

Scratch Building Radio- Controlled Model Airplanes

By Dan Pemble

Member Osceola Flyers RC Club

THE FOLLOWING PAGES FOUND ON A WEB SITE PROVIDE SOME GENERAL GUIDELINES FOR SCRATCH DESIGNING AND BUILDING YOUR VERY OWN RADIO-CONTROLLED MODEL AIRPLANES. IN THE COURSE OF BUILDING AN AIRPLANE FROM SCRATCH (DRAWING YOUR OWN PLANS, ETC.) , THERE IS MUCH TO LEARN & A WHOLE LOT OF EXCITEMENT TO BE HAD WHEN YOU TAKE YOUR CREATION TO THE SKY!!

AS A PREREQUISITE TO ANY SCRATCH BUILDING ATTEMPTS, YOU SHOULD FIRST HAVE EXPERIENCED CONSTRUCTING A COUPLE MODELS FROM COMMERCIALLY-AVAILABLE KITS. THIS WILL ASSIST YOU IN DETERMINING THE THICKNESSES OF THE WOOD (BALSA & PLYWOOD) TO BE USED IN THE VARIOUS STRUCTURAL ELEMENTS OF YOUR PROJECT, THE GLUE TYPES, HARDWARE TO BE USED & ASSEMBLY METHODS – ALL ALL OF WHICH WILL HELP ASSURE THE SUCCESS OF YOUR CREATION! GOOD LUCK!

FOLLOWING THE DESIGN GUIDELINE PAGES, I HAVE INCLUDED EXAMPLES OF SOME OF MY OWN SCRATCH-BUILT PROJECTS – TOGETHER WITH A DESCRIPTION OF THE FLYING RESULTS!



Here are some design thoughts

First let me say that I do not hold myself out as the ultimate authority. I do reserve the right to be smarter today, than yesterday. That way I get to change my mind. These notes are simply my understanding of how airplanes fly. There will be very little math and what math I will offer will be pretty basic. I have scratch built a lot of airplanes. Some flew, while one made a snappy looking race car (didn't get off the ground).

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[But before we get into all of the things listed above, I have some great NEWS!!!!!!](#)

NEW !!! - My book - The Making of Daisy Mae is now available. Just click here <http://users.mo-net.com/shirl/Daisy27.html> for test flight results and all the info on how you too can have one of the most definitive aircraft design books on the market, written in a very easy and understandable form. No complicated nutten. Here is what others have said:

"An enjoyable read about the personal and technical challenges of designing and building a sport airplane. Written in a personal and realistic style. A must read for anyone considering such a challenging project" ... Pete Reynolds, former VP, Flight Test - Bombardier Aerospace - Fellow - Society of Experimental Test Pilots

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"A textbook story of the driving force behind the EAA""I've met the author, seen the aircraft & read the story"... "it's hard to sit here in this chair right now because my sides are hurting so much from laughing" "Damned funny, damned true, and damned informative" ... "Really nice to read something from someone who isn't worried about being "politically correct."...Jon Aldridge - Pres. - EAA Chapter 821 - Springfield, Mo., former FBO, Home builder, & 38 years as a pilot.

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Ok I'm done blowing my horn so here we go.

General

Yes. If you have a better and simpler explanation of one of these items, I would appreciate your email. I don't want to get into physics or theoretical discussions or calculus or any other complication. In other words don't confuse me with facts. Here we talk simple logic. What works ,what doesn't, and why, told in an easy and understandable form.

If you haven't tried to design a model you are missing out on one of the greatest thrills in modeling. In addition you get to show off a brand new idea to everyone. Yes it takes time but once you do it, it gets easier. I hope to explain some terms in the process, just in case you are brand new to the hobby.

What you need handy

Chuck Cunningham wrote for Radio Control Modeler for a long time. About once a year he offered some basic criteria for designing your own model. I use his criteria as much as possible. Next, if you don't own a copy of Model Aircraft Aerodynamics by Martin Simmons, published by Argus Books then let me recommend it. Now all you need is a tablet, quad ruled with 4 blocks to the inch, a ruler, a pencil and a huge eraser. After you get the general airplane figured out & the side view drawn on the small pad, you then need a roll of meat wrapping paper to make your initial full scale drawing, and a 60 inch straight edge. That is about as basic as you can get. Yes, every one of my airplanes, from the Ligeti Stratos, the Mooney, the 1/2A Sky Pecker and even the 18 foot Sailplane were first drawn on a regular size notepad. After they looked right (subjective), the dimensions were transferred to the meat wrapping paper. Yes I know meat wrapping paper isn't dimensionally stable and that it isn't the best way. Like I said above let's keep it simple for now. I always try to be creative and try to make my craft look like an airplane ... and if not pretty, then something with character. Not look like a 5 gallon bucket of Monkey butts. (a phrase used by friend Jerry Shoemaker when describing another friend's 1996 Cadillac. (where the hell he came up with that one I'll never know-- and yes he has a very cruel sense of humor) [Back To Top](#)

Design Parameters

Here, the first thing you want to figure out is the wing span. Everything else keys from that. Next you need to get a handle on the power needed to fly whatever you come up with. If you scan a few catalogs, you can get some general ideas of what power plant goes with what wing span and model weight. After awhile you will soon realize the power parameter and just about everything else can be varied somewhat. For example you would initially think an old 60 four stroke would never fly an 18 foot, 19 pound airplane but it does on my Ultimate Solitude powered sailplane. Mainly because it has a lot of wing area. (the length of the wing times the width = the area). On the other hand my initial Mooney (the Blue one) has about a thousand square inches of wing area and weighs 14 pounds and is marginal on an O.S. 120 four stroke. Actually it fly's more scale, but you need some runway to get off.

