motor. Based on my vague knowledge that a glider of this class requires a motor of about 130W per kg of weight, I decided that a motor of about 1,100 to 1,200W would be appropriate for this glider, which weighs a maximum of 8.7kg.

I researched and listed the combinations of motors, LiPo, and ESCs in this class in the table below.

	Candidate Power Systems		
Candidate Motors		OS OMA-5020-490	FSD FC5065-6T	E-MAX GT4030/06
KV	rpm/V	490	430	420
Normal Current	A	50	60	
Max Current	A	90	70	60
Weight	g	350	361	380
Price	¥	14,900	7,236	6,483
Candidate LiPo		KYOPOM 5,100mAh	KYOPOM 5,101mAh	KYOPOM 5,101mAh
Number of Cells		5	5	5
Capacity	mAh	5,100	5,100	5,100
Weight	g	600	600	600
Price	¥	0	0	0
Candidate ESCs		Hobbywing Flyfun 100A	sunrise Model 80A	sunrise Model 80A
Allowable Current	A	100	80	80
Weight	g	76	65	65
Price	¥	6,804	4,495	4,495
Total Weight	**g**	**1,026**	**1,026**	**1,045**
Total Price	**¥**	**21,704**	**11,731**	**10,978**

Table 1: Candidate motors and their corresponding LiPo and ESCs.

Three brands of motors, OS, FSD, and E-MAX, have KV values of 420 to 490 and weights of 350 to 380 grams.

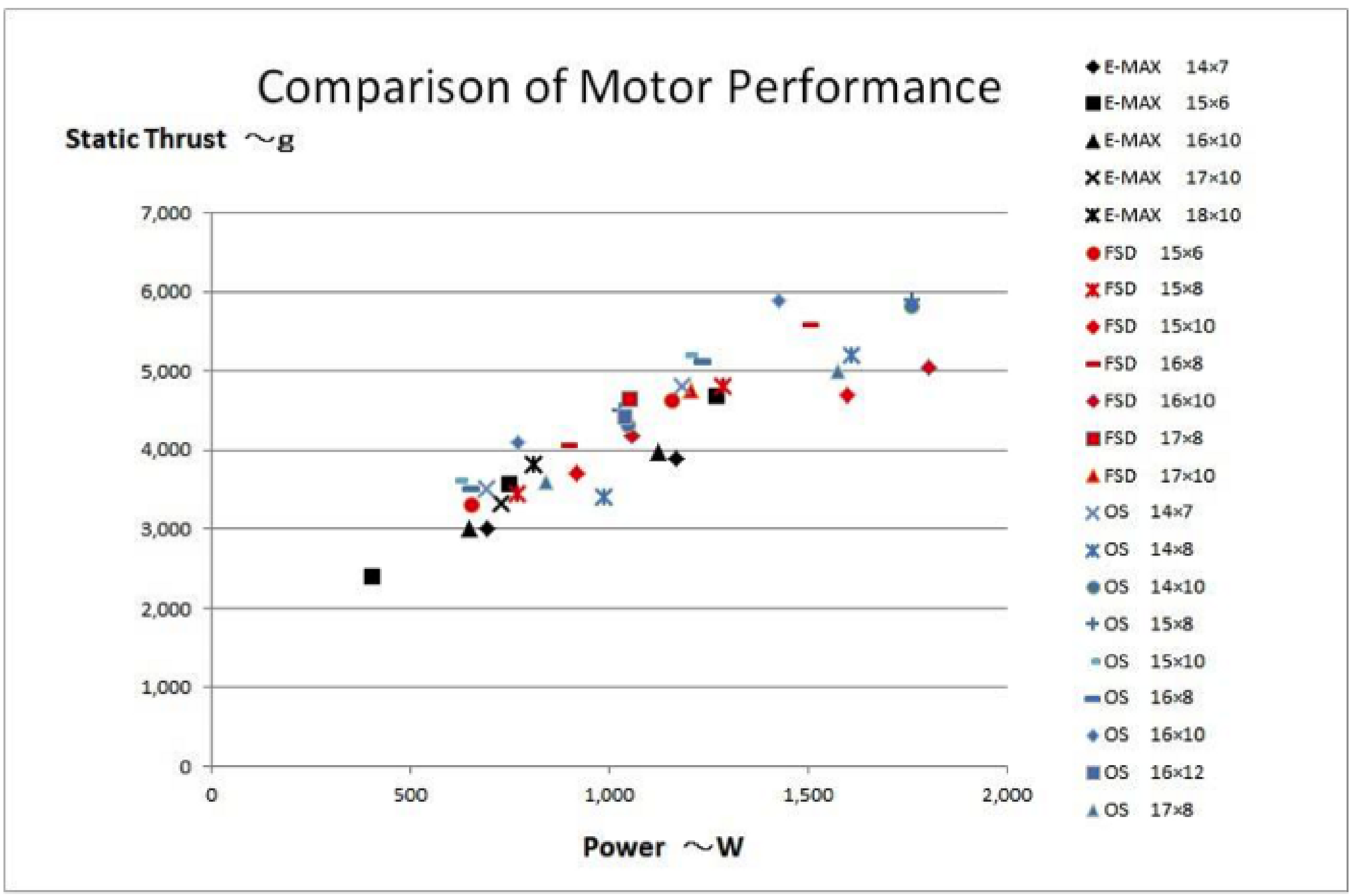
I have used several OS motors that are a class smaller than these. I am satisfied with the quality and performance of those motors. The OS motors have a slightly higher KV than other manufacturers' motors, so they have more power for their weight.

FSD motors are reasonably priced and offer good performance. I use a smaller motor for my 1/5 Mita and 1/5 Minimoa.

The E-MAX motor is the least expensive motor, but it is well made and has no problems. I use this same motor in my Curtiss Jenny.

Photo 14: My Curtiss Jenny with E-MAX GT4030/06 motor.

The figure below shows a graph comparing the performance of the three motors using published data, with the OS motor data from the OS website and the FSD and E-MAX motor data borrowed from the KKHOBBY website.



Graph 6: Performance comparison of candidate motors.

The horizontal axis is the power consumption (W) and the vertical axis is the static thrust. There is a slight difference depending on the propeller installed, but there is not much difference in performance. However, there seems to be a slight difference in the appropriate power range, with E-MAX motor consuming around 1,000W, FSD motor consuming around 1,100 to 1,200W, and OS motors consuming around 1,200 to 1,400W.

LiPo battery for power

The nominal voltage of a 5-cell LiPo is 18.5V, but when fully charged it is over 20V, and even in normal use it is close to 20V, so 60A will give 1,200W. The required battery capacity was calculated as follows.

