CUNNINGHAM ON R/C

R/C Design Made Easy
Part I

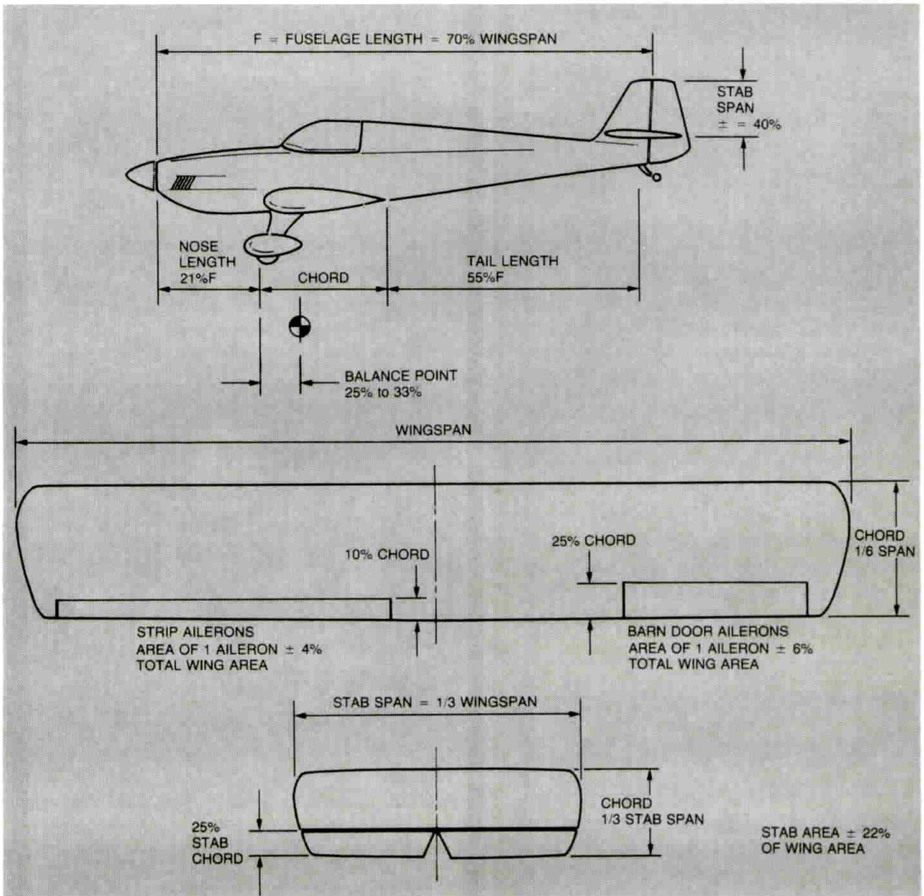
Way back in 1964 I started writing about designing your own radio controlled aircraft. About every four or five years since that time I have compiled that information to bring to you, and now it's time to do it all over again. The last time was back in early 1985. Many new fliers have come into this great hobby/sport and, judging from the questions that I get asked, lots of RC'ers are interested in putting their own aircraft together, so let's explore the mysteries of creating your own successful design. The emphasis of today's modeler seems to be on scale, or scale looking aircraft. This is the feeling that one gets from the model magazines and fly-ins. Actually, it seems to me that there are several levels of modeling. The first is the entry level that starts out with a ready to fly trainer. Next is the hot and fast stick type aircraft. The third level tends to lean toward more realism, while the fourth seems to be the larger aircraft that are very scale-like. Each level has its variations, and I certainly don't mean that each is a stepping stone to the next, but they do exist and lots of modelers are interested in creating their own thing within the differing levels. Naturally, it's kind of hard to create your own thing in the level of ready to fly aircraft. But, if a couple have bitten the dust and some usable parts are left over, it would be nice to be able to blend these parts together to form a flying aircraft, wouldn't it? We're going to break this subject of R/C Design in several installments so that we can give an indepth look at several types of models. Before we go any further, let me make the following statement, "Nothing is engraved in stone." Everything is a series of checks and balances. Just because I indicate that the nose length should be about 21% of the fuselage length, in reality it can be longer or shorter, but should be offset with another balance. If you're flying with a very heavy engine, then you can offset this weight by making the nose short and the tail longer. We will get into this more later, but, please remember, these are average figures, and an average means just that.