So one of the first things you need to estimate is the wing loading, and how to figure it out. If for example your wing is going to be 80 inches long (SPAN) with a width (CHORD) of 13 inches, then your wing area will be $13 \times 80 = 1,040$ square inches of wing area. Now that we have figured that out I will throw in another term called aspect ratio. Aspect Ratio is the width of the wing (chord) divided into the length (span). Generally a sailplane has a greater aspect ratio, maybe even 20 to one. The wing we just figured out has an aspect ratio of 80 divided by 13 which equals about 6 to one. Six to one is a good number for a basic airplane.

But back to calculating wing loading. First you take the area of the wing and divide it by 144 to get the actual square footage of the wing. In our case $1040/144 = 7.22$ sq. ft. Next, if we have properly estimated the weight of our model..... for this example let's say it should weight about 14 lbs..... so we now need to convert pounds into ounces. Sixteen ounces to the pound x 14 pounds = 224 ounces. So to calculate wing loading you divide the weight in ounces by the square footage. i.e.- 224 divided by $7.22 = 31$ ounce wing loading per square foot. At this point you pretty well know how the airplane is going to fly. It will fly a little faster than you might like and the landing speed too will be higher than you might like. For models of 80 inch span you generally want wing loading around 22-26 ounces per sq. foot. Keep in mind that the larger the model becomes, the higher wing loading you can handle without adverse effects and vica versa. A very small rubber powered model may come in around 3-6 ounce wing loading. Yes there are a lot of other factors that will affect how your model fly's but then we get into complications we don't want to cover here.

Next we will define other parameters such as determining the area of the horizontal stabilizer, the area of the vertical fin and rudder, the length of the fuselage, the nose and tail moments, & the area necessary for ailerons if you are going to use them.

The Horizontal Stab should equal about 12-15% of the wing area with about a 3 to 1 aspect ratio. The Vertical Fin & Rudder should equal about 33% of the Horizontal Stab/Rudder with the Rudder itself consuming about 1/3 rd of that area.

The Length of the Fuselage should be about 75% of the length of the wing.

The Nose Moment (oh gawd another term) around 25-30% forward of the wing balance point.

The Tail Moment in the area of 65-70% of the fuse length (and aft of the balance point)

Fuselage height around 10-15% of the fuselage length.

(below I will define Nose and Tail Moment)

Aileron Area should be about 10% of the total wing area with the length of each about 8 times its width.

Landing gear placement should have the axle even with the leading edge of the wing on a tail dragger. On a tricycle gear you need the main gear slightly aft of the balance point. If you run a vertical line from the wheel touch point and then a line from there through the C.G. and note the angular difference, it should be between 15 and 25 degrees on a tail dragger.

Separation between wings if you decide to build a biplane. Vertically they must be separated by at least the Chord (width) of the largest wing.

Nose Moment - the distance from the balance point of the wing (approximate aerodynamic center of lift) forward to the prop. Most wings should be balanced initially 25% of the average chord back from the leading edge of the wing.

Tail Moment - the distance aft to the tail from the 25% average chord of the wing.

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The Wing

Let's talk some more about the wing. Most average airplanes fly because of the wing. Duuuuuhh! Seems simple enough. Most average airplanes under average conditions land because the wing stops flying. Again duuuuaahh. The wing stops flying (stalls out) before landing.... or it loses lift or whatever you wish to call it. The reason I say this up front is because you and I have both seen flyers DRIVE their airplane to the ground rather than let them settle in for a nice smooth and cool landing. If it is windy, then you too need to DRIVE your model to the ground with more power than normal because it gives you better control. But generally you need to pull in some up elevator until the craft begins to lose altitude, then continue jockeying the flight controls slightly so that

you can FLARE OUT (lose all lift) just before you land. That way your model won't just bounce up in the air again and start flying all over again.

Here again in generalities ... most models need to be balanced 25% or more back from the leading edge of the wing. If the wing is 13 inches wide, it needs to balance 3 1/4 inches back from the leading edge no matter what or how much is attached to the wing (–fuselage, tail feathers, landing gear, etc.). If you start your initial test flight with anything other than 25% aft, you are probably going to be surprised. You don't need these kind of surprises. To make your model less sensitive to flight control movements, you can balance at 2 1/2 inches for example. To make your model more sensitive to flight control movements, then move it back to 33% aft of the leading edge. The farther aft you move the balance point the touchier things get. I offer this very simple explanation at this point because it is something you really need to understand when you get into designing Canard's and/or tractor designs (engine up front) with lifting horizontal stabilizers. If you have ever flown a Carl Goldberg Sailplane (it was designed around the early 40's as a free flight) you quickly realized it thermaled & flew better with the balance point about 25% aft of the TRAILING edge. If you want to see what this old timer looks like then [click here](#) . I suspect the same could be true with the Hobby Lobby Telemaster I mean the Telemaster probably will fly with a balance point way farther aft than 33% because it has a lifting horizontal stabilizer. Lifting ... meaning it too has an airfoil just like the wing rather than a flat plate stab.