If you run the motor at full power of 60A for one minute, you can gain a lot of altitude. After that, you can stop the motor and enjoy it as a glider. Once you get a thermal, you don't need any more power. If the thermals are weak and you are losing altitude, you can do another motor run to regain altitude. If you do three such motor runs, you will probably be flying for more than 10 minutes, and you will get tired, so you will have to land the plane. In other words, we only need a LiPo with enough capacity to run 60A current for 1 minute 3 times (60A x 1/60h x 3 = 3Ah = 3,000mAh). 50–70% consumption of LiPo is usually the best, so a battery with a capacity of 4,300–6,000 mAh would be appropriate.

Fortunately, the battery for the Curtiss Jenny pictured above is a 5,100 mAh 5-cell LiPo, and it fits the requirement perfectly. This battery had no other use and was underutilized, but now I don't have to buy a new battery.

ESC

The OS motor has a maximum current of 90A, so it needs a 100A class ESC, but the FSD and E-MAX motors have a maximum current of 70A or less, so an 80A class ESC is sufficient. This is also important for Sunday flyers because ESCs become more expensive as their capacity increases. Sunrise ESCs are also used in my 1/5 Mita model and other and are very solid ESCs for the price.

Conclusion

Based on the above considerations, I decided to use the FSD FC5065–6T as the motor, taking into account its power range, price, and experience with similar products, and decided to use the KYOPOM 5-cell 5,100mAh LiPo and Sunrise 80A ESC (which I also had on hand) and ordered the motor.

As for the propeller, from the performance comparison graph above, I thought that 16 or 17x8 would be good.

> **Mistake 4:** *As I will explain later, this decision was not well thought out and I had to buy a new motor/ESC/LiPo. I made the mistake of assuming 130W per 1kg of weight without thinking too much about it. It was a painful expense.*

Payload weight

The above power system is included in the payload that I discussed in the target weight. The payload also includes the receiver and its power supply, so I estimated the total payload weight including them here.

Estimated payload weight			
	Motor	361 g	
	LiPo	600 g	
	ESC	65 g	
	Folding propeller & hub	50 g	
	Receiver	10 g	
	Power supply for receiver	155 g	(2,500mAh NiMH)
	S/W for saame	11 g	
	Harness	100 g	
	Total	1,352 g	

The target payload weight was 1,800g, so it would be about 450g lighter. However, I may need to add some weights to align the center of gravity, so next I calculated the CG.

Weight & Balance Calculation and its Management

I found that the payload weight is lighter than what I had planned in the power system study, but I was not sure if the center of gravity would match. Therefore, I studied CG. I also set a method to manage the weight and balance by which I can check it as the design and fabrication progresses.

Target CG position

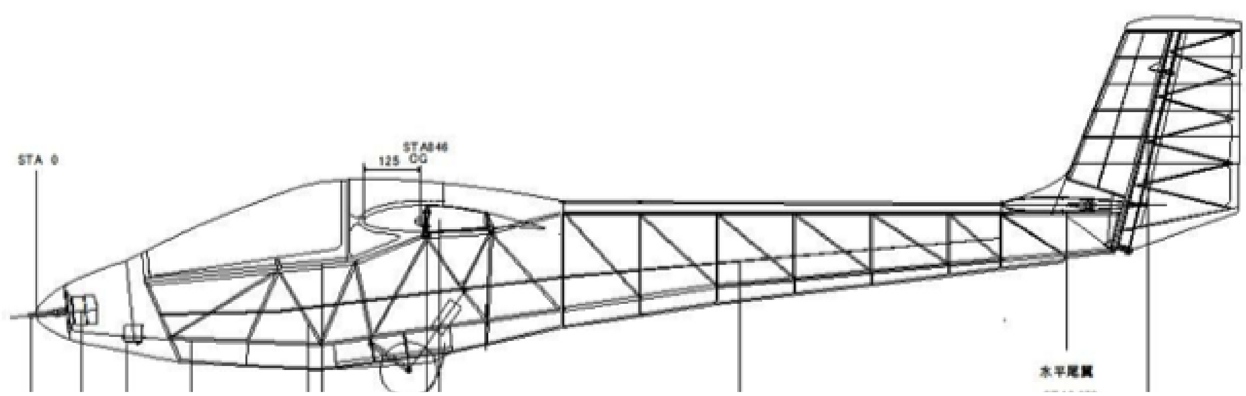
At this point, I did not know the allowable center of gravity range of the actual model. Therefore, the target center of gravity of the 1/3 Mita Type 3 Kai 1 was set to the same as that of the 1/5 model made by Thermal Studio. Since the center of gravity of the 1/5 model is 75 mm behind the leading edge of the main wing, the center of gravity of the 1/3 model is 75 x 5/3 = 125 mm behind the leading edge, which is STA846 mm from the nose.

0th check of weight and balance

The center of gravity was calculated based on the target weight of the aircraft's each component. In the target weight calculation, the long fuselage including the tails was combined into one body, but in the center of gravity calculation, it needs to be broken down a little more. So the fuselage is divided into front and rear at the narrow point just after the trailing edge of the main wing. Further, the rear fuselage is divided into three parts: the rear fuselage itself, the vertical tail, and the horizontal tail. The weight of the rear fuselage, vertical tail and horizontal tail is calculated as follows

Rear fuselage	560 g
Vertical tail	240 g
Horizontal tail	400 g

Therefore, the target weight of the front fuselage was 1,600g, subtracted from the target weight of the entire fuselage of 2,800g. These target weights and the positions of the payload weights considered in the selection of the power system are shown in Drawing 6.



Drawing 6: Weight of each component and its position.

Based on this figure, the moment created by the weight of each component is calculated in Table 2.

0th Weight & Balance	2018/5/15	Completion Ratio		0.00 %	
	Weight	STA	Moment	Actual Weight	Estimated Remain Weight
Outer Wing Left	700	860	602,000	0	
Outer Wing Right	700	860	602,000	0	
Center Wing	1,600	890	1,424,000	0	
Forward Fuselage	1,600	630	1,008,000	0	
Aft Fuselage	560	1,550	868,000	0	
Vertical Tail	240	2,450	588,000	0	
Horizontal Tail	400	2,270	908,000	0	
Motor	361	100	36,100	0	
Propeller & Hub	50	-10	-500	0	
Battery for Radio	155	200	31,000	0	
LiPo	600	340	204,000	0	
Others	186	600	111,600	0	
Total	7,152	892	6,382,200	0	
Target CG		846			
Weight	483	160	77,343		
Normal Flight Condition	7,635	846	6,459,543		

Table 2: Calculation of the 0th weight and balance.

Weights are target weights, not actual measured weights. In this sense, the completion ratio is 0%, and the accuracy is only moderate. This is the reason why I call it the zero-order calculation. The actual weight of each component will be measured as fabrication proceeds, I will revise this. If no weight is added the total weight will be 7,152g, but the center of gravity will be 892mm, 46mm behind the target of 846mm. The reason for this is that the motor and the power supply for the receiver are lighter than those expected from a 1/5 model. Since it cannot fly as it is, it is needed to put a weight of 483g on STA160 just after the motor in the nose. In the end, the weight in normal flight will be 7,635g, which is 35g over the target of 7,600g.

