Flight Controls Info
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Flight Controls

Aircraft flight controls allow a pilot to guide a plane to a destination. This article describes controls used on a fixed wing aircraft of conventional design. Other fixed wing aircraft configurations may use different control surfaces but the basic principles remain. The controls for rotary wing aircraft helicopter or autogyro) are completely different.

Axes of motion: An aircraft is free to rotate around three axes which are perpendicular to each other and intersect at the plane's center of gravity (CG). To control position and direction a pilot must be able to control rotation about each of them.
Vertical - The vertical axis passes through the plane from top to bottom. Rotation about this axis is called yaw. Yaw changes the direction the aircraft's nose is pointing, left or right. The primary control of yaw is with the rudder. Ailerons also have a secondary effect on yaw. **The Rudder controls movement around the vertical axis**.
Longitudinal - The longitudinal axis passes through the plane from nose to tail. Rotation about this axis is called bank or roll. Bank changes the orientation of the aircraft's wings with respect to the downward force of gravity. The pilot changes bank angle by increasing the lift on one wing and decreasing it on the other. This differential lift causes bank rotation around the longitudinal axis. The ailerons are the primary control of bank. The rudder also has a secondary effect on bank. **The ailerons contol movement around the longitudinal axis** , on larger airplanes in conjunction with the spoilers.
Lateral - The lateral axis passes through the plane from wingtip to wingtip. Rotation about this axis is called pitch. Pitch changes the vertical direction the aircraft's nose is pointing. **The elevators are the primary control of pitch**, on larger airplanes in conjunction with the stabilizer.
It is important to note that these axes move with the aircraft, and change relative to the earth as the aircraft moves. For example, for an aircraft whose left wing is pointing straight down, its "vertical" axis is parallel with the ground, while its "lateral" axis is perpendicular to the ground.

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Main Control Surfaces
The main control surfaces are attached to the airframe on hinges so they may move and thus deflect the air stream passing over them. This redirection of the air stream generates an unbalanced force to rotate the plane about the associated axis.

Ailerons - Ailerons are mounted on the back edge of each wing near the wingtips, and move in opposite directions. When the pilot moves the stick left, or turns the wheel counter-clockwise, the left aileron goes up and the right aileron goes down. A raised aileron reduces lift on that wing and a lowered one increases lift, so moving the stick left causes the left wing to drop and the right wing to rise. This causes the plane to bank left and begin to turn to the left. Centering the stick returns the ailerons to neutral maintaining the bank angle. The plane will continue to turn until opposite aileron motion returns the bank angle to zero to fly straight.
Elevators - An elevator is mounted on the back edge of the horizontal stabilizer on each side of the fin in the tail. They move up and down together. When the pilot pulls the stick backward, the elevators go up. Pushing the stick forward causes the elevators to go down. Raised elevators push down on the tail and cause the nose to pitch up. This makes the wings fly at a higher angle of attack which generates more lift and more drag. Centering the stick returns the elevators to neutral and stops the change of pitch.
Rudder - The rudder is mounted on the back edge of the fin in the tail. When the pilot pushes the left pedal, the rudder deflects left. Pushing the right pedal causes the rudder to deflect right. Deflecting the rudder right pushes the tail left and causes the nose to yaw right. Centering the rudder pedals returns the rudder to neutral and stops the yaw.

`Secondary effects of controls`
`Ailerons:` The ailerons primarily control bank. However because the air underneath a wing is denser than that above it, the lowering aileron causes more drag on its side than the rising aileron. Using ailerons causes a small amount of yaw to occur. This is more pronounced for light aircraft with long wings, such as gliders. It is usually counteracted by the pilot with the rudder.
Rudder: Using the rudder causes one wing to move forward faster than the other. Increased speed means increased lift, and hence rudder use causes a small roll effect. For this reason ailerons and rudder are generally used together on light aircraft.

Turning the aircraft
Unlike a boat, turning an aircraft is not normally carried out with the rudder. Instead the ailerons are used to bank the aircraft. The forces on the plane cause the aircraft to turn in the same direction as the bank, with a steeper bank causing a faster turn. While this is happening the nose of the aircraft has a tendency to drop, and the aircraft may also yaw, so the nose is not pointing in the direction it is flying. The elevators are used to counteract the first, and the rudder to counteract the second.

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`Alternate main control surfaces`
Some aircraft configurations have non-standard primary controls. For example instead of elevators at the back of the stabilizers, the entire tailplane may change angle. Most supersonic aircraft will have a fully-moving tail. Some aircraft have a tail in the shape of a V, and the moving parts at the back of those combine the functions of elevators and rudder. Delta wing aircraft may have "elevons" at the back of the wing, which combine the functions of elevators and ailerons.

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Secondary control surfaces
Trimming controls allow a pilot to balance the lift and drag being produced by the wings and control surfaces over a wide range of load and airspeed. This reduces the effort required to adjust or maintain a desired flight attitude.

