Next Wave Automation — Projects

The Balsa Glider

Compatible with the Current Version of

VCarve | PRO & DESKTOP

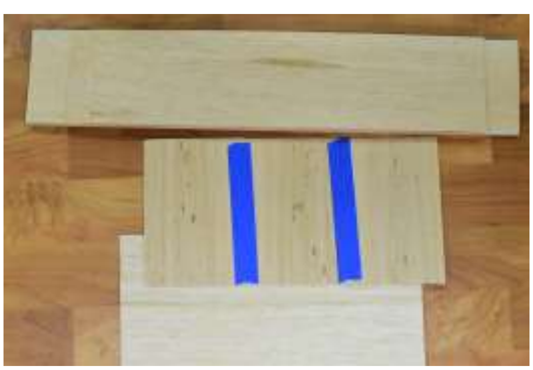
Welcome to this episode of NextWave Automation monthly project. This month's project we are going to make a fun but challenging project a balsa glider. It has 1 glue up, 2 machining operations, lots of test flights and internet research.

The samples were made using balsa wood however, you might use foam or paper or a material of your own choosing. This is a nice project to give as a gift or make for yourself.

The Instructions, crv. files are found on Nextwave Automation Website
nextwaveautomation.com
This project is aimed at the woodworker with moderate to advanced skills. You will need access to the current version of V-Carve with updates, the tools are listed below.

The main topics today are:

- Project Materials
- Designing
- Machining
- Finishing and Assembly



Project material list for Balsa Glider:

The materials you will need for this project are:

1. 4 pieces of balsa wood 5"x 36"x 1/16"
2. Glue
3. Finishing Materials

Next Wave Automation

Projects

The Balsa Glider

Project Tool List:

Tools that you will need for this project are:

1. 1/16“up spiral bit

Project CNC Files:

- Shark Fuselage 4.crv
- Shark wings4.crv

Creating the Tap Files:

With the V-Carve software, open the project CNC files. Carefully review all the toolpaths and make necessary changes to suit your tools and machine. The toolpaths are currently set with tool, feeds and speeds that were used in designing the original project. Be sure to review them for your machine. Edit the tools and change the settings to fit you own machine and requirements. It is very important to recalculate all toolpaths after making any changes. Once having made the necessary recalculations for your own machine and tools, reset the preview, and then preview all toolpaths, again, to visually verify the project outcome. Create the tap files for your machine by using the correct post processor. Once satisfied with your settings, save the tool paths using the appropriate post processor for your machine. Check tool paths by air cutting the project or use rigid foam board to run a sample tool path. Now you’re ready to make your own Balsa Glider!

Material and prep:

On this particular project we have to laminate our balsa together. We will take a 1/16” balsa and laminated one sheet one way and next sheet 90° from grain direction of the first sheet. This way we have created a balsa plywood. The only other thing you need to do is cut your other 1/16” balsa for the wings and the aileron on the tail.

Designing information:

An aeronautical engineer I am not so to do this project I had to do a little research on the internet, I have included a couple of the articles that I relied on to make this design. I took a lot of test flights to come up with the glider you see.

Balsa Glider Design

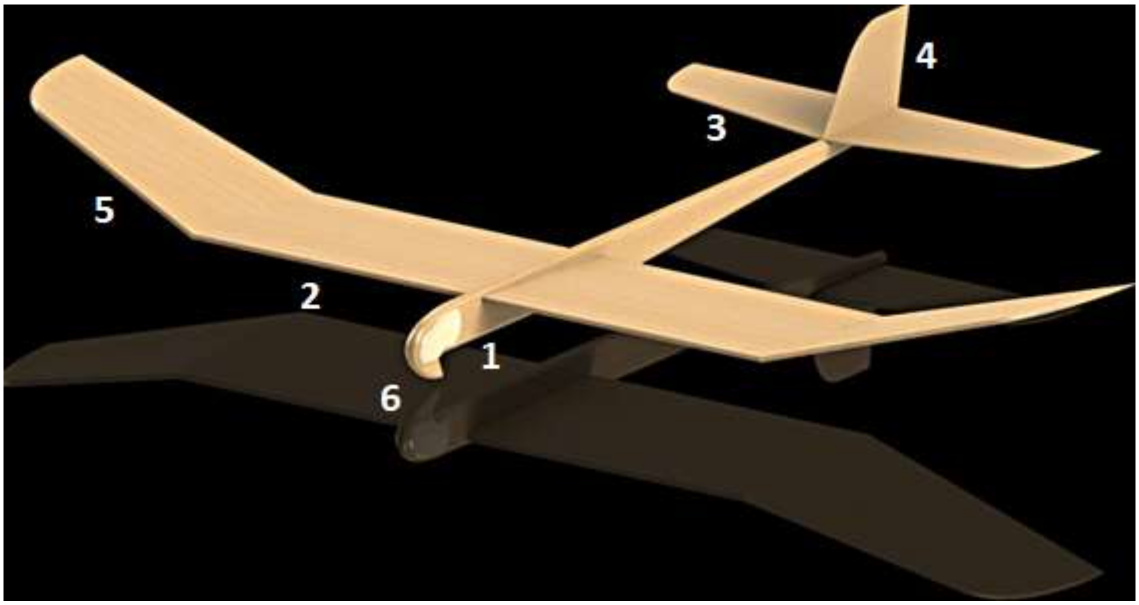
This section aims to provide you with all the concepts, workings and designing principles associated with balsa glider design. So that you can not only build but design your own glider according to your needs and preferences.

