ONE WING TO RULE THEM ALL

The Mechanics of Flight

by Alan Robertson

More than 99% of people, and that includes pigeon fanciers, don't have any idea of the principles that make heavier-than-air bodies overcome gravity and fly. Everyone knows that you need wings to fly. Perhaps this outline of the basic principles of flight and the function of the wing in particular, will encourage a few pigeon breeders to pay more attention to the type of wing they want to base their loft on.

The medium in which flight is accomplished is air. Air has certain properties, eg it has weight, exerts pressure, is invisible, is compressible, holds moisture, can be heated or cooled, is viscous or sticky and has resistance.

Gravity is the force of attraction that the earth exerts on all matter on the surface of the earth. Any large body exerts its own force of gravity on other bodies, not just our planet.

In order to fly it is necessary to be able to use the properties of air to overcome the pull of gravity. Air also has to be used to propel our flying object, our pigeons in this case, forward as efficiently as possible.

Four forces interact in normal flight and these are: 1. Gravity, 2. Drag, 3. Thrust, 4. Lift. To understand the interaction of these forces better, the sketch, fig 1 should help to explain.

To overcome the force of gravity, lift has to be created and for this purpose, nature developed the wing.

For the wing to work, it has to be propelled forwards and for this, thrust is required (in the case of birds, a flapping motion, for aeroplanes, engines). When a body moves through air, the air offers resistance to its passage and this is known as drag. As you can see from the sketch in fig 1, lift and weight are opposing forces and thrust and drag also work against each other.

In the middle of these forces, we have the centre of gravity. This is situated approximately one-third of the way back from the leading edge of the wing. Nature has also decreed that the centre of lift also be located in this area.

If we consider our sketch and suppose that our little aeroplane was flying at 80kph (50mph), the wing would be inclined at a certain angle, so that it would provide sufficient lift to overcome the pull of gravity, this is called the Angle of Incidence. Therefore, at a given Angle of Incidence and thrust, our aircraft will maintain a given altitude and speed. The four opposing forces at this point are balanced in that the lift is equal to the opposing force of gravity and the thrust is equal to the drag. If the thrust were reduced, say as our pigeon tires, the speed too would reduce along with the amount of lift produced by the wing and altitude would be lost. To counter the loss in altitude it would be necessary to increase the Angle of Incidence to a point where a given altitude would be maintained. This increased Angle of Incidence would increase the drag and in the case of a pigeon, be more taxing on its energy reserves and become an added factor working against the tiring bird. See fig 2 for the Angle of Incidence.

As the lift provided by the wing has to counteract the force of gravity, the lighter our pigeon, the easier it will be able to fly. As drag is also the opposing factor to forward motion it is necessary to minimise it as far as possible. To provide energy the pigeon needs good muscle. Therefore, put in a nutshell, we have to breed pigeons that are light, well-muscled and equipped with the most efficient wing for the job of racing, and that has the least drag in its passage through the air.

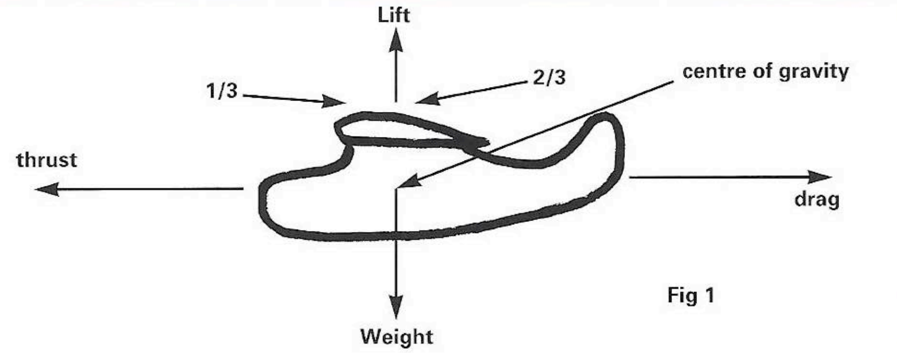


Fig 1

Another factor that has a fundamental influence in flight is Aspect Ratio. Aspect Ratio is the ratio of the span in relation to the chord. To understand this better, look at fig 3 and notice that while both wings in the sketch have the same area, one of them is longer and narrower than the other.