The design of model aircraft is really very simple. A little bit of 9th grade math is involved, and this can all be handled by the use of an inexpensive calculator. If you don't have one, and are going to buy one, then purchase a calculator that can calculate square root. The calculations that we are going to do hold true for an aircraft that is powered by a .10 size engine, a .61 size engine, or a 3.7 engine. The basics are all the same.

We're going to concentrate on the design of sport type aircraft, either non-scale or scale and leave the exotic types up to the other guys to play with.

To start with, let's select the engine size that we're going to use in our bird, then design an aircraft around this engine. We have an entire spectrum of engines from which to choose, but let's stay in the middle of the road and aim for a .61 powered model. In a later segment we will discuss how to figure out what size aircraft to build for what size engine. This, by the way, is a very imperfect science with much overlapping, but we will go into that another day.

We can design a .61 size model to be hot and fast, such as a 600 sq. in. model would be, or nice and docile such as a 1000 sq. in. aircraft would be. Let's take the middle of the road approach and shoot for an aircraft that sports a wing area of something around 800 square inches. Probably more important is to start out with a



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wingspan that you can transport easily. A six footer isn't too big. Sure it may seem big if all of your aircraft have had wingspans of 56" or less, but 72" isn't bad, and will give you a reasonable sized aircraft for your .61 to toe around. For that matter, it will give you a large enough aircraft if you're flying a .90 or 1.20 4-stroke.

Starting with a 72" wing, we then need to decide upon the width of the chord. The relationship between the wingspan and wing chord is called the "Aspect Ratio" or A/R. To make it very simple, an A/R of 6 to 1 means that the wingspan is 6 times greater then the wing chord. With our 72" wingspan, dividing it by 6 gives us a wing chord of 12". This is based upon a wing plan that is a simple rectangle. Our wing relation is A/R = 6:1 or the wing is 72" x 12". Looking at another example, say that we wanted a shorter wing, with the same wing area (72" x 12" = 864 sq. inches). We can only fit a 66 wing into our compact car, but we know that we want 864 square inches of wing area to have a reasonably light wing loading on our model. Well, simple math shows us that 864 divided by 66 gives us a wing chord of 13". Our aspect ratio is then 66 divided by 13 or 5:1. A shorter, stubbier look, but still not too bad. About twenty-five years ago I designed a short stubby, ugly looking little bird with a 3:1 aspect ratio. It was ugly but it flew fine.

Getting back to our basic aircraft with a 72" span and a 12" chord. When we subtract the area lost by rounded wing tips, and so on, we will get less wing area, but we will lose a proportionate amount at the tail end also. Don't sweat trying to figure out the exact wing area when figuring the tail areas; work from the squared corners.

What if you decide that what you really want is a wing that is tapered and not rectangular? You want to stick to a 72" wingspan, and a 12" root chord. You want the wing tip to be 8", and you want it to taper just as much on the leading edge as the trailing edge. What, then, is the wing area and what is the aspect ratio of this wing? We need to find the average chord. Add the root chord to the tip chord (12" + 8" = 20") divide by 2 and you get an average chord of 10". 72" divided by 10" = an A/R of 7.2:1, making a very pretty wing. I have been asked why I don't design an aircraft with a wing like this? It's because I'm lazy and don't want to plot out all the different wing ribs. For purposes of mathematical relationship, our tapered wing will have less wing area at 720 square inches, so other parts of the aircraft will be smaller and the overall wing loading will be higher.

Once we have established the wing size and area we are ready to move on to the fuselage. For simplicity I like to consider that the length of the fuselage is measured from behind the propeller to the hinge line of the horizontal stabilizer. For the purpose of our discussion, we will also assume that the hinge line of the vertical fin falls at this same location. We are now going to establish some relationships of the fuselage to the wingspan. Once more, let me be very positive here. These relationships are not hard and fast, and can be adjusted a considerable amount. These are average figures, and will insure that your first design effort will be successful.