Here is a simple way to figure out where to balance a tapered wing, assuming it is a straight taper. We will use an example of a 14 inch root chord and a 7 inch tip chord. Add the two together and divide by 2. $14+7 = 21/2 = 10\ 1/2$. If half of your wing is 40 inches long, then measure out 20 inches and the chord at that point should be 10 1/2 inches. You need to balance 25% back from the leading edge of the AVERAGE chord of the wing. So 10 1/2 divided by 4 is 2 5/8 inches back. From that point, make a 90 degree line directly to the root of the wing and that is the balance point, even if the wing sweeps back.

Note: Sweep back normally helps stability whereas sweep forward is somewhat de-stabilizing. It is felt that the sweep back adds to the Dihedral of the wing. Oh lord ... another term. If you look at an airplane directly from the front or back you may see that the tips of the wing are physically higher than they are at the fuselage. This is dihedral. It adds to stability. Model sailplanes have about 6 degrees of this stuff, while low wing models may have up to 12 degrees. I usually just eyeball it. What the heck. Slam the damn thing together and go fly it. Right?

Another thing you want to design into your craft are the stall characteristics. You want the inner portion of the wing to stall before the outer portion and you either want a sharp stall or a mild stall. The shape of the leading edge defines whether you have a sharp stall (a sharp leading edge) or a mild one (with a more rounded leading edge). Let me point out an observation. A rectangular wing needs no twist in it (wash) as the inner panel just naturally stalls before the outer panel. A tapered wing DOES need some WASH OUT (twist). Whereas an indoor models wing looks more like a propeller with the right panel trailing edge twisted up (WASH OUT) and the left panel trailing edge twisted down (WASH IN).

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The Airfoil

Now if you really want to learn about airfoils and how to plot them I may cover that later. For now I won't. Why? Mainly because about any ol shape you lay out will fly. Some better than others. You can get perfection later if you want. For sport flying and biplanes I like the NACA 2415. My friend George Sauer likes a NACA 23012. Both are basically a semi symmetrical airfoil. What is an airfoil. Well look at the end of any wing and you will see a shape. The top part

is rounded and the bottom may or may not be rounded. The shape is what is called the airfoil. I like some of the Eppler airfoils. Haven't tried any of the Selig-Donavan airfoils but will someday. Another friend Dennis Reichenberger draws out, what he calls, a tear drop airfoil. Big ol round leading edge with the high point maybe 15% aft of the leading edge. It fly's very gentle. All of his 9 foot Quadra powered airplanes are made totally of cardboard and have unparalleled flight characteristics. Anyway just draw out something that looks like an airfoil and try to make the high point about 25% back from the leading edge. If you want a more aerobatic airplane then make the top and bottom of the airfoil curvature the same. If you want a trainer kinda airplane then make most of the bottom flat. About 35 years ago many people used a diamond shaped airfoil. They drew a round leading edge, then a straight line up to the high point on the top of the airfoil (about 25% back from the leading edge), and a straight line from that point to the trailing edge.

Next ... how thick do you need to make the airfoil? (from bottom to top). A good number is 12 to 15% of the chord. If your wing chord is 13 inches, then it should be about 1 3/4 inches thick including sheeting and covering. The thicker you make it, the more drag but probably more lift. The Ligeti model has an 18% thickness on the aft wing and about 13% thick on the front canard. [Back To Top](#)

Wash Out

If you want a tapered wing then just remember that the more you taper, the more WASH OUT you will need. The Mooney has a 50% taper as I recall. The ROOT (the middle of the wing) chord is about 14 inches and the Tip Chord is about 7 inches. This wing also has a symmetrical airfoil at the root and a flat bottom airfoil at the tip, just like the real one. It HAS to have about 3 degree's of WASH OUT. The trailing edge of the wing, out at the tip, has to be raised about 3 degrees and if you don't have it, it just fly's like crap. This twist needs to be linear in that it gradually twists from the root to the tip. If you don't have the proper twist (wash out - trailing edge higher than the leading edge) the tip of the wing stalls out before the middle of the wing. When that happens, the tip of the wing drops down violently when it loses lift and causes the airplane to try to flip on its back. Not good. A long slender wing (high aspect ratio) such as you will find with sailplanes need less twist. After you have drawn your airfoil, you need to approximate about where the middle of your leading edge circle is and make a mark there. Then plot a straight line from that mark to the trailing edge of your airfoil. We will call that a datum line. The datum line needs to be tweaked up at the trailing edge 3 degrees for a 50% tapered wing. Note: Sometimes a wing will do this kind of a flip anyway and this suggests that you may have your balance point too far aft. [Back To Top](#)

Wing Incidence

Above we talked about the datum line of the airfoil. You will probably need to draw this kind of a line for the fuselage. Pick out a place about midway (vertically) on your fuselage side and draw the line from the nose to the tail. Generally you will place your horizontal stabilizer flat in relation to this line. Your wing placement in relation to the fuselage datum line can vary some. Again, generally I want the wing to be zero degrees incidence from this line. Same for the horizontal stabilizer. The heavier wing loading your airplane has the more you want the wing to have positive incidence. This means that the leading edge of your wing, when viewed looking at the side of the fuselage drawing, needs to be up from 1 to 2 1/2 degrees. I do the same with biplanes. Zero degrees all the way. Some like the bottom wing to be more positive than the top wing, so that the bottom wing stalls first, letting the tail end come down first on landing and it also makes for better snap rolls. I understand that most real biplanes with positive stagger (top wing ahead of bottom wing) have more incidence in the top wing so that it will stall first, causing the

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nose to drop and stall recovery will be quicker. My der Jager was kitted that way and it originally didn't fly the way I wanted, so I changed it. Now it fly's better.