A glider is a heavier-than-air aircraft that is supported in flight by the dynamic reaction of the air against its lifting surfaces, and whose free flight does not depend on an engine. It is designed to glide after being towed aloft or launched from a catapult. In flight, a glider has three forces acting on it as compared to the four forces that act on a powered aircraft. Both types of aircraft are subjected to the forces of lift, drag, and weight. The powered aircraft has an engine that generates thrust, while the glider has no thrust. For a glider to fly, it must generate lift to oppose its weight. To generate lift, a glider must move through the air. The motion of a glider through the air also generates drag. In a powered aircraft, the thrust from the engine opposes drag, but a glider has no engine to generate thrust. With the drag unopposed, a glider quickly slows down until it can no longer generate enough lift to oppose the weight, and it then falls to earth.

How does glider achieve the velocity needed for flight?

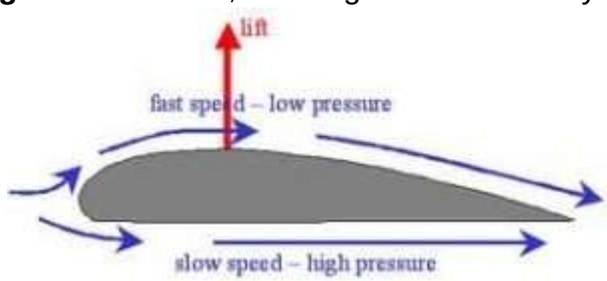
For balsa gliders, the aircraft is given an initial velocity by throwing the aircraft. Gliders are always descending relative to the air in which they are flying.

How does the Balsa Glider Design work?



1. **Fuselage** links all the components together and supports most of the load when glider is on the ground.

2. **Wings** create the lift, allowing the aircraft to fly. **But how do they create this**



lift?

A cross section of a typical airplane wing will show the top surface to be more curved than the bottom surface. This shaped profile is called an ‘airfoil’ (or ‘airfoil’). As the fluid elements approach the wing, they split at the leading edge and meets again at the trailing edge. As a result, the air must go faster over the top of the wing since this distance traveled is larger. Bernoulli’s equation implies that pressure will be lower on the upper surface. This net pressure difference causes lift.

3. **The horizontal stabilize**r helps to make the glider stable in the nose-to-tail direction (pitch), preventing it tipping nose up or nose down.

4. **The vertical stabilizer** prevents the glider twisting side to side (yaw), so it continues in a straight line.
5. **The winglets** help to make the glider stable in the wing-tip to wing-tip direction, preventing it rolling side to side.
6. **Nose weight** helps to move the center of gravity forward. This works with the horizontal stabilizer to make the glider stable in the nose-to-tail direction.

A glider can be divided into three main parts:

a) fuselage

b) wing

c) tail

FUSELAGE

It can be defined as the main body of a glider Comparing it with a conventional aircraft, the

fuselage is the main structure that houses the flight crew, passengers, and cargo. Howsoever, in this case it is only a 2-D fuselage.

Typically, it is advisable to cut a slot into the fuselage and then attach the wing.

Since in this way the wing remains firmly attached and also since the model is of small size, dihedral is of little importance.

The front part of the fuselage is called nose. It is rounded in shape to avoid drag and to ensure smooth flow.

WING

It is the most essential part of a plane. When air flows past it, due to the difference in curvature of its upper and lower parts lift is generated, which is responsible for balancing the weight of the plane, and the body can thus it can fly.

BASIC TERMINOLOGY OF WING

- Airfoil: Cross sectional shape of a wing
- Leading Edge: Front edge of wing

- Trailing Edge: Back edge of wing
- Chord Line: Line connecting LE to TE
- Camber line: A line joining the leading and trailing edges of an airfoil
- equidistant from the upper and lower surfaces. High camber found on
- slow flying high lift aircraft.
- Camber: It is the asymmetry between the top and the bottom curves of
- an airfoil in cross-section.