This is an unreasonable situation where the payload weight can be lighter than the target weight, but since the center of gravity is not aligned, an extra weight is loaded, and the total weight exceeds the target weight. It is obvious that the most effective way to solve this problem is to reduce the weight of the vertical and horizontal tails, which are located at the very rear.

1st check of weight and balance

The center wing rib assembly has been completed. The actual weight was 700g and the expected weight of the remaining work was 860g. Using this data, I quickly revised the calculation table and made the first weight and balance calculation as shown in Table 3.

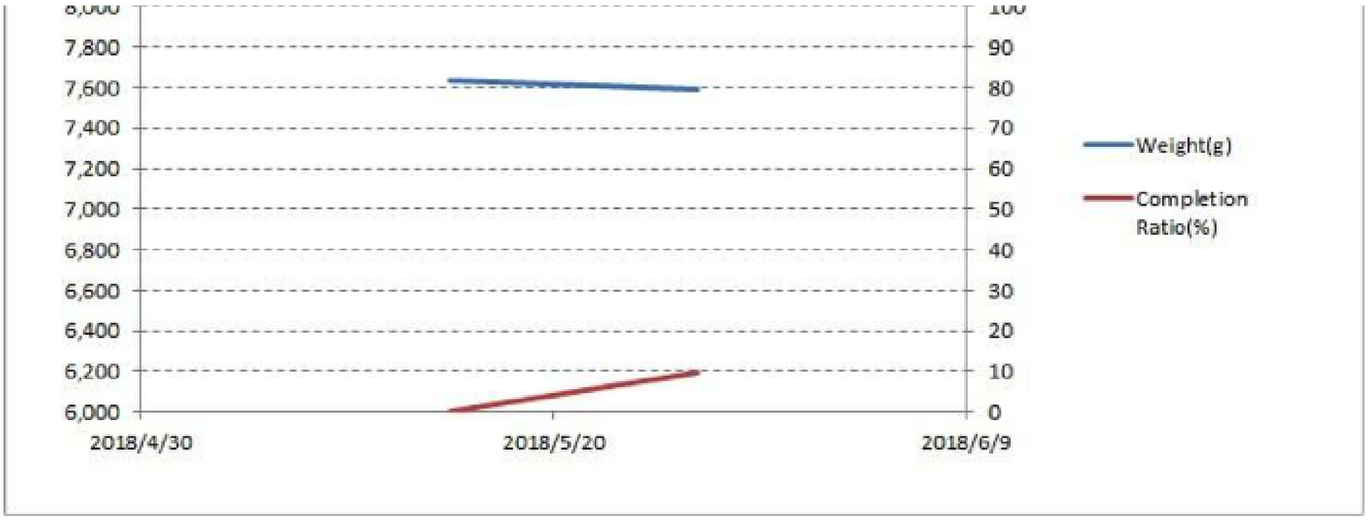
The total weight was estimated to be 7,112g, of which 700g was actually measured, so the completion ratio increased to 9.84%. The tail wings are still the same as in the 0th calculation, so there is no significant change in the center of gravity and the weight needed is 481g. The total weight in normal flight condition is expected to be 7,593g, which is barely within the target.

1st Weight & Balance	2018/5/27	Completion Ratio		9.84 %	
	Weight	STA	Moment	Actual Weight	Estimated Remain Weight
Outer Wing Left	700	860	602,000	0	
Outer Wing Right	700	860	602,000	0	
Center Wing	1,560	890	1,388,400	700	860
Forward Fuselage	1,600	630	1,008,000	0	
Aft Fuselage	560	1,550	868,000	0	
Vertical Tail	240	2,450	588,000	0	
Horizontal Tail	400	2,270	908,000	0	
Motor	361	100	36,100	0	
Propeller & Hub	50	-10	-500	0	
Battery for Radio	155	200	31,000	0	
LiPo	600	340	204,000	0	
Others	186	600	111,600	0	
Total	7,112	892	6,346,600	700	
Target CG		846			
Weight	481	160	76,932		
Normal Flight Condition	7,593	846	6,423,532		

Table 3: First weight and balance calculation.**Weight Control Chart**

Weight Control Chart

The following graph shows the weight and completion ratio obtained as a result of the 0th and first weight and balance calculations.

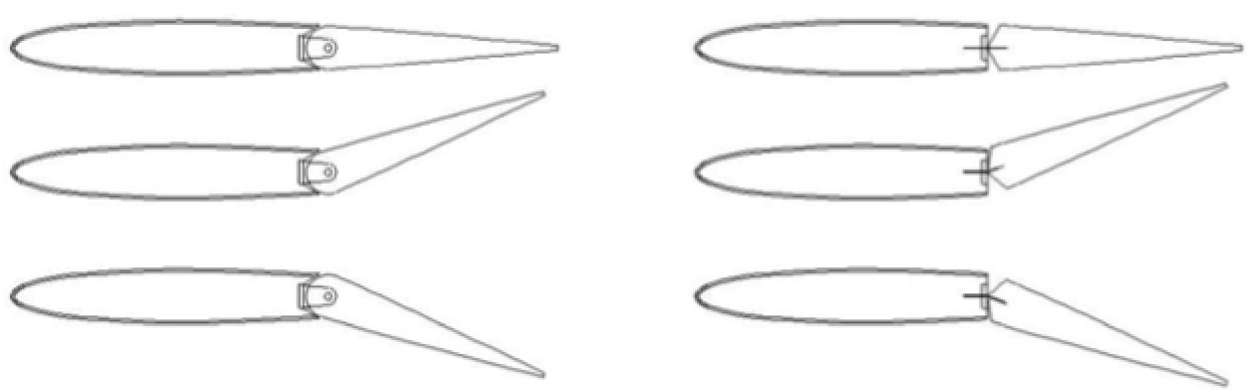


Graph 7: Weight control chart.

As the fabrication progressed, this figure also grew to the right as the calculations were revised. While keeping an eye on this figure, I proceeded with the design and manufacture of the glider, always taking care not to exceed the target weight. Although the completion ratio increases steadily, the degree of freedom for design changes that affect the weight decreases, so it is necessary to deal with this issue carefully from the beginning.

Fabrication Part 3: Vertical tail

After making the center wing rib assembly, I started to build the vertical tail. There is a reason for this. For this large glider, I planned to make the leading edges of the control surfaces rounded, just like the actual glider (drawing 7, left). These leading edges of a usual RC aircraft are pointed in a V-shape and attached with a cloth or rod hinge (Drawing 7, right).