While both wings have the same area, they are very different from each other and act differently on the air too. Wing A has a span of 8m and a chord of 1m, giving a total wing area of eight square metres. Wing B has a span of 6m and a chord of 1.35m which also provides a wing area of eight square metres. We say Wing A has a higher aspect

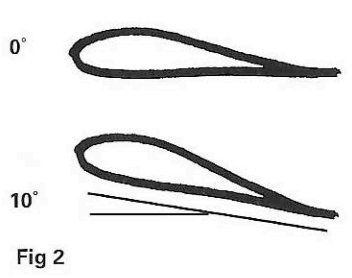


Fig 2

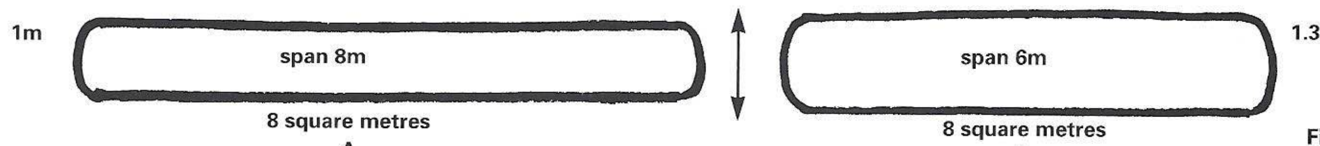


Fig 3

ratio than Wing B.

The wing with the highest Aspect Ratio is very efficient and provides very good lift at low speeds because it interacts with a wider front of air than Wing B. If Wing A, with the high Aspect Ratio, were to progress forwards at ten metres per second, it would interact with 80 square metres of air every second. Wing B on the other hand would only interact with 60 square metres of air per second. Wing A comes into contact with a broader band of air, and therefore, has more air interacting with it than Wing B, and thus, has the potential to provide more lift than Wing B at a given speed.

This may be the case, but the extra lift is obtained at a price. Because Wing A comes into contact with more air than Wing B, it also has more drag, in fact 25% more drag. Furthermore, Wing A would be subject to more stress and buffeting in strong, windy weather. Wing B, although shorter, is 35% broader and this extra width provides extra float to compensate. The advantages of Wing B are therefore:

1. The drag coefficient is substantially less than Wing A.

2. Owing to less stress at high speed or in windy conditions, our pigeon would not be inclined to tire as quickly as it would with a wing like A.

The basic principles sketched so far must be kept in mind as we continue this study of the mechanics of flight. Before the practical application of the wing can be discussed, it is necessary to know how lift is provided. To begin with, a wing is not merely a flat plate or object that is buoyed up by air when propelled in one or other direction.

A cross-section of a wing will reveal to us that it has a very distinctive shape. This shape is called an aerofoil section (see fig 4).

Fig 4

Aerofoil section

The function of an aerofoil section is to direct the flow of air and to create a reduction of pressure on the upper surface of the wing. To illustrate the function of an aerofoil we will once again use sketches to assist with the explanation. Fig 5 shows a flat plate passing through the air. Note the passage of the streamlines.

Note the turbulence both in front of the plate and along its upper and lower surfaces. Also note that in such undisciplined circumstances of air turbulence, no lift is produced. Now, look at the airflow over an aerofoil section as shown in fig 6, and note the orderly and disciplined flow of the air and how this airflow interacts with the aerofoil to produce lift.

Note how the streamlines A lift up and over the upper surface of the wing, while streamlines B1 and B2 start parting even before they come into contact with the aerofoil. Take special note of the fact that the air passes smoothly over the surfaces both top and bottom. Furthermore the air travelling over the top of the wing has a greater distance to travel than that on the underside. As the air passes over the top of the wing, it accelerates so that it will arrive at the back of the wing at the same time as the air passing under the wing. In the process the air on the upper side of the aerofoil is stretched and this brings about a drop in pressure. The wing is then drawn up into this area of low pressure and we have lift.