SHAPE OF AN AIRFOIL WING

The point in airfoil where the lift can be supposed to be concentrated upon is called the center of pressure. Generally, it is located at c/4, where c is the chord length. The point where the weight of the glider acts is termed as center of gravity (CG). For weight balance, the center of gravity must coincide with the center of pressure. To bring the CG to c/4 we add some weight at the nose in the form of coins and paper clips.

TAIL

A tail or a stabilator is attached at the rear end of the glider. It is composed of two parts a horizontal stabilizer and a vertical stabilizer to provide stability and control to the vertical up down movement of the nose. This up-down movement of the glider is termed pitching.

HOW AIRPLANES FLY?

Essentially there are 4 aerodynamic forces that act on an airplane in flight

These are:

a) lift: upward force (generated by wing)

b) gravity: downward force (due to weight of the plane)

c) thrust: forward force (power of the airplane’s engine

d) drag: backward force (resistance of air)

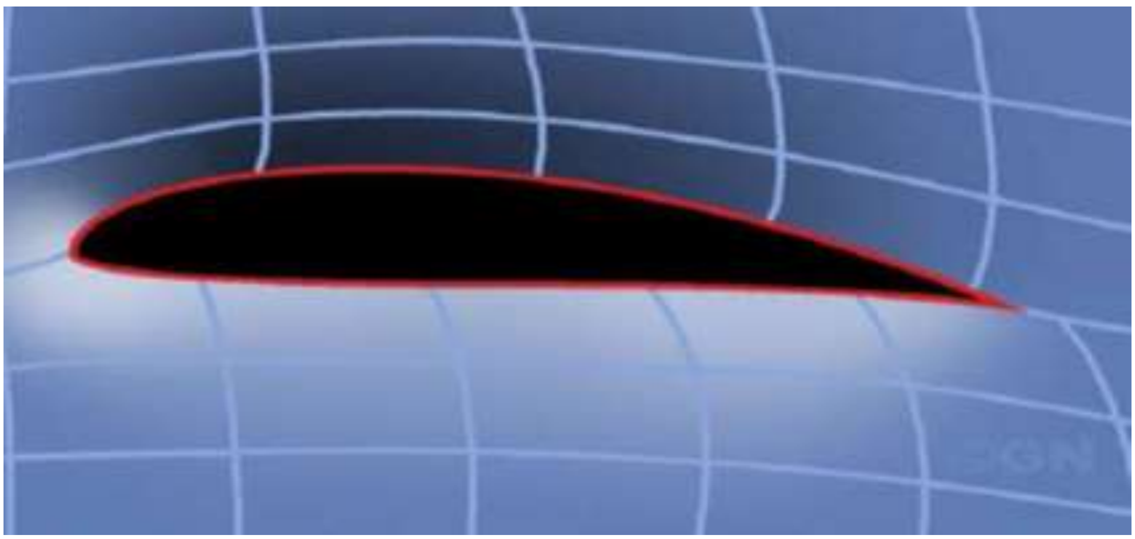
So, for airplanes to fly, the thrust must be greater than the drag and the lift must be greater than the gravity (so as you can see, drag opposes thrust and lift opposes gravity). This is certainly the case when an airplane takes off or climbs. However, when it is in straight and level flight the opposing forces of lift and gravity are balanced. During a descent, gravity exceeds lift and to slow an airplane drag has to overcome thrust.

HOW WINGS GENERATE LIFT?

A cross section of a typical airplane wing will show the top surface to be

more curved than the bottom surface. This shaped profile is called an 'airfoil' (or 'airfoil').

HOW WINGS GENERATE LIFT?



As the fluid elements approach the wing, they split at the leading edge and meets again at the

trailing edge as a result, the air must go faster over the top of wing since this distance traveled is larger