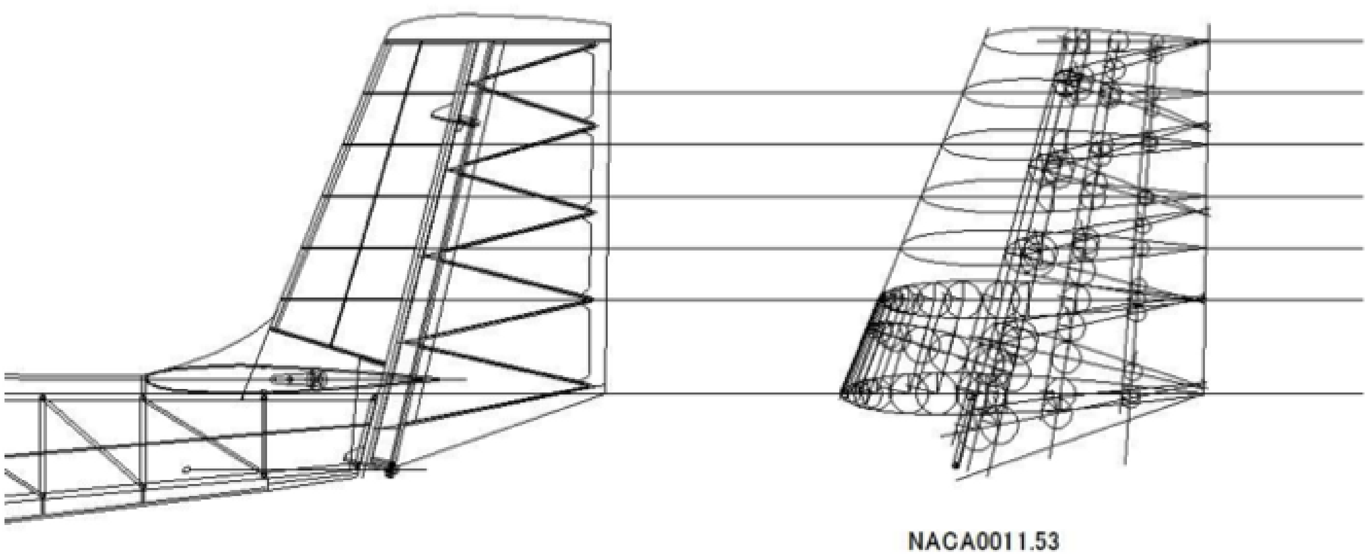
Drawing 7: Control surface attachment; actual aircraft (left), usual RC model (right).

All the aircraft I have built so far have been of this type. This is sufficient for a small RC aircraft, but for this aircraft, which is 1/3rd the size of the actual aircraft, the gap between the control surfaces and the wing will be large, which may have a negative effect on aerodynamic performance. In addition, the ailerons of the actual aircraft are of the so-called “frise” type, in which the leading edge juts out from the underside of the wing when the airelon is raised. To make ailerons that resemble this, it is impossible to apply the conventional RC aircraft’s aileron attachment method.So I decided the leading edge of the control surfaces are rounded and covered by wing trailing surfaces. This minimizes the gap at the attachment point and makes the air flow smoother. The hinges also need to be changed in order to achieve this.

Since this is the first time for me to build this type of control surfaces, I thought I would first gain experience in building a vertical tail with one control surface and reflect the know-how I would gain in building the main wing and the horizontal tail that have two control surfaces.

Structure of the vertical tail

The figure below is the structural drawing of the vertical tail.



Drawing 8: Structural drawing of the vertical tail.

For the airfoil shape, I tried to make a smooth connection between the side of the fuselage and the vertical fin, and found that a target airfoil with 11.53% thickness was the best choice, so I decided to use NACA0011.53.

In the process of making this drawing, a troublesome problem arose. All the control surfaces of Mita Type 3 are covered with cloth and not planked. Therefore, all the ribs are attached diagonally to get torsional rigidity. Since the airfoil shape is naturally defined in the airflow direction, the rib shape of the control surfaces has to be obtained by drawing which are shown in the figure on the right.

The ribs of the rudder are 3 mm thick. For the front edge, I put several semicircular ribs on the rudder front spar and planked them with 1mm thick balsa.

Vertical fin is full plank. There is a thick 10mm spar at the very rear which is attached to the fuselage rear end with two bolts. A hard board is embedded in the mounting area for reinforcement. The stringers are made of 1 x 5 mm cypress sticks and run diagonally around the maximum wing thickness to prevent the planks from dent. In the actual model, it seems to run vertically a little further back. The ribs of the vertical stabilizer are made of 2mm thick balsa, and the planks are made of 1.5mm thick balsa sheets.

The rudder hinges are installed in two places, upper and lower, as in the actual model, and the rudder is hinged so that it can be removed freely. For the upper hinge, a short 4Φ bamboo string is attached upward to the end of the carbon plate stay extending from the fin to form the rotation axis, and the acrylic plate with holes attached to the rudder side supports the axis of the bamboo string. The hinge on the lower side is a 4Φ bolt inserted from the underside of the rudder and screwed into the rudder body through the stay of the carbon plate with holes extended from the fin. A carbon rudder horn is also attached to this part.

Fabrication of the rudder assembly jig

As with the center wing, the ribs of the rudder and the parts for the assembly jig were cut out at the same time. The photo below shows the assembly of these parts.

