Model glider books by Martin Simons: part 4

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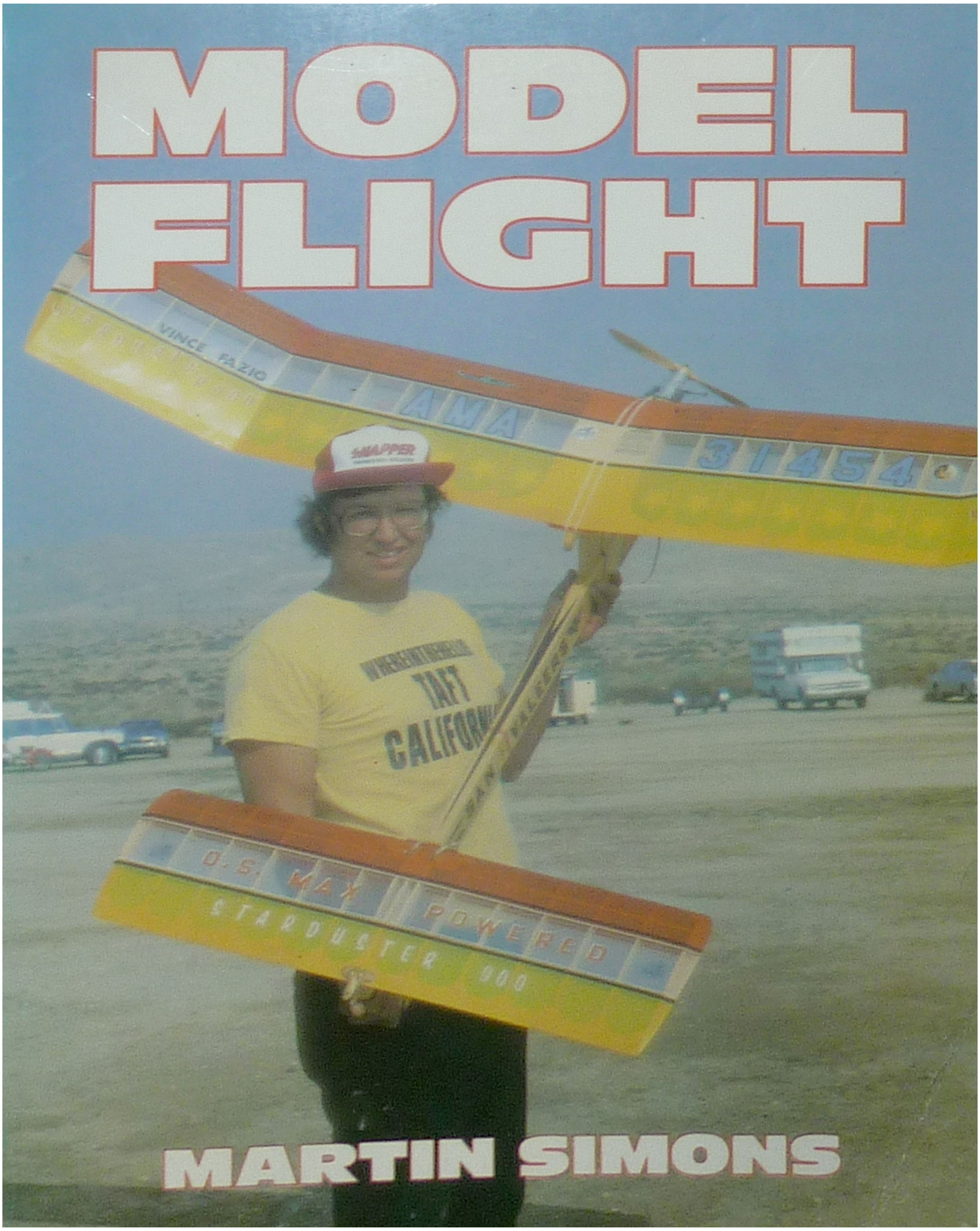
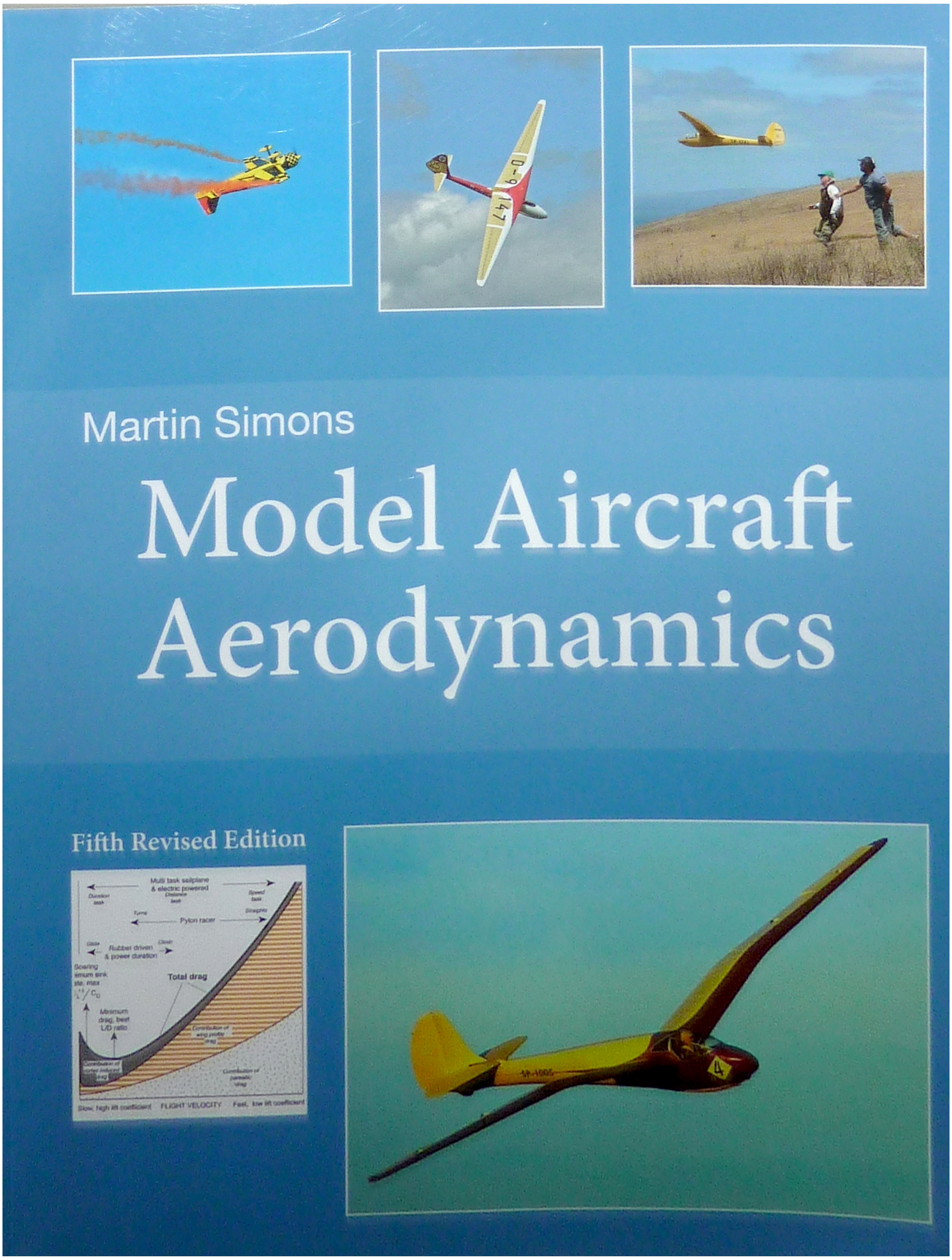
Martin Simons has written three books about model aircraft. Aerodynamics is still available to buy new. Each has a definite target reader.