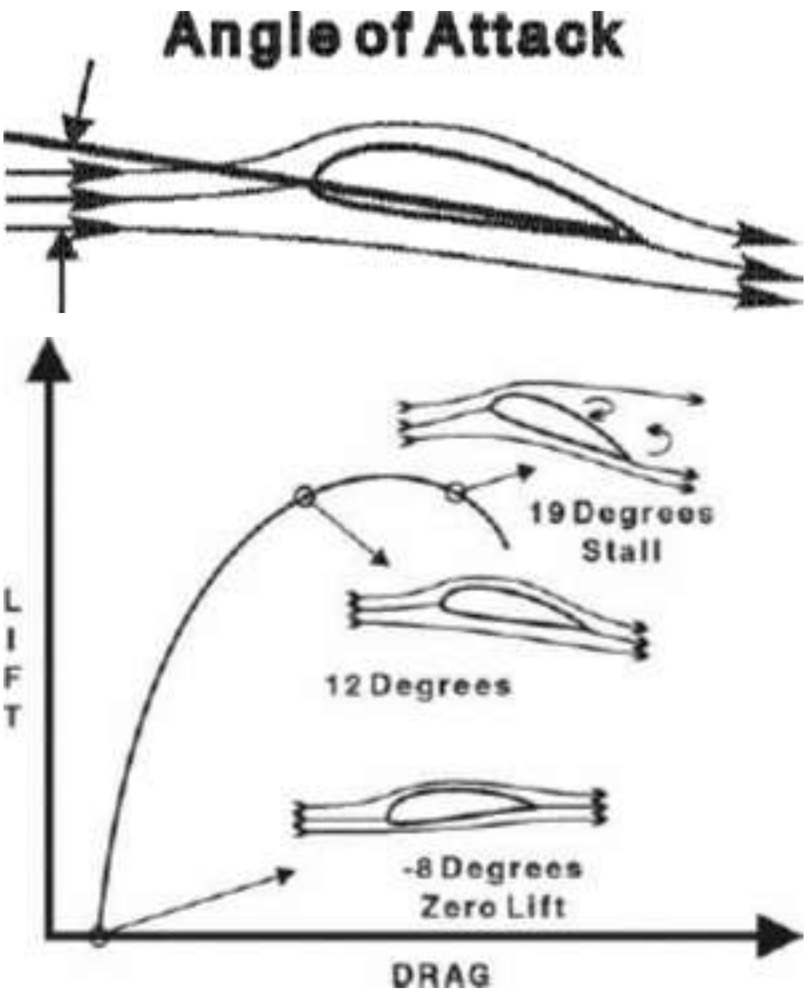
Bernoulli’s equation implies that pressure will be lower on the upper surface

This net pressure difference causes lift Arrows A and B is air getting split at the same moment, and meeting up again at the same moment

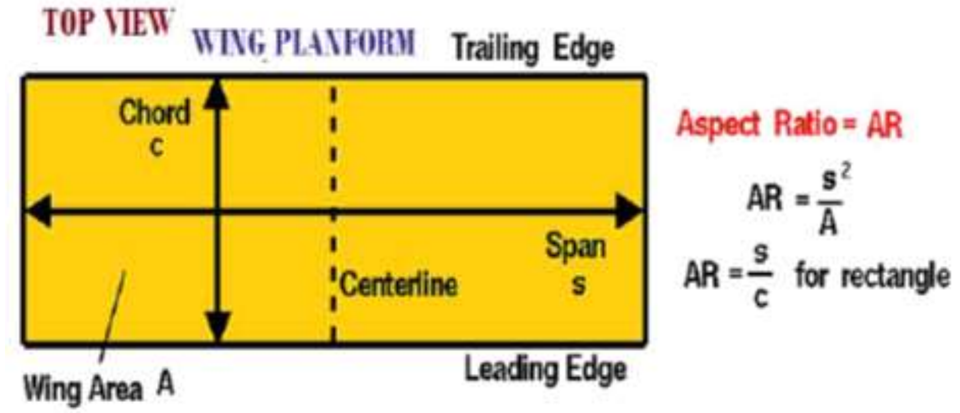
SOME TERMINOLOGIES

- Wing loading is defined as the weight of the aircraft divided by the wing area.
- The glide ratio is the distance travelled in a horizontal direction compared with the vertical distance dropped on a normal glide.
- A 20 to 1 glide ratio means that the aircraft would lose one foot of altitude for every twenty feet of distance travelled
- Ballast is extra weight added to a glider to help it penetrate better in windy weather or to increase its speed.
- We generally add paper clips and/or coins on the nose in balsa gliders.

ANGLE OF ATTACK



It is the angle the wind makes with the wing (relative wind). As the angle of attack increases, so more lift is generated -but only up to a point until the smooth airflow over the wing is broken up and so the generation of lift cannot be sustained. When this happens, the sudden loss of lift will result in the airplane entering into a stall, where the weight of the airplane cannot be supported any longer



ASPECT RATIO It is the Ratio of the wing span to the wing's chord length(c).