After you fly the model you will want to observe how it fly's. Is the tail end hanging down or is it way up? If it is hanging down that means you don't have enough positive incidence in the wing so you will need to raise the leading edge of the wing a degree or so. (or lower the trailing edge) The model has told you that the wing needs to attack the air at a higher angle, probably due to the overall wing loading of the model.

Now if you really want to impress someone, then talk about DECALAGE. Hey weird-o what's the decalage on your airplane? Weird-O answers " I thought I got all that stuff off ... damned cat!" The word simply means the angular difference between the wing and horizontal tail surface. If the rear end is set at zero incidence and the wing at +2 degrees incidence then the DECALAGE is positive 2 degrees. Not only that but no one really cares unless they are working with Indoor Models or rubber powered outdoor ones. Still it really doesn't matter in my mind because you have set the incidence at both ends the way you wanted them so screw it. [Back To Top](#)

Thrust Line

If you look at the side of your engine it is pretty easy to imagine the line of the crankshaft from fore to aft. This is the thrust line of the engine. Unless your engine is a firewall mounted engine, the mounts will be horizontal to the thrust line. If it is firewall mounted, then the thrust line has to be imagined along the line of the crankshaft and exactly 90 degrees from the firewall vertical mount. When you mount your engine, make sure you have built in 2-3 degrees of right thrust (engine pointing to the right for a tractor set up (engine up front), and 2-3 degrees of down thrust. (crankshaft pointing down). This imaginary thrust line is in relation to the datum line you have drawn for your fuselage. Some plans show these datum lines for the wing and the engine but many of them don't and you can end up with a very pretty model that fly's like crap. Here is where purchase of a \$20 incidence meter comes in very handy. Don't buy or use 2 of them as they usually don't match each other. (found that out the hard way too). After your first few flights you may need to adjust your engine thrust line. Get your model tracking straight and true at altitude, then chop the throttle. The nose should drop some. If the model's nose pops skyward then you have too much down thrust. If you have designed a tail dragger, it will be very easy to tell if you have enough right thrust, when you try to take off. Your model naturally tries to turn to the left. If you have set up the right thrust just right, your model will track straight ahead on take off. [Back To Top](#)

Balance

The balance point is not the Center of Gravity. Generally all we want to worry about is the balance point of the wing. As I said earlier, it needs to be about 25% of the chord back from the leading edge. If you have a biplane then draw a line connecting the leading edge of the wings and make a mark at the half way point, then from that point move aft 25%. For canard's see the information below as they are a little different.

In addition you should balance your model fore and aft. Put one finger on the end of the crankshaft and the other finger at the tail. If it continually flops to the same side, then that side is too heavy. Probably because you have the engine set sideways with the head of the engine on one side or the other. If not the engine then it is something else, like maybe you covered the cat inside the wing or more plausible, the cat took a dump in the wing. Just start adding lead to one wing tip or the other till it balances, then kill the damned cat.

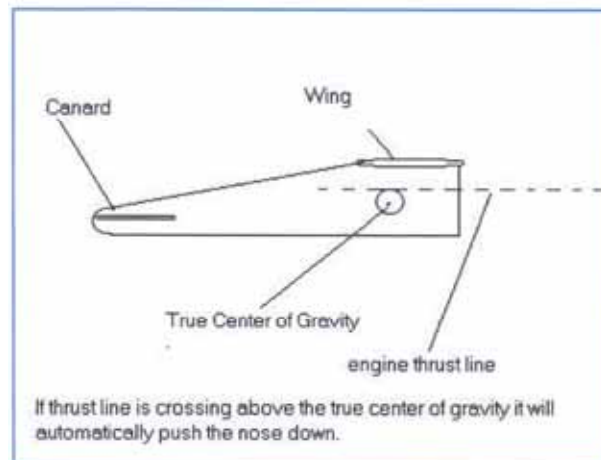
If you want to get a rough estimate for the Neutral Point of your model (i.e.-where it will become unstable) then use this formula: The distance between the quarter chord point of the wing vs the horizontal stab times the area of the horizontal stab divided by the wing area times the wing chord.

example: Lets say the distance is 38 inches and the horiz. area is 410 square inches with a wing area of 3000 sq. inches and a wing chord of 14 inches. The formula would work out this way: $38 \times 410 = 15580$ divided by $14 \times 3000 = 42000$. And $15732 / 42000 = .37$ or 37% of the average chord. In this case $.37 \times 14' = 5.18$ inches aft of the leading edge. To be safe you need to deduct from that measurement. Using a chord of 14' times a **minium** safety factor of 10% you would come up with 1.4". Just deduct the 1.4" from the N.P. measurement of 5.18 inches and you would initially balance at 3 3/4 inches aft of the leading edge or a balance point 26% aft of the leading edge. I wouldn't start out any farther aft than that.

Summary: I have found that anytime you balance beyond 33% you are getting into an unstable condition. For rough estimates I would use that normally and just make sure I was balancing ahead of that point.

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Pushers



Here is where you probably really need to know the real center of gravity. Imagine a circle with a dot right in the middle.(see drawing) That circle would be the real center of gravity. On a high wing pusher model, the circle (real center of gravity) will be back 25% from the leading edge and somewhere under the wing. Gotta think about how to explain finding this so give me a minute because you have to basically stand your model on a wing tip and then balance it that way.