Gliding with Radio Control is for the beginner, covering all areas of the field including types of model, radio gear including installation, and how to fly. Starters will probably do well to read it from front to back and make their own. Of course some of the technical aspects of the electronics are out of date. The glossary will help newcomers to grasp all the new words. There is no index but the table of contents will help readers find what they want.

Model Flight is more advanced, with theory to give the developing flyer a better understanding of how models fly. There is an excellent index that refers to paragraph numbers rather than page numbers.



Model Aircraft Aerodynamics is hardcore for those who want to know the ideas in depth and possibly design their own models. It has an excellent index but that refers to a numbered paragraph rather than a page. It is a substantial work and when first written perhaps the software used did not handle indexes as well as it now does? Paragraph numbering makes assembling and editing a large work much simpler. For the real lovers of the maths and technical side there are two appendices of those topics, a third of aerofoil information and references and a fourth which is a booklist. Overall it is an outstanding piece of work.



Martin Simons

Model Aircraft Aerodynamics

Fifth Revised Edition

I wondered how best to give you a taste of these excellent books and decided to pick on topics that have interested me lately and show how each book tackles them. The topics I chose are:

- Centre of Gravity
- Turbulators
- Winglets

Centre of Gravity is of special interest due to my glider experiments, which have given me a club reputation as a nutter. I like to point out that my gliders now fly rather well, though they are not useful for training as they are less stable. I have based those ideas on an excellent article by Brian Agnew in the1997 Radio Control Soaring Digest. I haven't used a turbulator since I stopped flying free-flight A/2 F1a gliders decades ago but always wondered how they worked. All of my newer gliders have winglets.

The quoted text and pictures will hopefully teach you something you didn't know. It will also give you a feel for the level of the books so you will be able to help club members and friends choose which one is best for them. For this article I will add Martin's work on centre of gravity. I hope he will approve my choice of text. The other elements will be the subject of later articles.

Centre of Gravity

Quite correctly Martin has set aside any extreme ideas about this matter, and covers it thoroughly and conventionally. My power scale model mates always fly with a forward CofG and Martin's explanation of how that works with small scale tailplanes got me to understand at last. From now on all text and images are from Martin's books, except my balance stand and my bracketted comments [ ].

Centre of gravity

From Gliding With Radio Control

THE CENTRE OF GRAVITY

The most important thing when the glider is completed with all the radio gear installed, controls connected and working correctly, warps removed etc., is to make sure the centre of gravity or balance point is in the right place. Probably more new models crash from neglect of this than all other causes.

On a good plan, there will be a clearly marked position for the centre of gravity or CG. If, when otherwise completed, the model does not balance ***at or in front of*** this point, trimming ballast must be added to the nose. One reason for keeping the tail end of a glider as light as possible is to avoid having to balance it by filling up the front with large amounts of ballast. Placing the battery, servos and receiver as far forward as possible helps to ensure that the CG will come out somewhere near the right place, but this is hardly ever enough.

If the plan does not show it, the CG should be **between one-quarter and one-third** of the **average** distance between the leading edge and trailing edge of the wing. In many cases, this will be **on, or in front of, the main spar.** A rough first check can be made by supporting the model with two fingers, one under each wing. The tips of the fingers should be fairly well apart when this is done, slightly less than half the total span ie about two-fifths of the way out towards the tips (this method works even if the wing has some sweepback, since the effective aerodynamic centre of each wing half is very roughly at the 40-45% spanwise point).

The aim is to get the glider to balance horizontally when the support points are between one-quarter and one-third of the chord measuring from the leading edge. Add nose ballast until the glider takes up a horizontal position when supported in this way. A little nose heaviness is not a bad thing. It makes for ***increased safety*** **if the CG is a little further forward than the plan shows. It is DANGEROUS to have the balance point even slightly too far back.**

More accurate measurements can be taken by making a simple wooden support of the kind shown in the diagram (Fig 10.1).