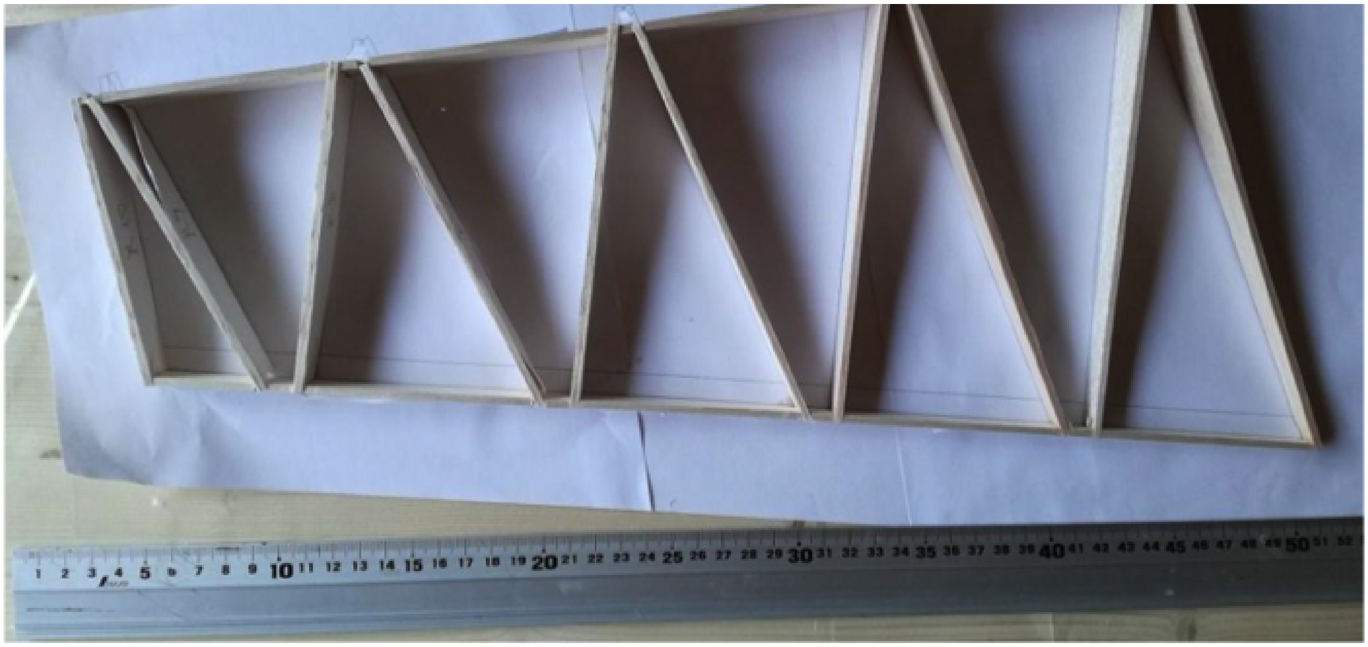


Photo 15: Rudder assembly jig.

Rudder parts

This is the rudder parts that have been cut out (Photo 16).

Photo 16: The rudder parts.

Rib assembly of the rudder

This is the rib assembly of the rudder. The heavy steel L-bars press it firmly against the assembly jig.

Photo 17: Rib assembly of the rudder.

Rudder rib assembly completed

Rib assembly is now completed. Thanks to the jig, the contour of the rib surface is nicely aligned.

Photo 18: Completed rudder rib assembly.

Fabrication of the vertical Fin

The vertical fin was assembled following the same procedure as the rudder. The assembly jig (left) and vertical stabilizer parts (right).

Photo 19: Assembly jig and parts of the vertical fin.

The bottom rib runs diagonally, so the angle of the assembly jig to receive the rib is different from the others. In order to firmly attach the ribs to the spar, the parts are not butt-jointed, but rather the ribs are inserted through holes in the spar.

Photo 20 shows the vertical fin rib assembly completed. The assembly jig was very effective, and accurate assembly was completed very easily.

Photo 20: Vertical fin rib assembly.

After this, the hinge shaft was attached to the spar and planked with a 1.5 mm balsa sheet. Then the rudder was attached and the vertical tail was assembled.

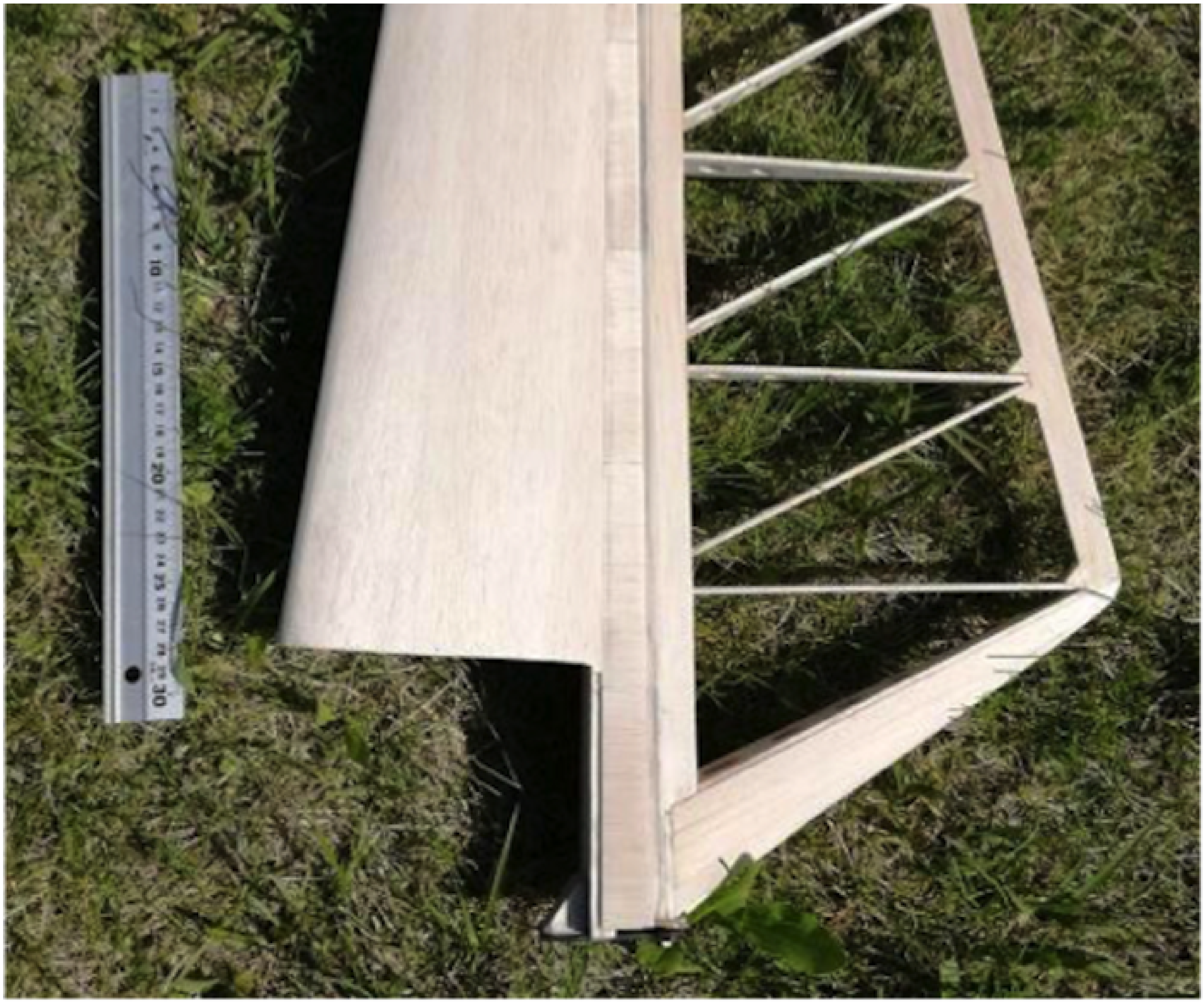


Photo 21: Finished vertical tail assembly.

I forgot to take a picture of the important R-shaped leading edge of the rudder. However, the rib spacing was too wide and the 1mm plank material was too thin, so the leading edge of the rudder did not become a beautiful semicircle, and some distortion occurred. I had to apply patches to the large dents, but fortunately they are no longer noticeable after covering.

The plank that protrudes behind the spar of the fin also has a few points to be considered in terms of accuracy. I simply attached a balsa plank to the spar in the vertical direction and stretched it over the leading edge of the rudder, but this caused a slight undulation in the longitudinal direction.

