Control Surfaces

What is a control surface? The name can be a bit misleading because it implies that it is a surfaces where things are controlled, similar to a military ground. But it is still not far from a literal translation of the name, it is a surface that that can be controlled so a more suitable name would be 'controllable surface'.

Introduction: Without control surfaces it would take a lot of energy for a plane to maneuver itself. This is because they take advantage of the drag created by the moving craft in a fluid to push it in the direction it wants to go. You see this kind of thing all the time in almost every flying machine, from the one created by humans to the flying machines that evolution perfected: birds. Or even fish under water. Trees can also make use of them in their seeds.

In planes, control surfaces are used for all kinds of things, the following diagram includes a few of those uses in RC planes.

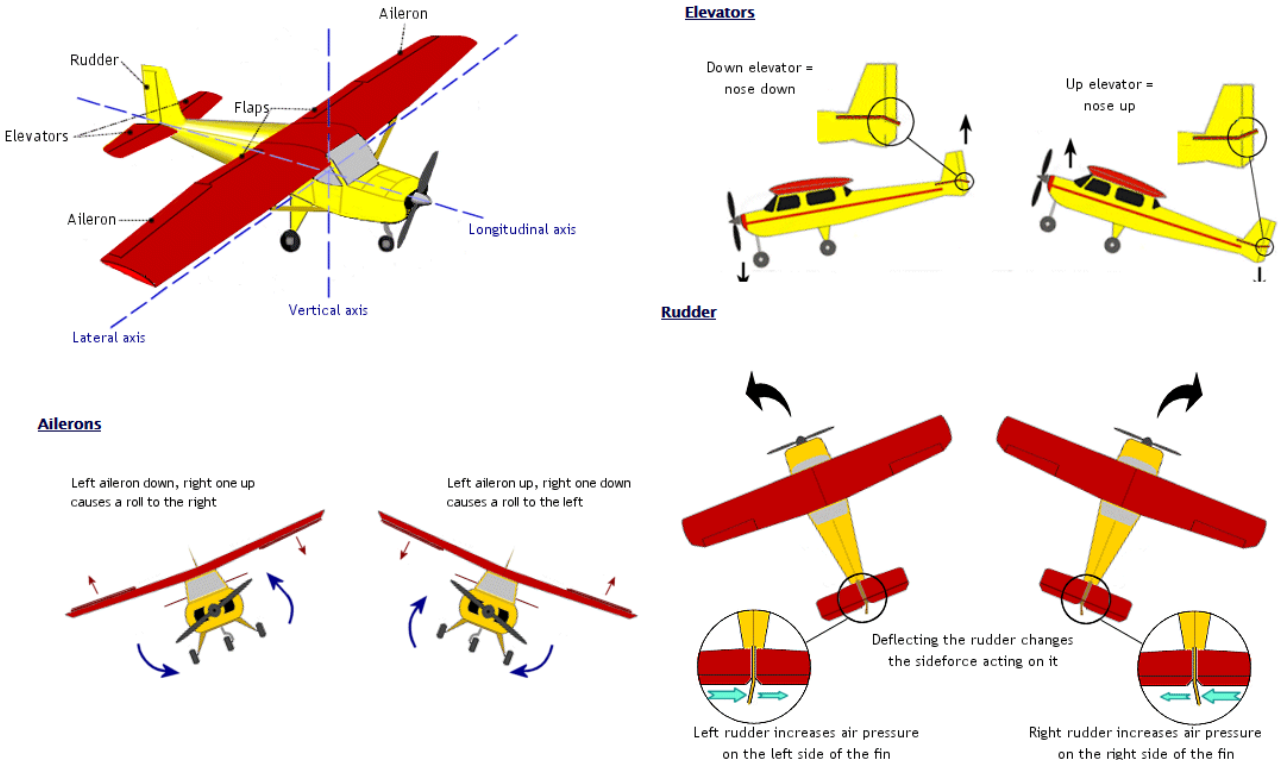

Fig 1.1

In Jet planes, they may also be used for braking by taking advantage of drag.