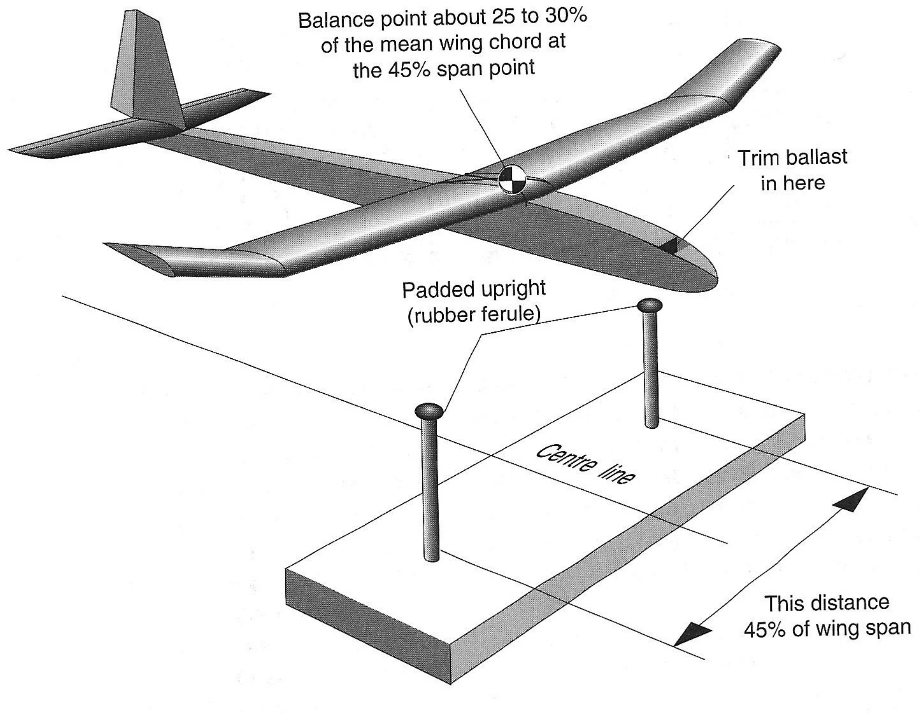
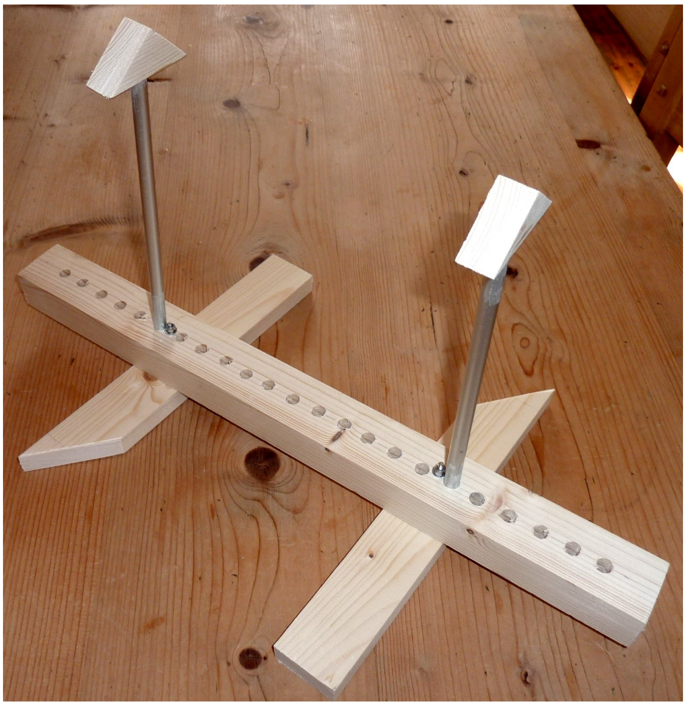