The fuselage length, from the back of the prop washer to the hinge line of the stab, should be about 70% of the wingspan. The nose length, from the leading edge of the wing to the back of prop, is about 21% of the fuselage length. The tail length, from the trailing edge of the wing to the hinge line of the stab, is about 55% of the fuselage length. The wing chord fits between these two points. These figures are a little different than those that I have given to you in the past. The reason is that it's easier to work

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from hinge lines; today, elevators, and rudder tend to be wider. Naturally, if you use a wider wing chord this will throw off the figures a little bit, but subtract the added width of the wing chord from the tail length to compensate. A purist in aircraft design would measure the nose moment from 25% of the mean average chord forward to the back of the prop, and the tail moment from 25% of the mean average chord of the wing aft to 25% of the mean average chord of the entire horizontal stab. Since we're not purists, and the answers come out about the same with much less math to wander through, stick to the easy way.

Next, let us consider the size of the horizontal stabilizer, elevator area included. All we're looking at now is a monoplane and, therefore, the area of this surface should be between 20% and 25% of the total wing area (ailerons included). Pattern aircraft today are leaning toward a stab area of about 25%, up from less than 20% a few years ago. I like to take an average figure of 22%. Looking at our basic wing of 72" x 12" = 864 sq. inches; we then have a stab with 22% of 864" or 190 square inches. Horizontal stabilizers look about right with an aspect ratio of 3:1. To find the dimensions of the stab, we use a bit of 9th grade algebra to find S(span) x C(chord) = 190. Since our aspect ratio of 3:1 means that the span is three times larger than the chord, we change our formula to 3C x C = 190, or 3C = 190, or C = 190/3 = 63.3. Using our calculator with the square root function we find that the square root of 63.3 is about 8, so horizontal stab has a chord of about 8" and a span of 24".

The vertical fin should have a total area, rudder included, of about 7.5% of the wing area, or about 1/3 of the total horizontal stab area. Today we are moving toward larger vertical fins, and I would not be surprised to see them in the range of 1/2 the horizontal stab in the next few years. For our consideration, figure that this area is all above the fuselage top, with the rudder area hanging down the back of the fuselage for just a bit of plus area. (Please don't get bogged down picking at nits.)

Take a look at the drawings and you will see what we are trying to achieve. The moving surfaces of the wing and tail sections need to be examined next. The total aileron area (makes no difference if they are strip ailerons or barn door ailerons) should be about 10% to 12% of the total wing area, 4% to 6% for each aileron. If you're using barn door type ailerons then use an aileron chord of 25% of the wing chord. Using our wing of 72" x 12" = 864", taking 6% of this for one aileron gives us an aileron of about 52 square inches. Since we have the aileron chord of 25% of the wing chord, or 3", then the total size for each aileron is 3" x 17". If we're going to use strip ailerons on this wing, then deducting about 6" for the width of the fuselage and another 3" lost in span at the wing tip, each aileron is about 30" long. 52 sq. inches divided by 30" gives us a strip aileron with a 30" span and a 1¾" chord. This size aileron need not be moved very much to give you very good control. If you like to bang the sticks from side to side, then move the strip aileron size down to about 4% for each aileron or 30" x 1¼".

The elevator portion of the horizontal stab works out pretty well if you use 25% of the horizontal stab chord as the elevator chord and work from there. The rudder portion of the vertical fin can be easily 1/2 or more of the total vertical fin area. Work on what looks pleasing to you.

As stated earlier, you can deviate a good bit from all of the dimensions listed here, or shown on the drawings. These are merely guidelines to help you along the way to create your own successful bird. R/C is lots of fun, and designing your own aircraft adds to this fun, especially so if the finished design is a good flying aircraft. It's a pretty nice feeling when you take your new creation out to the field, and when someone asks you what kit it is you can say, "It's not a kit, I designed it myself." □