Having established the function of the aerofoil, let's go on to say that there are different types of aerofoils for different purposes. To keep it simple, there is a high-lift section normally used for transport aircraft, designed to provide maximum lift while speed is no real criteria. High-speed aerofoil sections are used for supersonic aircraft and provide less lift, but also have less drag. As supersonic aircraft have an abundance of thrust, the high-speed section is designed to provide the required lift at much higher speed than the high-lift section. We also have a general purpose aerofoil section used mainly on subsonic passenger aircraft. This widely used section provides good lift while not being too prone to drag. Drag, it must be remembered, is the main inhibitor of forward progress or

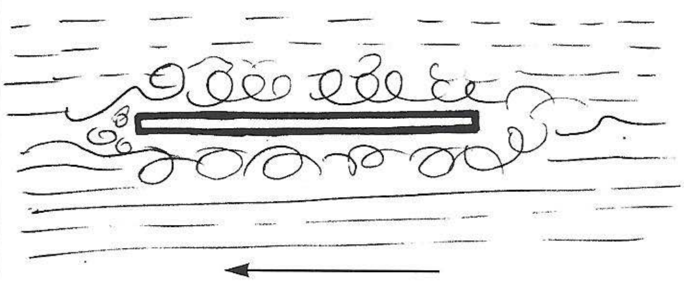


Fig 5

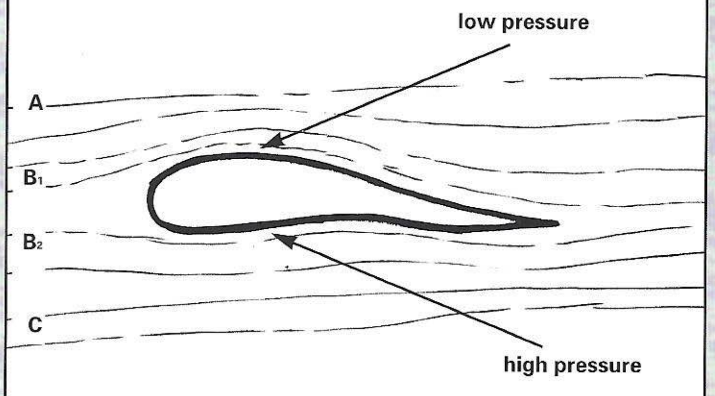
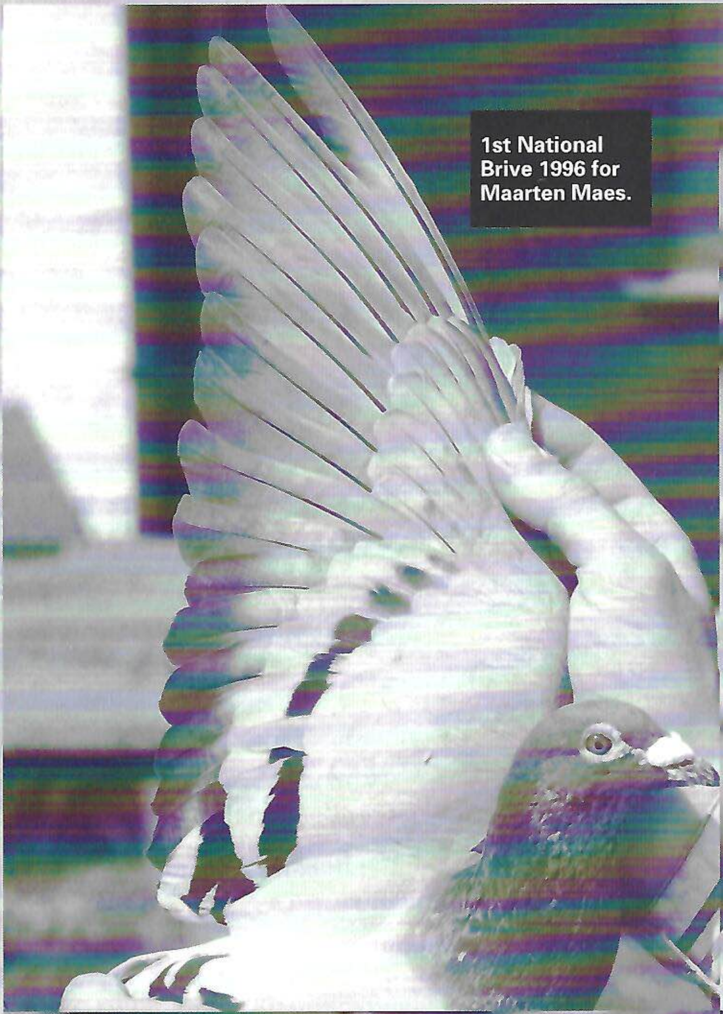
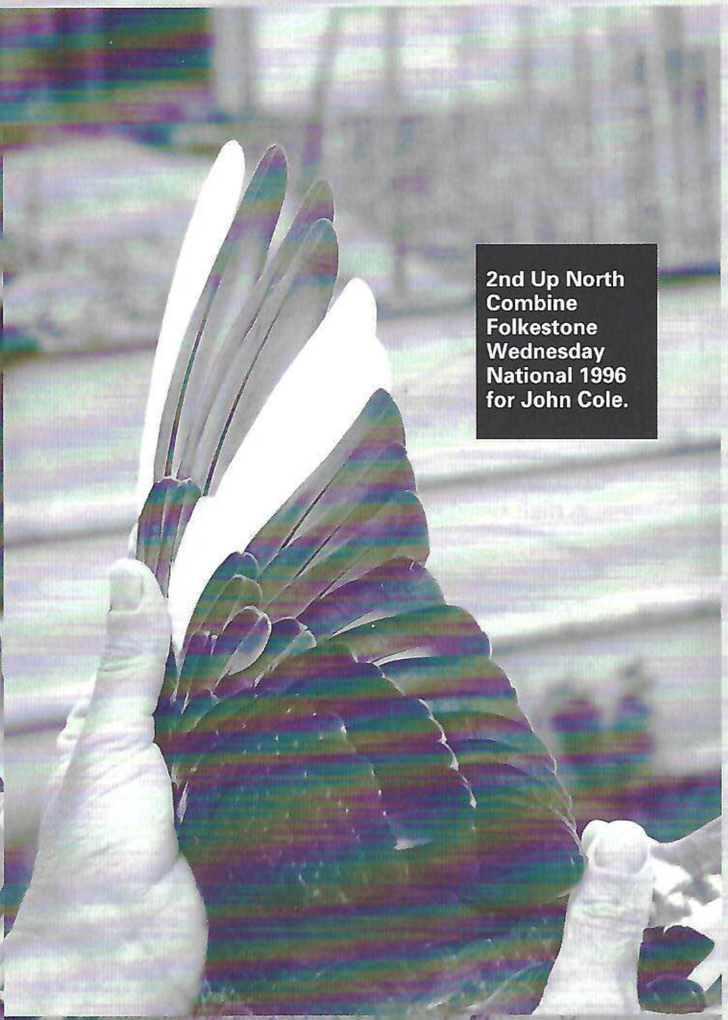