Fig 10.1

A rearward position of the balance point makes any aircraft, glider or aeroplane, full sized or model, unstable and ‘twitchy’ in response to the controls. On the other hand, balancing the model well forward reduces the sensitivity and makes for gentle and smooth response. A very experienced pilot may actually like a model which leaps instantly about in response to the merest feather touch but for a beginner this is disastrous. After some successful flying with the CG safely forward, it is worth a little experimenting with balance points to see how much difference it makes to add, or subtract, nose weight. The pilot then can adjust the stability and responsiveness to whatever is preferred. It is incorrect to suppose that moving the CG aft beyond about 35% improves the performance of the model. All it does is to make the elevator more twitchy and the model less stable in flight. If anything it tends to increase drag and hence take a slight edge off the performance.

[Here is an alternative folding CG stand made out of scrap by yours truly. The angled cuts on the feet are to extend the footprint.]



Picture by Peter Scott

From Model Flight

5.4 Centre of gravity location

As the angle of attack of the aircraft changes in response to gusts etc., at a given flight speed, the resulting variation of lift force is felt at the neutral point. An increase in angle of attack produces an increase of the lift force and a reduction of the angle produces a reduction of the lift. The pitching stability of an aircraft is almost entirely determined by the position of the centre of gravity in relation to the neutral point where these changes of lift force act. Any surface, such as wing, forewing, or fuselage, which has its aerodynamic centre ahead of the centre of gravity tends to destabilise the model, and any such surface aft of the c.g., tends to stabilise it.

Almost all pitch stability and elevator control problems can therefore be overcome by *adjustment of the centre of gravity position.* It is very easy to change the centre of gravity, much harder to alter the neutral point position since this involves changing the areas of wings and stabiliser, and perhaps altering the length of the fuselage.

Moving the c.g. forward, by adding ballast to the nose of the model, increases stability. Moving the c.g. aft reduces stability and, if carried too far, can produce serious instability. The pilot should experiment with c.g. position to find the degree of elevator response that suits the model and the pilot’s taste. There is no single answer. The pilot’s preference is the decisive factor.

Every change of c.g. position requires readjustment of the elevator trim for straight and level flight (Figure 5.6). Moving the c.g. forward increases the total nose down pitching moment. This is balanced out by setting the elevator and/or stabiliser at a new angle, i.e., adding nose up trim. *This change does not shift the neutral point.* In the same way, moving the c.g. aft requires a different elevator angle, without altering the neutral point location.

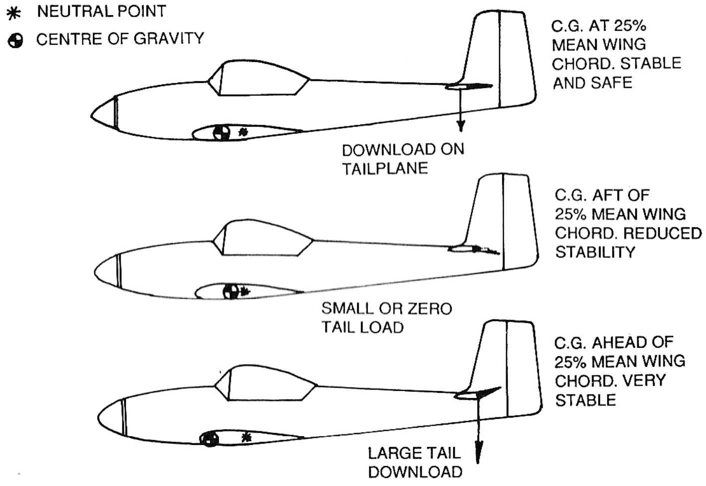


Figure 5.6 C.G. Location and stability in pitch

It must be emphasised again that altering angles of incidence and elevator trim does not change the location of the neutral point, although changes of centre of gravity position do require new trim settings. Putting this the other way round, if a model is unstable in pitch, or too stable, altering the angular settings will not improve the situation. The centre of gravity should be adjusted, *after* which trim changes will be required.