Next I need to point out that the picture shown is of a canard and that the circle I have drawn very probably is not the balance point nor the center of gravity. The balance point, quite likely will be forward of the circle I have drawn. This is because you are now dealing with 2 wings flying rather than just one and both of these wings have to be balanced.

For now just look at the the circle under the wing (above) and 1/4 back from the leading edge. You are now looking at a side view of your model with the engine mounted to your right and back near the tail end of the aircraft in a pusher configuration. Also imagine the center of the circle as an axle. If you put your finger on top of the circle and pushed toward the front of the model, the circle would rotate counter clockwise, assuming the prop was to your right as shown above. If this were the actual thrust line pushing on top of your circle, it would tend to push the nose of your craft down. Generally a pusher engine on a canard is mounted above the Center of Gravity, so

generally it will automatically push the nose down without having to cant the engine one way or the other and give you down thrust.

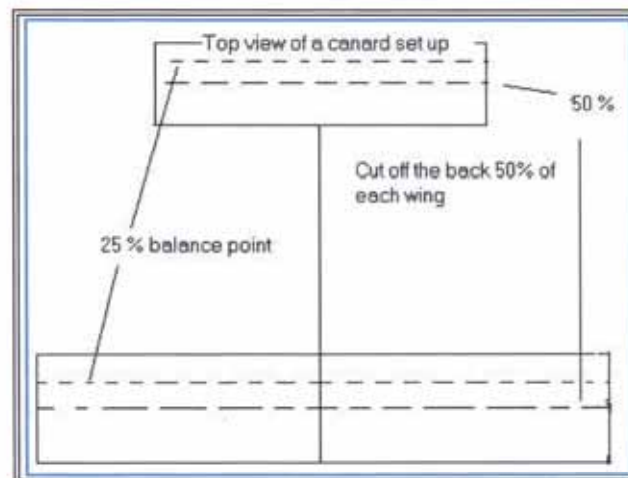
For side thrust it works the same as that in a tractor configuration. Right crankshaft, when looking at your model from the pusher end is right thrust.

Here is a very simple but objective way to determine if your pusher model has down thrust or upthrust before you fly it, assuming you don't know where the Center of Gravity is located and/or don't have some other means of measuring the thrust line. With the engine running at idle, place your hand around the nose of your model and lift up about a quarter of an inch then apply full throttle (assuming the model is properly restrained and junk isn't going to be sucked through the prop). If it pushes your hand down to any degree you have too much down thrust and vica versa. Simple and effective. You actually want a little upthrust so that as you chop the throttle in flight, the nose drops slightly maintaining airspeed and setting you up for a landing approach.

While on the subject of pushers. Make sure the prop is on correctly. Many of the pusher props have their insignia on what would be the back of a pusher prop. So when flipping the prop, you won't see the insignia. (hey it was all learned the hard way) [Back To Top](#)

Canards

I need a scanner before I get into canards. So give me awhile. Hey maybe the library has one. Yes Virginia there is a library in Shell Knob, Missouri..... population 7 more than a few ... but we have thousands of ticks, raccoons, squirrels ,birds and well you get the idea. But talking about squirrels, we do have flying squirrels. They are neat. They are nocturnal so you have to go out on the porch swing at about 10 pm and wait. I've seen them glide from the top of our telephone pole to my main front tree about 30 yards. They glide quite fast, indicating a higher than we want wing loading, but they actually flair as they grab onto the tree. They are quite small with big red eyes. They make you think of a bat.



The sketch above is of a simple canard layout with the front wing (canard) at the top and the main wing (wing) at the bottom. Here is a simple way to balance a canard as generally described

in the book Model Aerodynamics by Martin Simmons. For this exercise you need some old fashioned cardboard from a real old cardboard box. The kind with flutes that add rigidity. Make a scale layout of both wings on the cardboard. (yes you can scale your scale model down even further if you want) After you have drawn both the wing and canard on the cardboard you now need to discard the back 50% of each.

Right throw away the back half of the canard and throw away the back half of the wing. Why? Mostly because I didn't tell you not to draw the back half in the first place.

Remember our discussion about balancing at the 25% point aft of the leading edge? If you have a wing and have thrown away the back half of it, then put a ruler on edge and try to balance what is left, you will be balancing it at the 25% point. Taaaa Daaaaah !!! Only trouble is the darned things are hooked together with a fuselage. So to simulate the fuselage you need another long piece of cardboard. Say an inch wide x 75 feet long. On this piece of cardboard you need to attach the front halves of the wing and canard exactly spaced as you have built the airplane. Now try to balance this mess. To do this you will need to cut off about 73 feet of the one inch wide cardboard strip we used to simulate the fuselage. Just chop and try to get this mess to balance. It doesn't matter if you end up with 7 inches overhang on one end or the other or both because the end result is you will be balancing both wings at the 25% point and the cardboard simulated fuselage spacer at 50%.



The picture on the left is of my cardboard model of half of each wing on the Stratos, as described above.