SOME USEFUL TIPS

- All the ends are rounded, again to minimize the effect of drag.
- Dihedral: the purpose of building dihedral on a wing is to improve the lateral (roll) stability of an airplane. The dihedral angle is the angle that each wing of an airplane makes with the horizontal
- Wing Taper: compared to a simple rectangular wing, using a wing with taper on your glider can decrease the amount of induced drag that develops at its wingtips. The total amount of taper angle should not exceed 10 degrees.
- Aspect Ratio: the aspect ratio (AR) of a wing is defined to be the square of the span, divided by the wing area. Aspect ratio is a measure of how long and slender a wing is from tip to tip. For a rectangular wing, this reduces to the ratio of the span to the chord length. Gliders have a high aspect ratio because the drag of the aircraft depends on this parameter. A higher aspect ratio gives a lower drag, a higher lift to drag ratio, and a better glide angle.
- Try to streamline the body as far as possible, in order to reduce drag.
- The weight of the model is kept as minimum as possible. For this purpose, we use balsa wood.

- The special quality of this wood is that is very light and hence adequate for our purpose along with the fact that it has good enough strength to not to breakdown away in wind.

- All the ends are rounded, again to minimize the effect of drag.

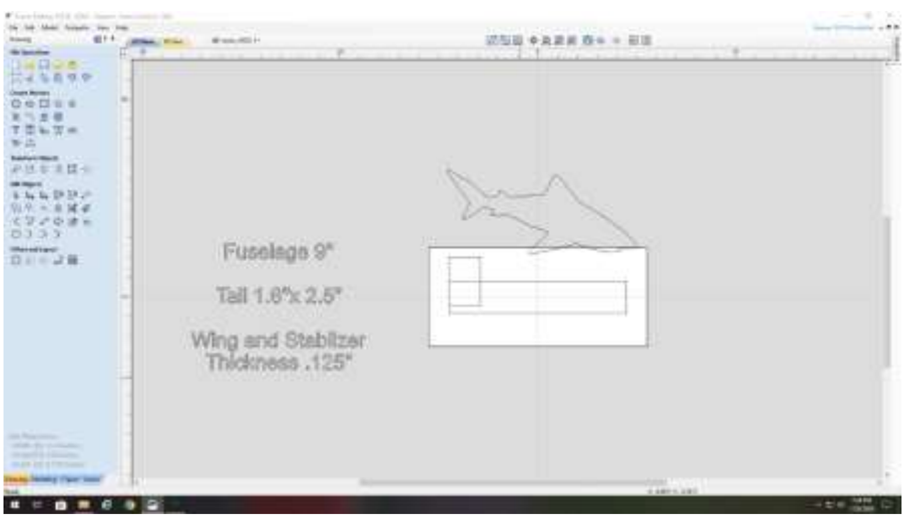
DIMENSIONING

- Aspect Ratio =9-10
- Wing span = Length of fuselage x 1.3- 1.4
- Angle of attack = 3-4 deg.
- Horizontal Stabilizer = 20-25% of wing area
- Vertical Stabilizer = 40% to 50% of Horizontal Stabilizer area.
- Dihedral = 2-3 deg.
- Length of fuselage = 65%-75% of span

http://students.iitk.ac.in/aeromodelling/downloads/glider.pdf

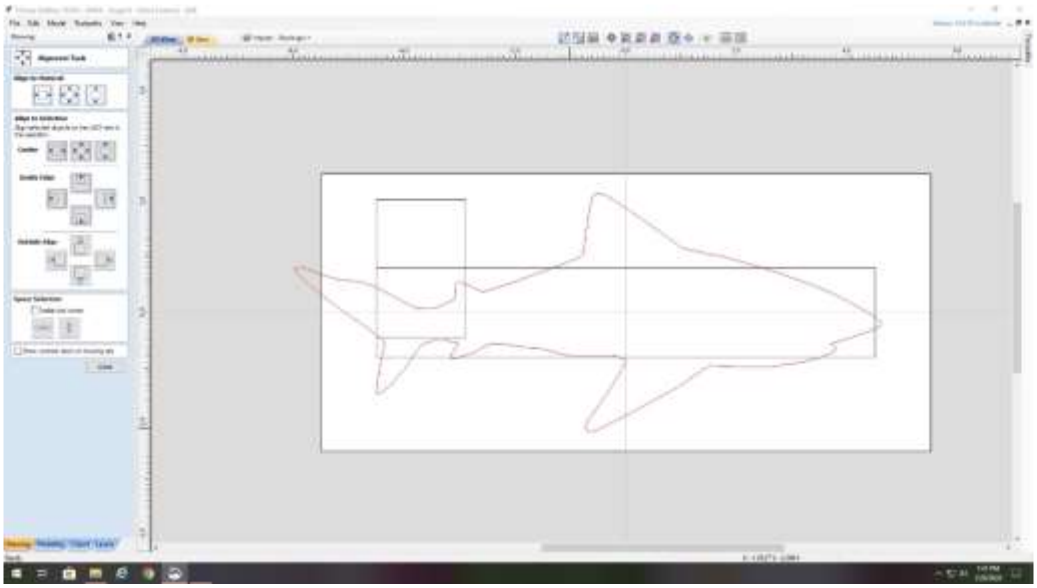
https://engineering.eckovation.com/balsa-glider-design/