With orthodox aircraft, if the centre of gravity is located exactly at the 25% mean chord point of the wing, as it often is, a small tailplane will provide adequate stability and will easily trim out the pitching moments to ensure balance. Such a placement renders the wing neutral in stability, so the small tailplane, well aft of the centre of gravity, is a powerful stabilising surface and does not have to fight against the wing during any disturbance.

If the c.g. is aft of the 25% mean wing chord position the wing will tend to destabilise the model. A larger tailplane will be required to counteract this. This is a common arrangement with model aircraft. Very frequently, the c.g. is placed at about 30 to 35% of the mean wing chord. The tailplane then has to be enlarged to give adequate stability. In most cases, a more forward c.g. with smaller tail (of similar efficiency) would be equally satisfactory. A small tailplane with c.g. at 25% of the mean wing chord gives the same static stability in pitch as a larger tailplane with c.g. at 35%. (See the discussion of *static margin,* section 5.7 below.) Putting this, too, another way, if a model is not stable enough, increasing the tailplane area will make it more stable but moving the c.g. forward will have the same effect, with less trouble.

If the c.g. is ahead of the wing quarter chord point, stability will increase. Flight in this forward c.g. trim is very safe except that it may tend towards the over-stable condition. To prevent this, the tailplane may be reduced in area. This kind of arrangement has enabled some scale models of full-sized aircraft with very small tails to be made more stable. [This is probably why club members who fly accurate scale models use a forward CofG.]

From Aerodynamics

[As you might expect, in this book Martin takes a much deeper view of CofG and stability. He approaches it from the ideas of the neutral point and static margin.]

12.15 THE NEUTRAL POINT

As described previously, every wing or wing-like surface in an airstream at a moderate angle of attack has an aerodynamic centre close to the quarter chord point. This applies to fins, tailplanes, fore planes and such streamlined shapes as struts, wheel spats, nacelles, faired undercarriage axles, etc, etc. Even long, slender forms such as arrow shafts or fuselages have an aerodynamic centre and this is normally close to the quarter length position for moderate angles of attack.

If the structure of a model is fairly stiff, it may be treated as a fully rigid body. Then it is possible to regard the entire aircraft as one object which produces lift and drag at some fixed point equivalent to the aerodynamic centre of the whole. The exact position of this point may be found by locating the aerodynamic centre of each separate component first, then, with an allowance for the efficiency of each part as a producer of aerodynamic force (area, angle of attack, body shape etc, and whether or not in the wake of another component), the total effect of all may be added and the aerodynamic centre of the entire aircraft found. As with a wing, providing the airflow is not generally separating, the centre of forces so found remains in one place at all useable flight attitudes.

It has already been pointed out that, for a model to be in trim, the total of all pitching moments on it, at any place on the fore and aft centre line, must be zero. Hence, when the aerodynamic centre of the airplane is located, if it is in trim the pitching moments of all the various components will total zero at this point.

For stability in the longitudinal sense, rotations about the Y-axis, it is necessary that if there is a disturbance of equilibrium, causing a nose-down or a nose-up pitch, then a corrective pitching moment should appear. A noseup disturbance causing an increase of the total lift force at the aerodynamic centre of the model must automatically produce a nose-down moment, and vice versa, a nose-down upset must produce a nose-up response.

An unstable aircraft will produce the reverse; a noseup pitch will produce a nose-up moment, making the situation worse, and again, vice versa.

A neutrally stable aircraft, when pitched either way will produce no correction force, leaving the attitude to be determined by chance gusts and random disturbances of the air. [Earlier] a symmetrical wing was shown, in trim, with zero pitching moment and the centre of gravity exactly at the aerodynamic centre of the wing. A disturbance of such a wing would produce no pitching moment in either direction because symmetrical wings have no pitching moment (unless stalled). Evidently, the condition of neutral stability for an entire aircraft just described is exactly similar; no corrective force arises either way if the model pitches.