This probably isn't where you want to balance the canard however because the forward wing (the canard) is destabilizing so you need to move the balance point even farther forward than the 25% point. This does tell you for a fact that you don't want the balance point to be any further back than this because you will probably get into instability problems. So for the canard set up I would suggest finding out the chord of your main wing. Let's say the average chord is 10 inches. We want to balance our canard about 12 to 20% ahead of the balance point we found above. So a 10 inch chord times, let's say 15% is 1 1/2 inches. Just move your balance point forward toward the canard 1 1/2 more inches. If you are still unstable then move it ahead 20% or 2 inches. My latest Ligeti Stratos was balanced at 16% for test flights and I think it should have been 20% instead.

If you want the scientific way by figuring the neutral point and static margin and all that crap then pick up a copy of the book I recommended and flip to page 169 and go figure. (or go to the next paragraph) Believe it or not you will come up with about the same answer. The big secret here is not to use a material of varying density like balsa. One end of a balsa stringer usually weighs more than the other end. If you don't believe that then grab a stick and balance it. Then measure fore and aft from the point you marked as the middle.

For a little more scientific way to figure out the neutral point and then the balance point, here we go

Measure the distance between the average quarter chord of each flying surface and multiply that times the total area of the canard. Then divide that number by the total area of each flying surface. Then add 10 to 20% of the average wing cord to that number and you'll have about the same balance point. Here is an example. Let's assume the distance between the quarter chord points is 10 inches, that the canard has 400 square inches of area and the wing has 600 square inches of area. The wing is 60 inch span (rectangle) by 10 inch chord. So you multiply the canard area (400 sq. in.) times 10 inches and get 4000. The total area of both the wing and canard is 1000 sq. inches so you divide that into 4000 and your answer is 4 inches. The neutral stability point is 4

inches ahead of the quarter chord point of the wing. The wing chord is 10 inches and 10 percent of that is 1 inch, while 20% of the chord is 2 inches. Add 1 or 2 inches to the 4 inches you just found and you will have a usable balance point. Initial test flights should be using the 2 inches plus the 4 inches and then you can move it back.

Canard Area x Distance=

canard area + wing area= Neutral Point ... then N.P. plus 20% of wing chord = initial balance point

So how large do you make the canard wing? Damned if I know but here is my logic for now. How large to make the canard appears to be answered by where you want the balance point to be. And where you want the balance point to be appears to be answered by the engine location and weight as well as the pilot location and weight (prob. applies more to a real one). For example if you were designing a real one, I would assume you would want the balance point somewhere near the pilots butt rump ... rear end poh-poh hinney ... well you get the point. Maybe to be politically correct we should call it your proctologist's smiley face. If you hang the engine on the front then you probably need a larger canard to get more lift up front. And on the other hand (the one with the liver spots) if you want the engine toward the rear-end (see definitions above) then you probably want a smaller canard area.

Probably the most important thing you want to remember about canards is you want the front wing (the canard) to stall first. If the back wing stalls first you are in deep hockey pooh. Generally you want the canard to have a higher aspect ratio than the wing. This has to do with downwash effects and stuff like that.

I could really use some help now on weird flight characteristics so if you definitely know the answer to these perplexing problems, then please email me because at this point I just think I know.

For example: I have seen canards fly just great, then all of a sudden the nose tucks under and the craft flips upside down, nose first, and flutters to the ground like a leaf. I mean it stops on a dime when this happens. I have also had one that really wanted to tuck under but never did. It just bobbed up and down like a 4 year old needing to go to the bathroom real bad. This, I think is because it is flying in a tail heavy condition, but really don't know for sure. I have also seen them fly fine until they try to land at which point the nose lifts straight up and they slide back on their rear end. This, I think also is caused by a slightly tail heavy condition. In addition I think it is possible that in all instances the balance point might have been O.K. but the oh goody ... I get to use it but the DECALAGE is off. Too much positive incidence in the canard, or not enough.

However please don't email me with facts like the center of lift triangulating 90 degrees to the center of gravity at all attitudes and needing to figure the volume coefficient of the tail plane and stuff like that..... even if you are right, I don't care. We just want simple answers to simple problems. If the damned thing tucks what the hell is wrong? (It is probably tail heavy) I realize that all of the problems described above quite probably deal with the center of gravity vs the neutral point but all we are looking for are simple answers to simple problems. Orville and Wilbur didn't know or care about it all they wanted to know was how to correct the problem because no one knew those terms in those days. Can't you just see Orville telling Wilbur to stop screwing with the static margin because he was going to upset the volume coefficient of the tail plane and possibly totally mess up the lift coefficient. Their conversations probably were more like Wilbur get that damned cat off-en my damned tool box or he'll crap on my pipe wrench again.

**OK – HERE ARE PICTURES & DESCRIPTIONS OF MY
SCRATCH BUILTS!**

As A McDonnell Douglas commercial airplane technical representative, during 1987-1992, I was assigned to an airline in Olbia, Italy, a town of only 40,000, located on the Island of Sardinia in the Mediterranean Sea. Having been in radio-controlled model airplanes since 1980, I actively promoted the hobby during this stay in Italy; after A couple years, I helped a number of younger resident Italians in getting their wings via some of my scratch builds!

I designed & built the two virtually-identical planes shown in the following photo using guidelines similar to those in the preceding article. I built the airplane on the left for myself (the airline's colors) and the second one (red, white, blue) for an airline employee.

The 52-inch Wings have flat-bottomed airfoils (not true "Clark Y's"). Both are 4-channel controlled (engine, elevator, ailerons, rudder/nosewheel steering). At their weight of no more than about 3 ½ pounds, the strong OS .25 motors worked great! These airplanes flew very well with no surprises at all! Since this was my very first design/scratch-built effort, I was very pleased!