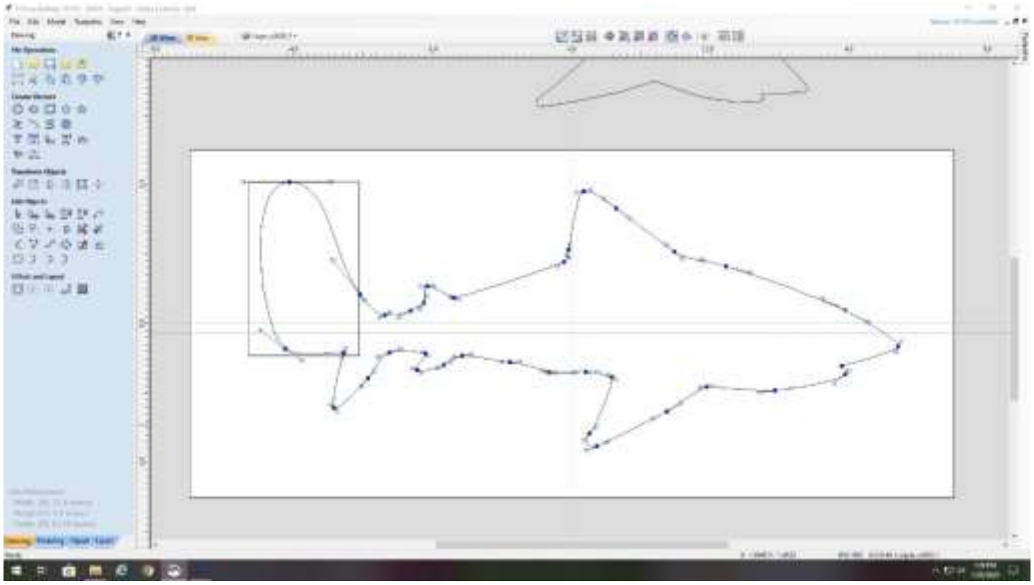
Step 1: Design



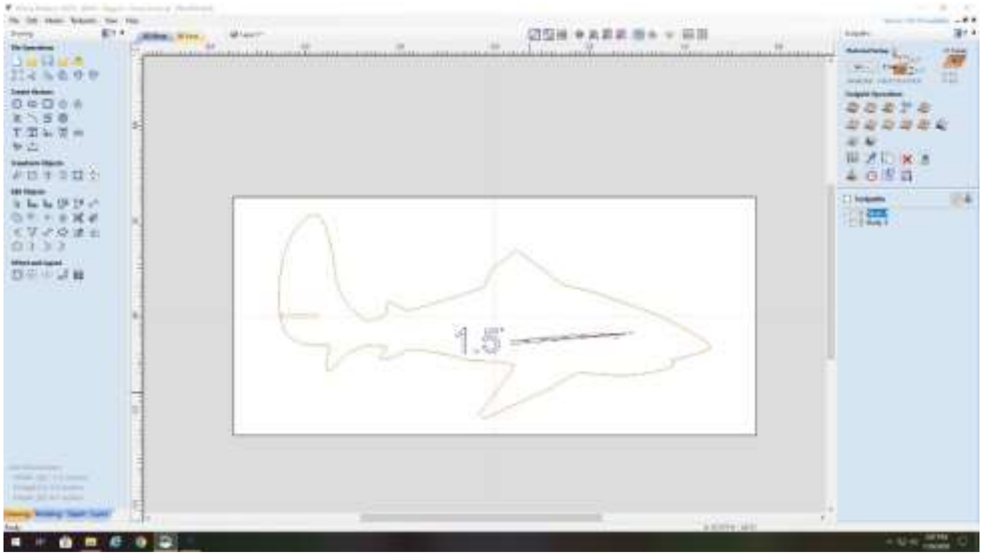
Using the above information, I started to design my flying shark. I open up V-Carve to start my designing. Okay the first thing you do is create a new file we want to make this file 11 x 5 this is our shark body. Zero position is on the material surface in the X -Y datum position is in the center of the document. Hit okay. Next thing that we want to do is bring in our outline of the shark, I had had a vector file that I used in the previous project in all I did is bring it into this project.