Figure 12.10 shows the results if the centre of gravity of any airplane or glider is at, behind or in front of the neutral point in a disturbance.

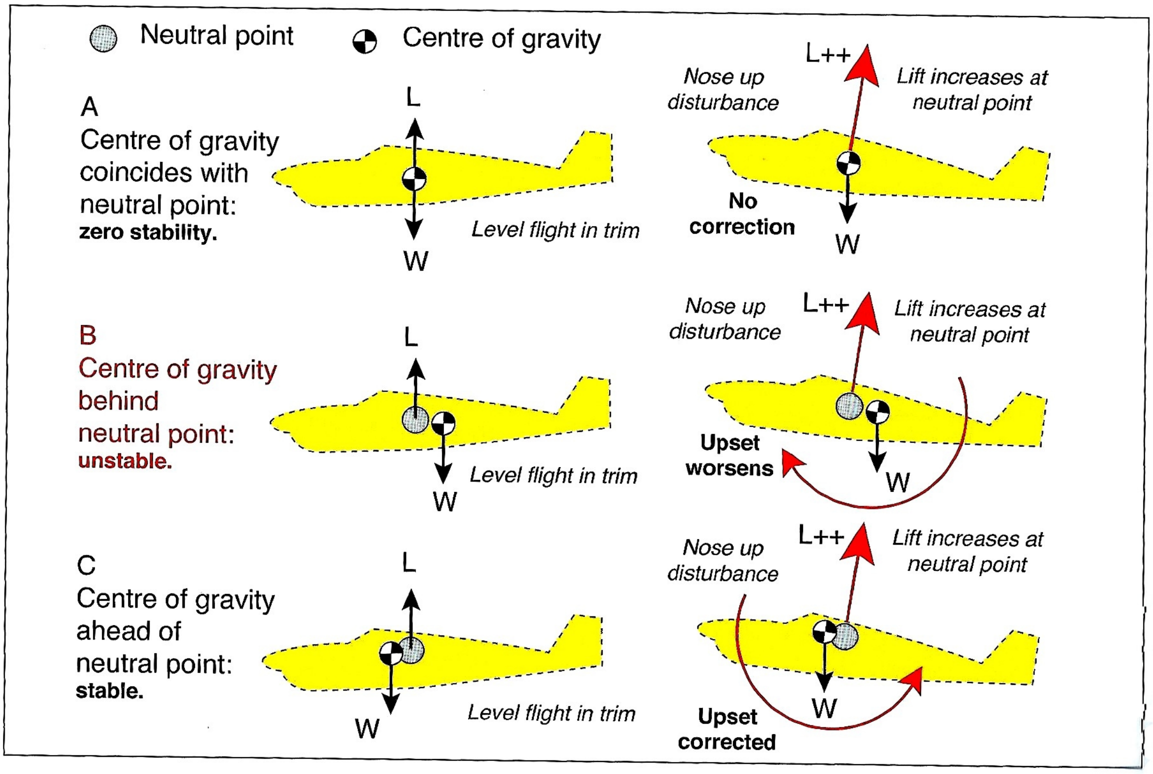


Fig 12.10

In Fig. 12.10A the centre of gravity is at the neutral point. A gust throwing the model into a climbing attitude causes an increase of the total lift force on the whole model. The centre of gravity and lift are still acting at the neutral point and no pitching moment results. There is nothing to make the model rotate in either direction. It will stay nose up until another gust happens to change it to something else. With a nose-down upset, again, there is no corrective force. If the centre of gravity is at the aerodynamic centre of the entire aircraft, neutral static stability is the result. For this reason, the aerodynamic centre of an airplane is termed the neutral point.