- Ailerons and flaps – These are located (as shown in the diagram) on the wingspan of the plane. Their job is to control the crafts rolling maneuver when one goes up, the other goes down to create a net torque that rolls the plane. Flaps are usually an optional component.

- Elevators – These are located at the back of the plane along the same axis as the ailerons. Both of the surfaces move in the same direction at the same time to control the planes pitch. These wont require as much energy to move because when they move a little, the wings where the ailerons are attached will assist the change in pitch which is also why they are significantly smaller (decreases the torque required to turn it).

- Rudder – The rudder is one single control surface that controls the planes yawing maneuver but they are not essential for turning the craft.

*NOTE: Aircraft will often not use the the rudder to complete a turn, this is because it causes too much centripetal acceleration (severe g-force) which can be harmful and can cause unnecessary drag on the side of the craft. Rather aircrafts would combine the movement of the ailerons and flaps with the elevators by first rolling, then creating lift in the sideways direction with the elevators, this is a far more efficient and safe way of completing a turn in a plane.

How do we make those control surfaces move? Servos.

- The basic idea is to convert electrical energy into kinetic energy. We already know how to do this, we can use a motor. But this is only half the solution because just placing a motor's axle onto a control surface is tedious and it ends up being a very inefficient device that is also hard to control. When moving a control surface, we require much more torque then angular speed because they don't need to move very fast and we also need a more effective way of controlling it.
- This device (robot muscle) is what is known as a servo. There are other ways of converting electrical energy into kinetic energy but this is the most common one. It looks like this, see figure 2.1