I go to the import vectors and import my vector file of my shark. Now I want to bring in a few dimensions that I'm going to need to create my shark body. If you remember the length of the fuselage is about 70% of the wing length wing length is 14 inches so my body is the to be about 9 inches long now my tail is about 50% of my rear stabilizer which is 25% of the wing area. So the next thing I figured out is how big my wing is. So, in order to find area of the wing, I have to take 14 divided by the aspect, the ratio we want is an aspect ratio of 9 to 10 so I take 14÷10 to give me 1.4 that is my cord 1.4 inches. My cord is 1.4 and my wing length is 14 1.4×14 will give me the area of my wing. That gives me an area of 19.6 inches multiply that by .25 and that's the area of my rear stabilizer. So, my tail will be 50% of the rear stabilizer or approximately 5 in.² so I make a box that is 5 in.² on my diagram. So, my box is about 0.5 x 3". So now that I have approximately where my dimensions are going to be with my boxes now,

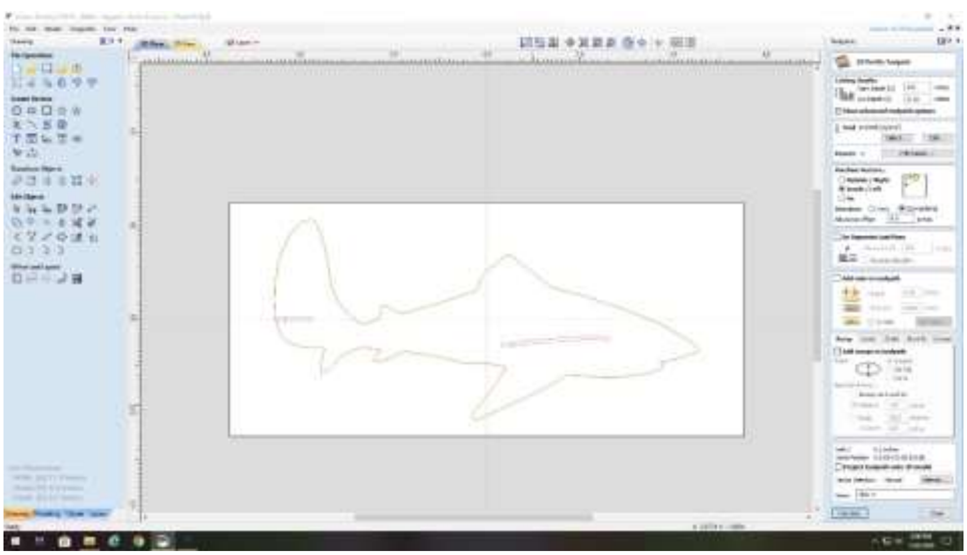




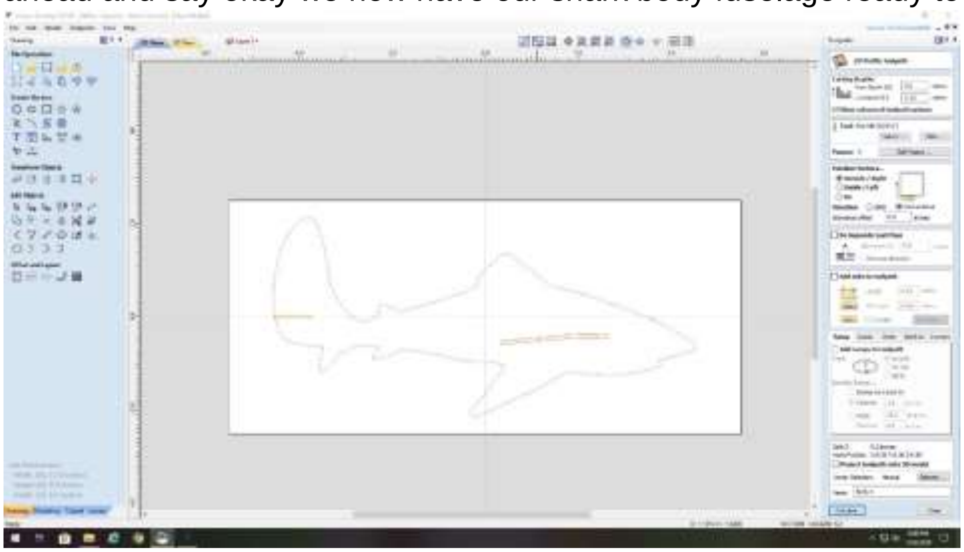
I can bring in my shark vector file and now start massaging it to fit within these parameters. So, the first thing I wanted to is reduce its size down to fit into the length box which is approximately 9 inches. Now I will modify the tale the shark more look like the tail of an airplane in its approximate sizes. Then I go on a node editing mode in I start to manipulate the tale two more resemble the size I need to tail my plane. Keep on massaging it until you give a tale that is pleasing but also meets your aerodynamic needs.