In Figure 12.10B, the centre of gravity is aft of the neutral point. Now a nose-up disturbance produces an increase in lift ahead of the centre of gravity and this produces a nose-up pitching moment. Vice versa for the nose-down disturbance; the lift is reduced and the nose-down pitch is worsened. To locate the centre of gravity of a model behind the neutral point produces instability. Any disturbance is immediately made worse.

It follows that for static stability the situation of Figure 12.I0C is essential. The centre of gravity of the aircraft must be in front of the neutral point. Then a nose-up disturbance produces an increase of lift behind the centre of gravity and this tends to restore the normal trimmed and balanced flight attitude. A nose-down change produces a decrease of the lift aft of the centre of gravity, and a nose-up moment arises. This applies to all model layouts, as in Figure 12.11.

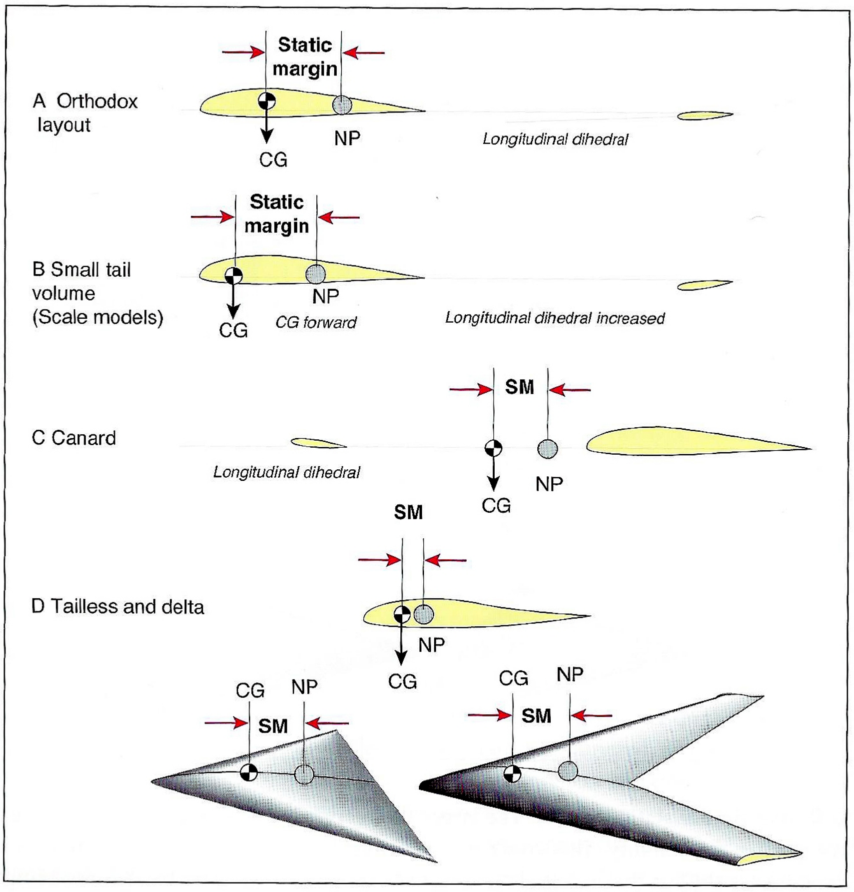


Fig 12.11

12.16 THE STATIC MARGIN

The distance between the centre of gravity and the neutral point is termed the static margin of the aircraft. It gives a very useful standard of comparison of one aircraft with another, since if they have similar static margins they will have similar static stability. The larger the margin, the greater the stability. This concept also brings into prominence the fact that a shift of the centre of gravity of any model aircraft will change the stability margin. By this very simple means a dangerously unstable model can be made stable, or an over-stable one made more sensitive and responsive. Stability is thus almost entirely under the control of the model flyer and can be varied, within limits, by the addition or subtraction of ballast at nose or tail [or battery movement]. Any such change of ballast will require a new elevator trim setting for level flight.

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