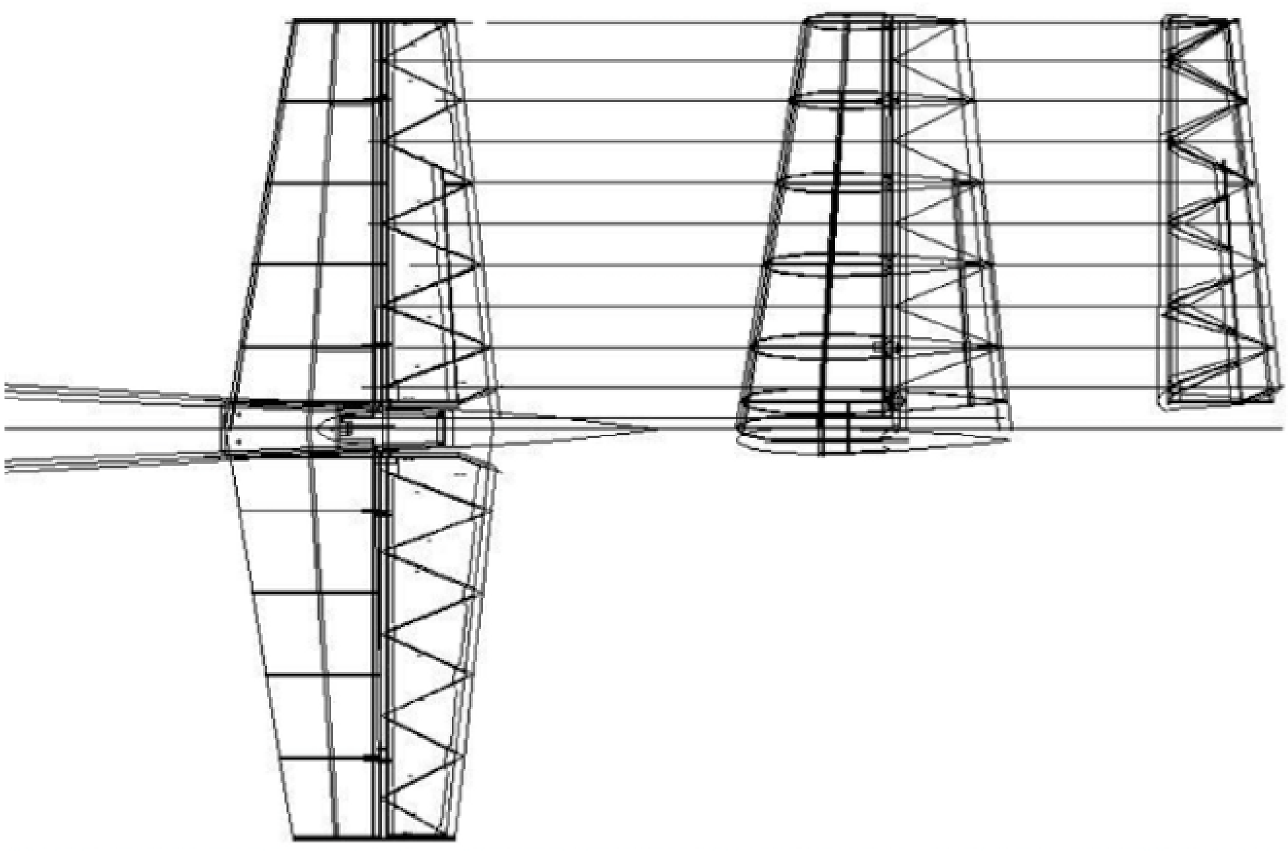
This experience taught me the following lessons for future elevator and aileron construction.

> ***Lessons Learned 2:***
>
> 1) The plank material at the leading edge should be thicker, or the number of ribs should be increased.
>
> 2) If the radius of the leading edge is small, it may be difficult to make a semicircular plank.It would be better to use a method of shaping by attaching a solid material to the leading edge with the intention of increasing the weight slightly
>
> 3) In order to secure the positioning accuracy and strength of the overhanging plank that covers the leading edge rounded part, the rear part of the rib should be triangular and extend to the rear of the spar to support the overhanging plank. (See the section on horizontal stabilizer below)

Fabrication Part 4: Horizontal tail

Outline of the horizontal tail

This is the drawing of the horizontal tail.



Drawing 9: Horizontal tail.

The span is 996 mm, or about 1 meter. Although the airfoil of the actual aircraft is not known, I found that the NACA0010 with 10% thickness would make the connection with the upper surface of the fuselage smoother, so I decided to use it. Since there are 10 ribs in one elevator in ±45 degree direction, the airfoil design was quite troublesome.

The right elevator has a large trim tab on the inside. The trim tab is not necessary for servo-driven RC airplanes, as they are used to trim the steering force for human control, but I decided to make them just like the actual airplane in order to give a sense of scale. However, it is not necessary to operate it, so the hinges are made firm so that it can be moved by hand.

The leading edge of the elevator is a semicircle. Since the elevator is tapered, its radius decreases as it moves outward. The structure of this part will be shaped from a thick plate, reflecting the lessons learned with the rudder.

There are two hinges on the left and right elevators, and the elevators are inserted from the outside. The shaft connecting both elevators is designed to be attached with screws so that the elevators can be removed. The elevator is operated by a horn attached to the center of the shaft, which extends into the horizontal fin and is connected to a link that rises from the fuselage side. For this purpose, there is a notch on the rear side near the center of the fin. In the actual model, a counterweight is attached to the tip of the horn to prevent flutter, and I have made it possible to attach a weight to the 1/3 model as well.

The trailing edge of the horizontal fin is a spar, but as mentioned above, the center area is cut out, so a thin I-shaped sub-spar was installed at the maximum wing thickness with a 2×5 cypress flange and a 2mm balsa web. In the actual model, the spar is set vertically from the notch, but in this model it is passed through the maximum wing thickness to get high bending rigidity, so it is a sweptback spar. The horizontal fin is fully planked with 1.5t balsa to ensure sufficient torsional rigidity.

Elevator fabrication

These are the elevator components placed on the elevator assembly jig.

Photo 22: Elevator components placed on its assembly jig.

This is the left elevator. The paper pattern for the cutout is still attached. Note the many square holes in the spar and the protruding ribs. The protruding portions of the ribs fit into the holes in the spar, contributing to assembly accuracy and rigidity. The small holes in the ribs are for ventilation to prevent the covering film from swelling due to the expansion of air inside the elevator in the sun.

This is the completed elevator assembly.The rounded front edge was fabricated nicely.

Photo 23: The left elevator completed.

Making Elevator Hinges

There are the hinges for the elevator. The upper parts are attached to the horizontal fin and are made of 2mm thick carbon plates and 4mm diameter bamboo strings. The hinge holders on the bottom side of the picture, made of 2mm acrylic plate, are attached to the elevator side.