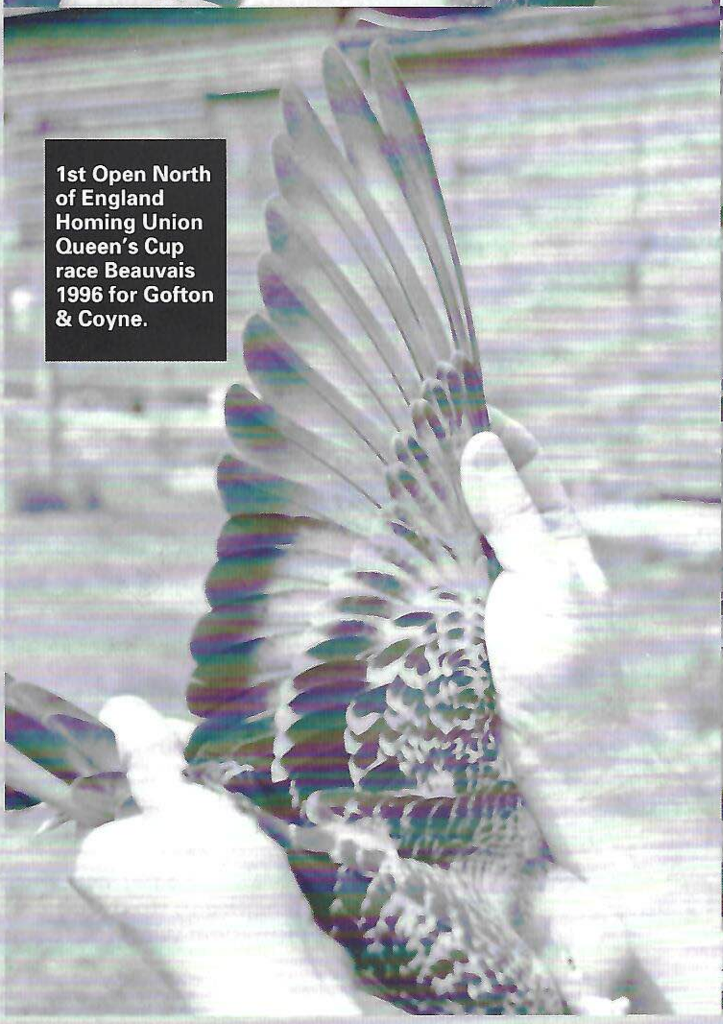
Fig 6



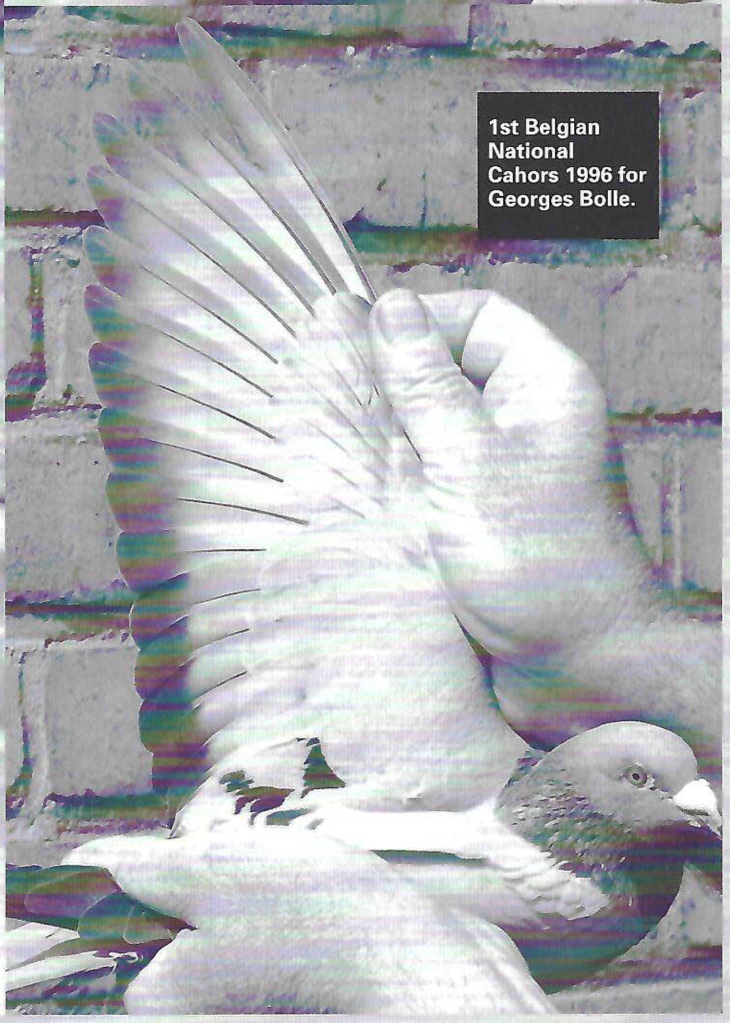
1st National Brive 1996 for Maarten Maes.



2nd Up North Combine Folkestone Wednesday National 1996 for John Cole.



1st Open North of England Homing Union Queen's Cup race Beauvais 1996 for Gofton & Coyne.



1st Belgian National Cahors 1996 for Georges Bolle.

speed.