The next thing we have to do is put the slots in for the wing in the rear stabilizer. Now according to the directions, we want the angle of attack for the front wing to be approximately 3° and remember the cord with of our wing is 1.4 inches. So we should make a slot that is slightly longer than 1.4 inches because we want to be able to slide the wing forward and backward to adjust the trim on and we have to know how thick our wing is going to be our wing is going to be a 1/16" of an inch so I'm going to make a slot 1/16" x 3" that should give me enough room to trim. On the rear stabilizer just put a 1/16" x 2" slot.

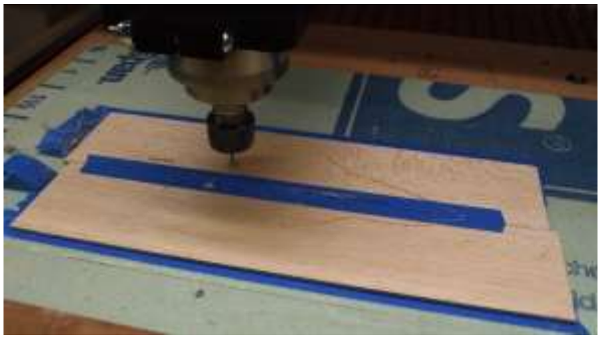


Now all we have to do is a to the profile tool path we will use a 1/16 inch end mill are cut depth is going to be the thickness of our material on the first profile tool path we are going to go on the inside because were to do the slots highlight the slots and go ahead and say okay. Now the next thing that were going to do is the to the profile tool path for the outside or the profile of our shark again make the cut depth thickness of your material really uses 1/16” end mill and this time we’re going to cut on the outside go ahead and say okay we now have our shark body fuselage ready to cut.



Now we’re ready to do the wings. Now just like before creating new file, anchor point is in the middle, it is a 16 x 4” job size and the Z0 position is on the material surface. Now we make a rectangle that is 14” x 1.4” and we’re going around off the front corners using the fillet command. I made my fillets ½ inch. Then we make the rear wing the rear wing is 1 .2” x 4” so we make a rectangle that sides and put fillets on each corner. And just like before run make a to the profile tool path again really use a 1/16-inch end mill and were go to the to the outside and depth of our material. So now we are ready to do all of our machining.

Step 2: Machining Fuselage and Wings



Body/Fuselage

Machining on this particular project is pretty straightforward. We have basically two operations, the first one is cutting out the fuselage/body in this particular instance I used 1/8-inch Laminated balsa wood I put masking tape on one side and double-faced tape on the other side of the masking tape. The reason I used masking tape on the one side because it doesn't adhere is hard to balsa wood so when I go to remove it it's not damaged. Mount our material set the X and Y axis to zero which in this instance is in the center of the material. And then we set the Z height with a touch plate. We have installed the 1/16-inch end mill and are ready to run the shark fuselage/body program.

Wings

On the wings, cut the out wing and the rear stabilizer just like with the fuselage we're going to put masking tape on the balsa wood and double-faced tape to our spoil board. Mont the material and set the X and Y axis to zero. In this instance it is in the center of the material. Set the Z height with a touch plate, install the 1/16 endmill and run the wing program.

Step 3: Sanding and Finishing

Couple things you have to remember about the finishing is that we don't want to get this too heavy. If the paint is too heavy it will increase the weight of our glider and the glide path will suffer, how far can glide etc. etc. So, what I'm going to do is paint on a black wash on the body and the wings. A wash is very thinned down paint, I dilute mine about 50-50.

Step 4: Final Assembly

Assembly is pretty straightforward you slide the wing into the forward slot slide the stabilizer into the rear slot I have been gluing mine in to give it more strength so the tail doesn't break at the grain of the slot of the rear stabilizer. The last thing you got to do is make you weight, I used 0.125 x 0.25" steel bent it to conform to the nose of the body. On my plane I had about 70 g on the nose yours may be different depending upon where your center of gravity is and how the plane flies. Remember the slot for the front wing makes it adjustable so you can trim out the flight of your glider. This center of gravity coincides with center pressure on the wing the center pressure on the wing is about one quarter of the cord back from the leading edge of the wing. that is where the center gravity should be. If all these dimensions coming correctly you should have a good flight from your glider.

In closing I hope you enjoyed this project it is a challenging project because I think most of us are not aeronautical engineers, I hope that I have created an interest in doing these kinds of projects and until next time keep on carving

Rick Frazier

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