52-inch trainers

OS .25 Powered



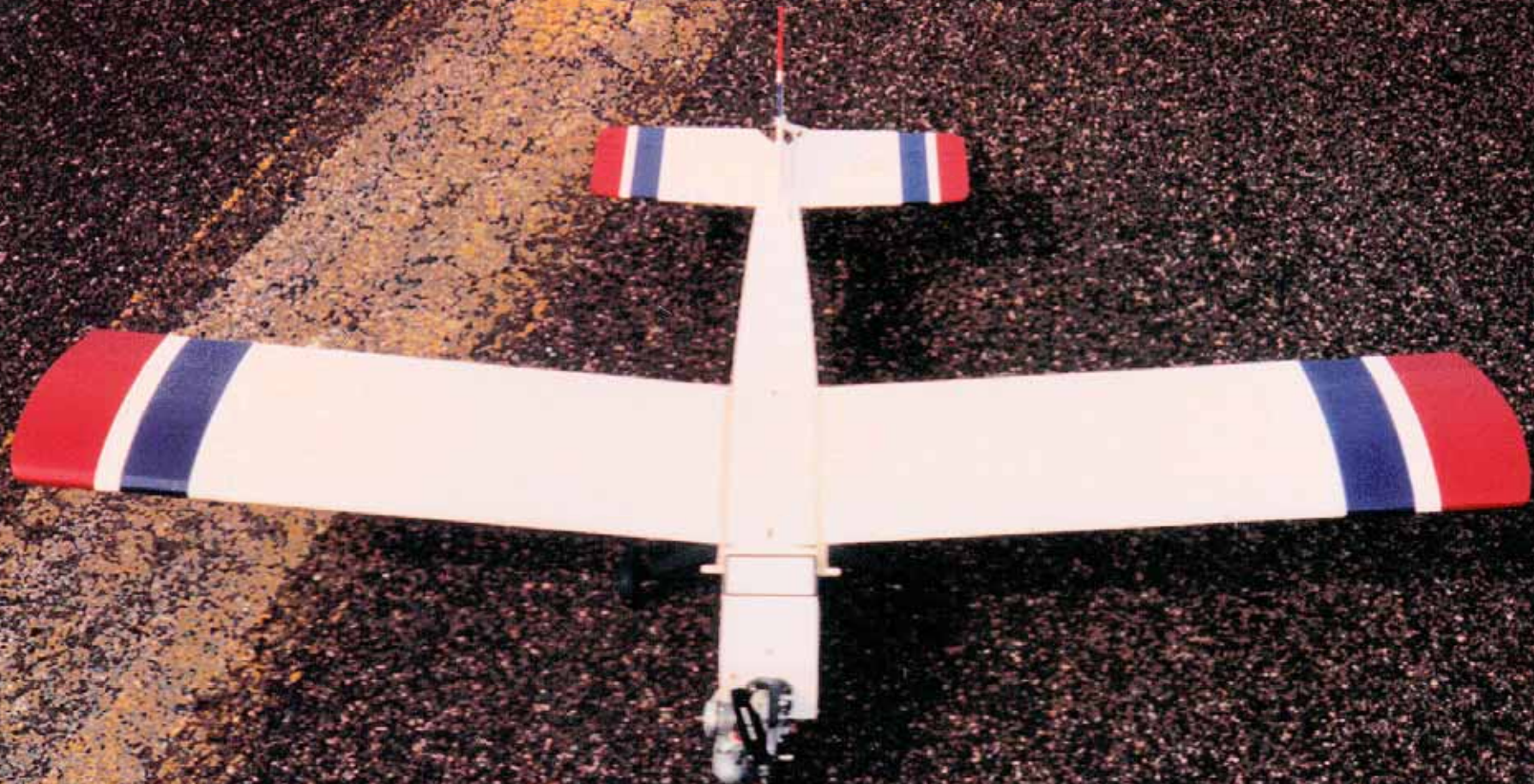
*Designed & Built by Dan Pemble
for my Italian friends*

A young Italian boy with “an itching” to get started in radio-controlled airplanes visited the flying site frequently. I offered to build an airplane for him and he was delighted!

The 50-inch wing span/OS .25 airplane in the following photo turned out to be just right for him! This design has a true Clark Y airfoil and is 3-channel (engine, elevator, rudder) with rubber band wing hold downs.

The airplane flew like a champ and I was amazed to see this young man flying all on his own after only a few weeks! I was even more amazed to see him put this airplane into a steep climb and do continuous rolls with rudder only!

*50-inch 3-Channel Trainer
OS .25 Powered*



Designed & Built by Dan Pemble for an Italian Friend

50-Inch Span 3-Channel Trainer



*Shown here on a deserted 3000-foot runway
(Venafiorita - "vein of flowers" airport)
Near Olbia, Italy on the Island of Sardinia
An excellent flying site!!*

MY 4TH SCRATCH BUILT AS SHOWN IN THE ATTACHED PHOTO TURNED OUT TO BE A UNIQUE (IF NOT SOMEWHAT PECULIAR!) FLYER, AS ATTRIBUTED TO SEVERAL OF MY OWN CARELESS DESIGN ERRORS & OVERSIGHTS!