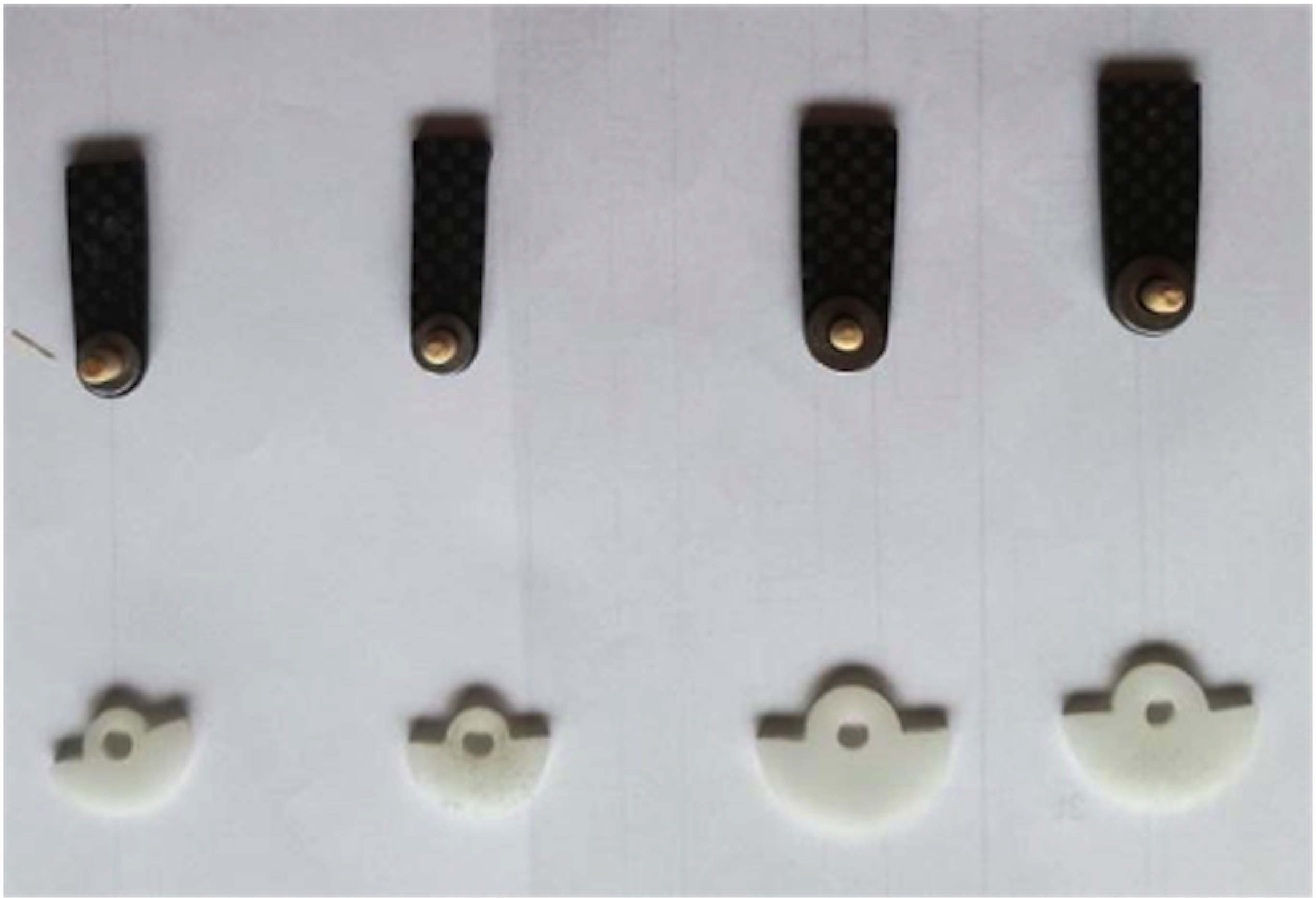


Photo 24: Elevator hinges.

Rib assembly of the horizontal fin

The rib assembly of the horizontal fin was fabricated in the same way.

Photo 25: Completed rib assembly of the horizontal fin.

The hinges are attached. Notice that the trailing edge of the ribs are cut in a triangular shape and extend behind the spar. This is the new improvement. This structure supports the planking plate that covers the front edge of the elevator to ensure the accuracy of the distance from the front edge R. In the case of the vertical fin, the planking plate attached to the spar was simply stretched out to the rear without this structure, so its accuracy and rigidity were not good. This design is based on the lessons learned 2.

Photo 26 shows the horizontal tail rib assembly with elevator and stabilizer. You can see the outline of the large horizontal tail.

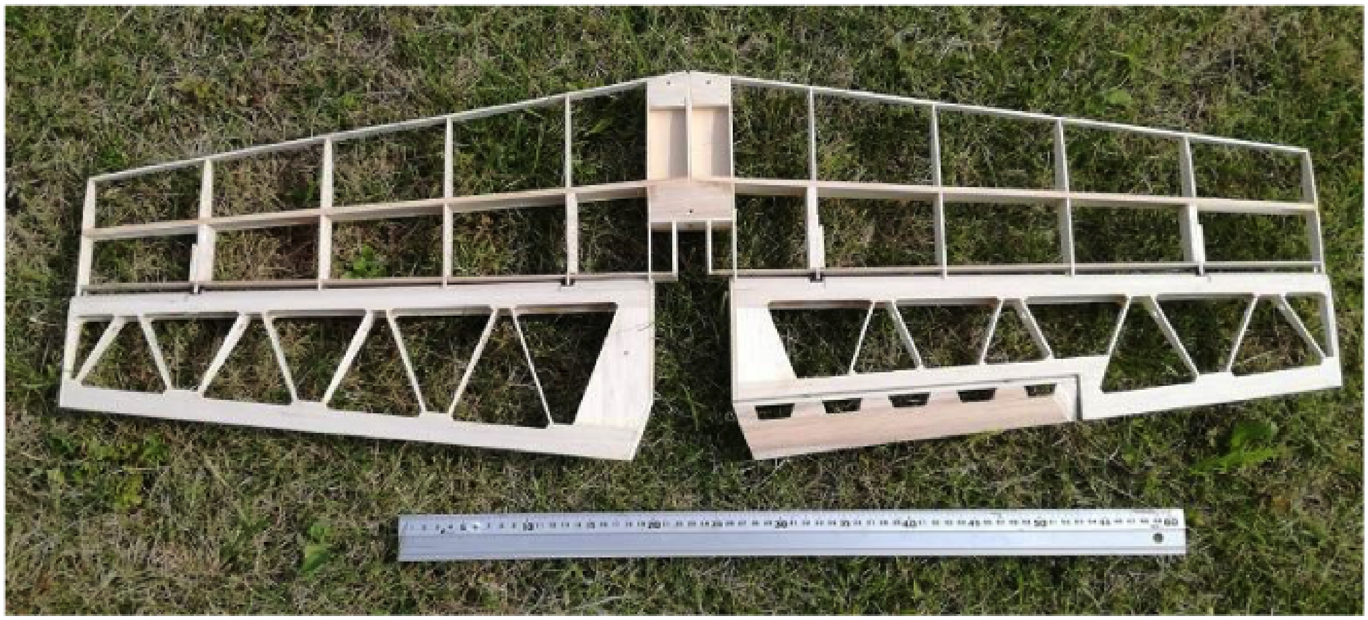


Photo 26: Horizontal tail rib assembly completed.