To give an example of this, suppose we have an aircraft capable of flying at 200kph (125mph), to double the speed to 400kpm (250mph) we would require four times as much power and not double the power. Alternatively, using the same power with the same thrust and want to design an aircraft able to fly at

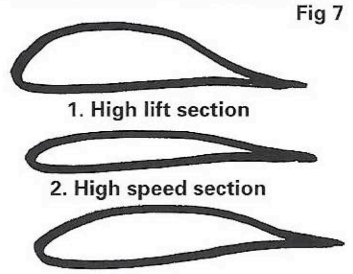


Fig 7

400kph (250mph), we must see where drag can be reduced. See fig 7 for the difference between aerofoil sections.

Taking into account that our average racing pigeon flies at approximately 80kph (50mph) we can make some assumptions:

1. To double the speed, four times more power is required and as far as I know, the pigeon able to fly at 160kph (100mph) has not yet been bred.

2. To increase the speed of our pigeon without increasing the power (muscle), we must strive to reduce the factors working against us, notably drag. We must also strive to have a loft of pigeons with the most efficient wings possible.

By increasing the efficiency of the wing, minimising weight and keeping drag down by having birds with soft silky feathers, we can cut down on the energy needed to fly at 80kpm (50mph). We may even be able to breed new improved pigeons able to fly at 83kph (52mph), while expending the same energy as the average pigeon. Undoubtably, this would provide the winning edge.

3. As our pigeons most definitely don't fly at supersonic speeds, we can discount the need for a high-speed section.

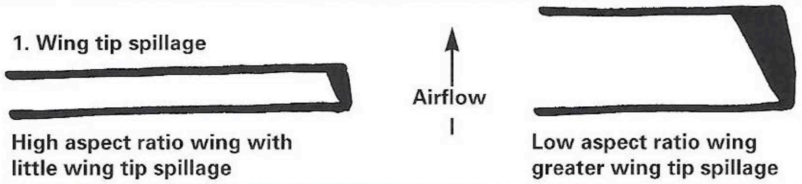
4. Many birds, including pigeons, have general purpose aerofoil sections as most of them only fly short distances in search of food. Our racing pigeons, however, are required to perform over distances of up to 1200km (750 miles) or even further. It would be prudent therefore to pay some attention to


1st Up North Combine Beauvais 1996 for Whittaker & Richards.

the lift potential, especially if you want to win on the longer races. Keep in mind too, that when there is plenty of lift, it makes controlled flight much easier and the pigeon will not tire so easily.

Factors which cause loss or breakdown of lift include wing tip spillage. At the wing tips, the air passing the end of the wing causes a breakdown of the streamlines and this in turn produces an area where no lift or disciplined air flow is maintained. This is called wing tip spillage. Nature has adapted the wings of some birds to counteract this problem. An eagle, for example,

Fig 8



has the primaries at the wing tip spaced apart, each feather in essence a separate little wing with its own aerofoil section. Each

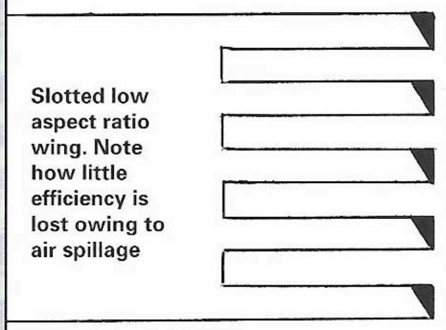


Fig 9

feather being narrow has very little wing tip spillage, and the end result is that maximum flight is efficiently maintained, see fig 9. The louvres between the primaries are yet another of Nature's methods of directing the flow of air by channelling the streamlines smoothly over the following feather. These are also known as slots.

Sea birds have wings which are pointed at the tips, the ends of their wings also point slightly back. With a wing like this there is only very minor spillage.

Because sea birds also have a very high Aspect Ratio; they are not able to fly very fast even though they can cover vast distances at slower speeds. Aircraft engineers and designers have worked for years to develop wings for special purposes and to improve the efficiency in general. Having Nature as our library, we must conclude that every different bird has a wing perfect for its environment and habitat, but inappropriate and unsuited in other circumstances. We must realise therefore, that we cannot ever design or develop the perfect wing. What we do aspire to do though is to arrive at the ideal wing for racing.

continued next month