THE FIRST FLIGHT IMMEDIATELY SHOWED ME THE ERROR OF MY WAYS! AFTER ROTATION & LIFT OFF, I MANAGED TO MAINTAIN WINGS LEVEL & CLIMB TO ABOUT 150 FEET; THE AIRPLANE THEN “MUSHED” INTO AN UNCONTROLLABLE/UNRECOVERABLE STALL. I SHUT DOWN THE ENGINE. LUCKILY, THE AIRPLANE REMAINED AT WINGS LEVEL AND AT ALMOST ZERO DEGREES PITCH ATTITUDE & GENTLY FLOATED DOWN TO THE GROUND VERTICALLY – LIKE A FLUTTERING LEAF! THE ONLY DAMAGE WAS ONE OF THE NOSE “CHEEK COWLS” BROKE OFF.

UNFORTUNATELY, I HAD INTENDED TO HAND THIS AIRPLANE OVER TO ITS NEW OWNER AFTER I HAD PROVEN ITS AIRWORTHINESS, BUT I DELAYED THIS “DELIVERY CEREMONY” IN FAVOR OF SOME FURTHER INVESTIGATION ON MY PART. PLEASE READ ON.

AFTER GLUING THE CHEEK COWL BACK IN PLACE, I DECIDED TO SHIM THE ENGINE TO ADD SOME ADDITIONAL DOWN THRUST; ON THE SECOND TEST FLIGHT THERE WERE NO STALL TENDANCIES, BUT IT TOOK SOME “HORISING” ON THE CONTROLS TO GET THIS “THING” TO CLIMB TO ALTITUDE. ONCE AT A LEVEL ALTITUDE, I FOUND THIS AIRPLANE TO BE A VERY GENTLE FLYER AT ONLY 1/3 THROTTLE; I ALSO NOTED THAT DURING SHALLOW TURNS (BANKS), NO, REPEAT NO, UP ELEVATOR WAS REQUIRED AT ALL & THIS WAS A SURPRISE! LANDINGS WERE ALMOST STRAIGHT-DOWN VERTICAL DESCENTS WITH A LESS-THAN-10-FOOT ROLLOUT! IN FURTHER ASSESSING THE UNIQUE FLIGHT CHARACTERISTICS OF THIS MACHINE, I NOTED THAT MY AIRFOIL DESIGN IS CERTAINLY NOT THE OPTIMUM; I HAD INTENDED THE AIRFOIL TO BE A TRUE CLARK Y, BUT IT DIDN'T TURN OUT THAT WAY! (PLEASE SEE THE LEFT-HAND WING AIRFOIL CROSS SECTION IN THE FOLLOWING PHOTO.) OTHER THAN BUILDING A WHOLE NEW WING FOR THIS PROJECT, THERE WAS NOTHING MORE I COULD DO; AFTER HAVING PROVED THAT THIS AIRPLANE WOULD FLY, I HANDED IT OVER TO ITS NEW OWNER!

AFTER LOGGING NEARLY 50 SUCCESSFUL FLIGHTS, THIS AIRPLANE WAS TOTALLY DESTROYED DURING A CRASH LANDING ON AN ASPHALT RUNWAY!

*6-Foot Span Trainer
Super Tiger .45 Powered*



*Designed & built by Dan Pemble for an Italian friend
(Shown here on some dried-up salt flats near the Mediterranean Sea
in Olbia, Italy on the Island of Sardinia - a great flying site!)*

Talk about a unique flyer! The Simitar Slo Motion .15 shown in the following photo was one of the most fun airplanes I have ever built! Its design was featured in the Jan/87 issue of Model Aviation magazine.

The wing was built on a foam core as ordered from the address mentioned in the Model Aviation construction article. Bill Evans designed a number of “simitar” airplanes. All designs use wings with similar airfoil cross sections. The high point of these airfoils is located just slightly aft of the wing leading edge. The center of gravity on the completed model is set at only about 1 inch aft of the wing leading edge.

Elevon (aileron/elevator) control on the model I built utilized a mechanical sliding tray arrangement with 2 servos, as shown in the plans, and this worked very well.

The overall weight of this craft with a full 4-ounce fuel tank was only about 3 lbs.

I usually always flew my Slo Motion from some dried-up salt flats along the coast of the Mediterranean Sea. There were some strong updrafts present here – perfect conditions for flying this glider-like model.

After takeoff and achieving quite a high altitude, I could “loiter” at altitude in powered flight with a reduced throttle setting for about 10 minutes before fuel ran out and the engine stopped. Then came the real fun part! Given the strong updrafts and the mostly stall-proof characteristics of the wing, I could stay airborne for an indefinite period! My longest single flight was probably over 45 minutes! I landed only out of concern for remaining battery power.

Many times while flying this model I would trim it to maintain a shallow turn, set the radio on the ground for extended periods, and just watch it do continuous turns while maintaining level altitude! It was a true fun flyer!

Later while residing in Oslo, Norway, I sold this model. I note on the AMA Plans Service web site that the plans for this model can still be ordered (No. 535B); thus, I fully intend to order these plans and get on with building another one!

*73-Inch span Simitar Slo Motion .15
.21 Powered*



*Scratch built by Dan Pemble from Bill Evans plans
(As featured in the Jan/87 issue of Model Aviation)*

I hope you have found this presentation to be of interest and of possible use to you. While I don't consider myself to be an expert in radio-controlled model airplanes, I welcome any questions or comments you may have. My e-mail address is:

jetvet@cfl.rr.com

ALWAYS KEEP THE BLUE SIDE UP!