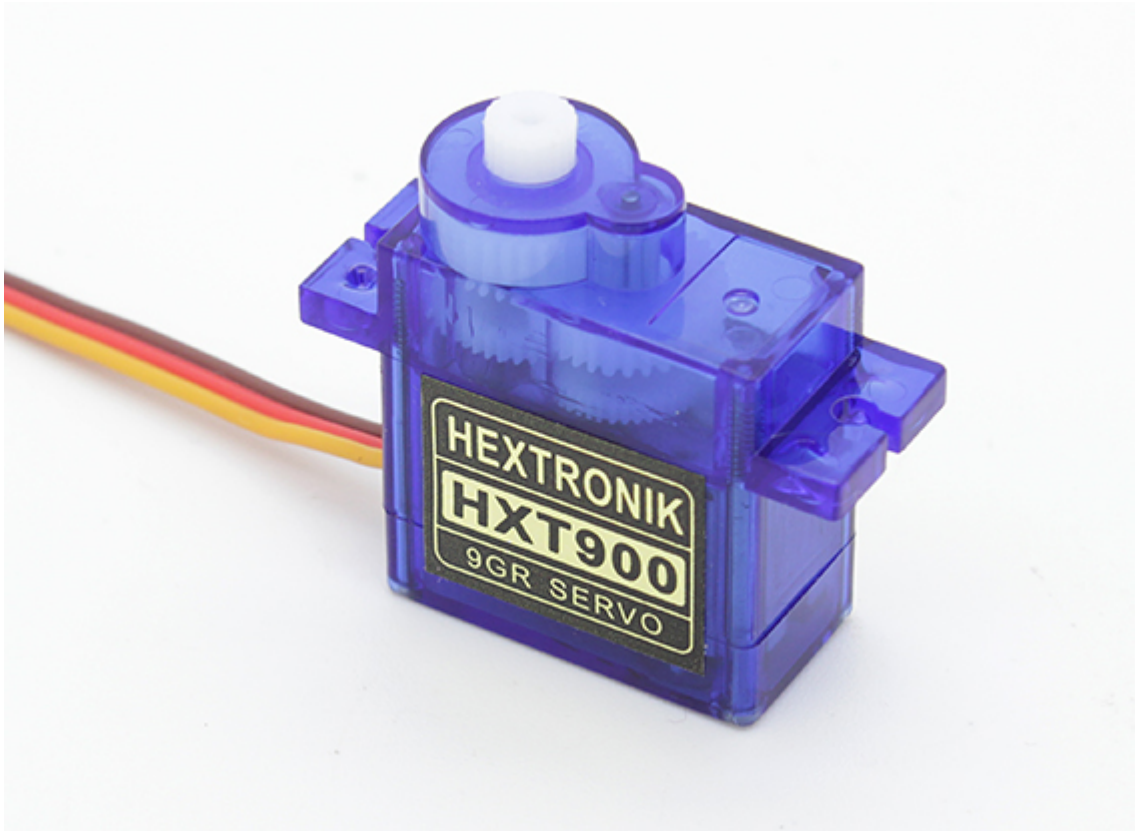

Fig 2.1

A servo this small, about 2cm long can produce a torque of up to 1.6kg (1600N). This is rather large compared to the torque produced by amotor. So how do we increase the torque? You will have to use the idea of gear ratios with the goal being to increase the work done/revolution of the final gear. If you begin with a gear with less notches attached

to the motor and have it move a much larger gear, the larger gear would spin slower but will produce more torque depending on how much larger it is.
In figure 2.3 you can see how the servo does this.

Fig 2.3

To make the servo move the required amount and no more or less with precision we use a certain type of wave function known as PWM (pulse with modulation). Which, put simply, sends pulses of a given voltage to the servo. As the pulses get closer to each other (lower duty cycle), the average voltage becomes higher and as they move further apart from each other (larger duty cycle) the average voltage drops, producing less motion. The function looks like this (a square wave), Figure 2.4

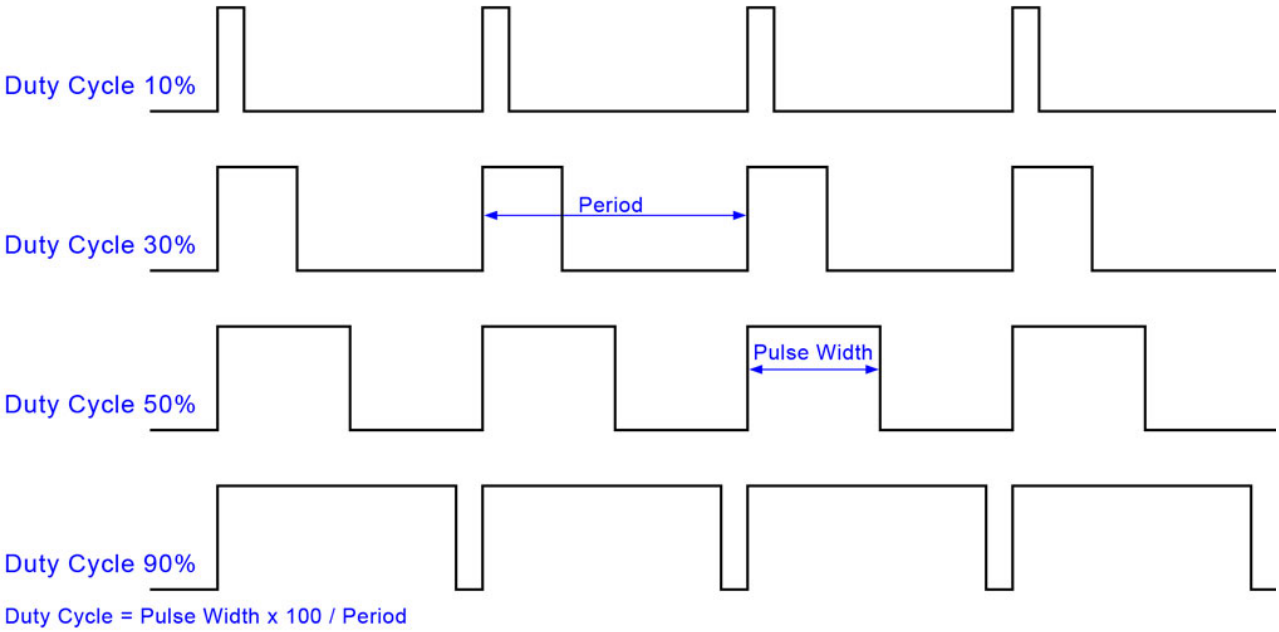

Fig 2.4

NOTE: this is the same type of function sent by the ESC to a motor.