Assembly of the horizontal tail completed.

I purchased 1.5 mm thick balsa plates for the horizontal fin plank. Balsa plates are usually sold cut to 80 to 95 mm in width, which is not wide enough for a large aircraft like this one. The plank material was made by joining multiple plates together. Then it was carefully attached along the ribs. After shaping the leading edge of the plank flat, I attached a 5mm thick leading edge material and shaped it into a round leading edge. The completed horizontal tail structure is shown in Photo 27.

Photo 27: Finished horizontal tail structure.

There are three holes near the center of the fin. 3mm bolts are inserted here to fix the fin to the fuselage. The left and right elevators are connected by a carbon pipe with carbon round plates at both ends. Photo 28 is a shot of that part.

Photo 28: Elevator connecting part.

The round plates at both ends of the shaft are screwed to the protective plywood ribs affixed to the innermost ribs of the elevator. A horn is attached to the center of the shaft. It is connected to the link coming up from the fuselage side by a pivot near its center. The horn extends forward from the pivot and a weight can be attached there to prevent flutter and reduce steering force, but nothing is attached in this picture.

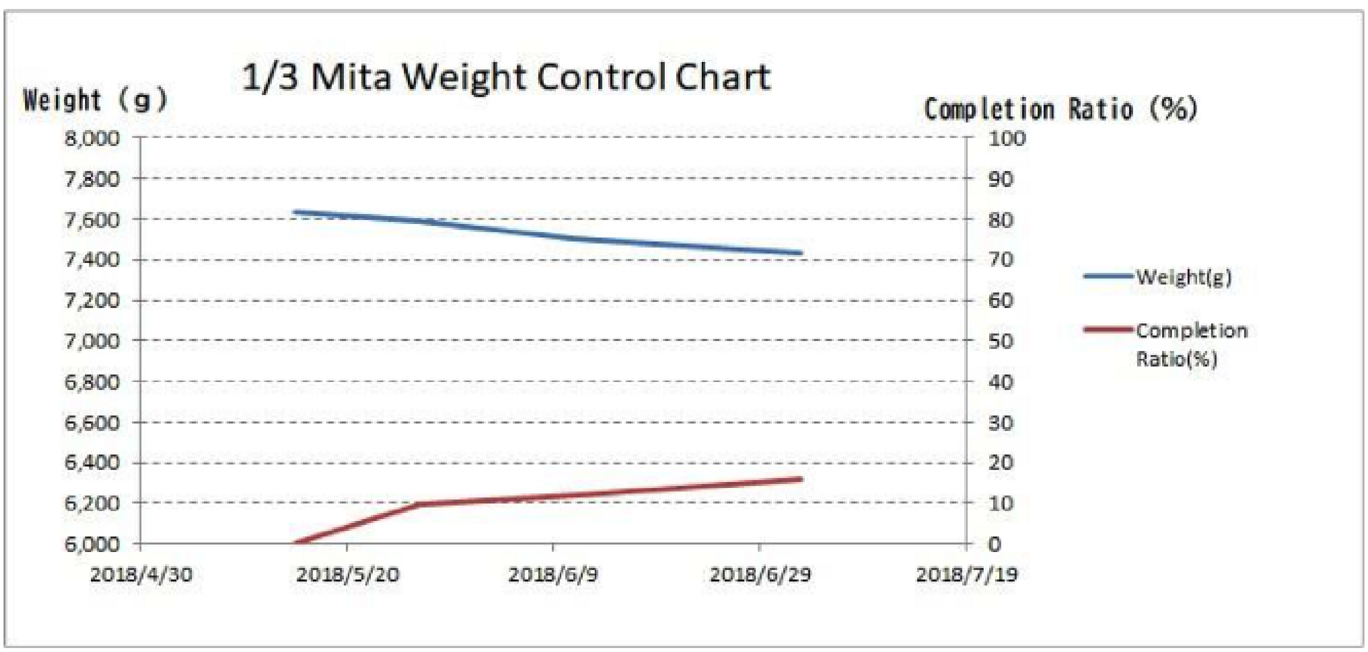
This completes the structure of the horizontal tail. The weight measured was 268g. The remaining works are covering and painting, which weigh about 70g. Including the weight of 40g for the flutter prevention, the estimated total weight remained is 110g.

3rd Calculation of Weight and balance

At this stage, weight and balance was reviewed as shown in the table and graph below. The 2nd calculation was done when the vertical tail fin was completed, but is omitted.

3rd Weight & Balance	2018/6/11	Completion Ratio		16.00 %	
	Weight	STA	Moment	Actual Weight	Estimated Remain Weight
Outer Wing Left	700	860	602,000	0	
Outer Wing Right	700	860	602,000	0	
Center Wing	1,560	890	1,388,400	700	860
Forward Fuselage	1,600	630	1,008,000	0	
Aft Fuselage	560	1,550	868,000	0	
Vertical Tail	212	2,450	519,400	162	50
Horizontal Tail	378	2,270	858,060	268	110
Motor	361	100	36,100	0	
Propeller & Hub	50	-10	-500	0	
Battery for Radio	155	200	31,000	0	
LiPo	600	340	204,000	0	
Others	186	600	111,600	0	
Total	7,062	882	6,228,060	1,130	
Target CG		846			
Weight	370	160	59,151		
Normal Flight Condition	7,432	846	6,287,211		

Table 4: The third calculation of weight and balance.



Graph 8: The 3rd Weight and CG Chart.

The actual weight increased to 1,130g and the completion ratio increased to 16%. The weight of the horizontal tail mounted at the rear of the fuselage was lighter than planned, so the weight needed to balance the center of gravity was reduced, and the weight in normal flight is 7,432g, which is 168g lighter than the planned 7,600g. It seems that the main reason for this is that the balsa weight is lighter than I used in the prediction. The weight of balsa varies depending on its hardness even with the same thickness, so in the planning stage, I measured the weight of several types of balsa I had on hand and used the heaviest value for safety. It seems that I can expect to reduce the weight of balsa parts in the future.

*This is the second part in a series. Read the **next article** in this issue, return to the **previous article** in this issue or go to the **table of contents**. Downloadable PDFS: just this article or this entire issue.*