Trim Tabs - Trim tabs are used to adjust the position of an associated main control surface. They are often hinged to the back edge of the control surface with a control in the cockpit. Some trim tabs on light aircraft are fixed sheets of metal that can be bent while the aircraft is on the ground but cannot be controlled in flight. In many newer airplanes the trim tabs may be adjusted by controls in the cockpit. They can be controlled from the cockpit by a manual trim wheel or an electric switch, to move the trim in the desired direction. Both types function by redirecting the air stream to generate a force which holds the main control surface in the desired position. Because they are furthest from the pivot point of the main control surface, their small aerodynamic effects are magnified by leverage to achieve the deflection of the main surface.
Balance Tabs look like trim tabs and are hinged in the same places as trim tabs. The difference between the two tabs is that the balancing tab is linked to the control surface by a rod, so that when the primary control surface is moved in any direction and the tab automatically is moved in the **opposite direction**.
Servo tabs are very similar to trim tabs. Servo tabs are used mainly on the larger airplanes to aid the pilot in moving the control surface. The flight control in the cockpit controls only the tab.
Trimming Tail Plane - Except for very light aircraft, trim tabs on elevators are unable to provide the force and range of motion desired. To provide the appropriate trim force the entire horizontal tail plane is made adjustable in pitch. This allows the pilot to select exactly the right amount of positive or negative lift from the tail plane while reducing drag from the elevators.
Dampening devices `Control Horn` - A control horn is a section of control surface which projects ahead of the pivot point. It generates a force which tends to increase the surface's deflection thus reducing the control pressure experienced by the pilot. Control horns may also incorporate a counterweight which helps to balance the control and prevent it from "fluttering" in the airstream. Some designs feature separate anti-flutter weights.

`Balance panels` are an extension of the flight control forward of the nose and operate in air separated chambers between upper and lower surface to dampen the movement.

`Balance weights` are attached behind the hinge, but reach forward with a long lever to relatively far forward of the flight control. This is another way to dampen the movement.

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`Other Controls`
Spoilers - On very high lift/low drag aircraft like sailplanes, spoilers are used to disrupt airflow over the wing and greatly reduce the amount of lift. This allows a glider pilot to lose altitude without gaining excessive airspeed. Spoilers are sometimes called "lift dumpers".
Flaps - Flaps are mounted on the back edge of each wing near the wing roots. They are deflected down to increase the effective curvature of the wing and produce additional lift, and also reduce the stalling speed of the wing. They are used during low speed, high angle of attack flight like descent for landing.
Slats are extensions to the front of a wing for lift augmentation, and are intended to reduce the stalling speed by altering the airflow over the wing. Slats may be fixed or retractable - fixed slats (e.g. as on the Fieseler Storch) give excellent slow speed and STOL (Short Take Off & Landing) capabilities, but compromise higher speed performance. Retractable slats, as on most airliners, allow higher lift on take off, but retract for cruising. Air brakes - these are used on high speed aircraft and are intended to increase the drag of an aircraft without altering the amount of lift.
Airbrakes and spoilers are sometimes the same device - on most airliners for example, the combined spoiler/airbrakes act to simultaneously remove lift and to slow the aircraft's forward motion. They are deployed on landing to assist braking the aircraft and to ensure that it stays on the ground. Mechanical braking of the wheels is assisted by both functions - the weight of the aircraft carried by its wings is transferred to the undercarriage when the lift is dumped, so there is less chance of a skid, and the airbrake effect increases the form drag of the aircraft.

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An **elevon** is an aircraft control surface that combines the functionality of the elevator (used for pitch control) and the aileron (used for roll control), hence its name. It is frequently used in tailless aircraft such as flying wings.
There will be one or more elevons on each side of the aircraft at the trailing edge of the wing. When moved in the same direction (up or down) they will cause a pitching force to be applied to the airframe. When moved differentially, (one up, one down) they will cause a rolling force to be applied. These forces may be applied simultaneously by appropriate positioning of the elevons. For another picture of an aircraft that uses elevons see F4D Skyray.

Canard: An aircraft whose horizontal stabilizing surfaces are forward of the main wing.

A flaperon is a control surface on an aircraft wing functioning both as a flap and as an aileron.

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Servo tabs are small flaps installed on aircraft control surfaces to assist the movement of the control surface.
Servo tabs move in the opposite direction of the control surface. The tab has a leverage advantage, being located closer to the trailing edge of the surface and thus can lever the control surface in the opposite direction. This has the effect of reducing the control force required by the pilot to move the controls.
An **anti-servo tab** works in the opposite way. It deploys in the same direction as the control surface, making the movement of the control surface more difficult and requires more force applied to the controls by the pilot. This may seem counter-productive, but it is commonly used on aircraft where the controls are too light or the aircraft requires additional stability in that axis of movement. The anti-servo tab serves to artificially increase stability and also make the controls heavier in feel to the pilot.

Types of ailerons & adverse yaw:
`Adverse yaw` caused by the deflection of the ailerons which results in more drag on one side of the plane than on the other. This difference causes the nose of the airplane to turn opposite to the desired roll.
`Frise aileron` is an aileron that has a bevelled leading edge and its pivot point is well behind and below the aileron leading edge. This minimizes the profile drag on the wing with the down aileron while increasing the profile drag on the wing with the up aileron. This counteracts the effect of induced drag thereby creating an adverse yaw effect.

`Differential ailerons:` solve adverse yaw by deflecting the ailerons by differing amounts, much less down deflection than up!.

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[1] **control surface:** The American Heritage ® Dictionary of the English Language, Fourth Edition. Houghton Mifflin Company, 2004. Answers.com GuruNet Corp. 25 Sep. 2005. http://www.answers.com/topic/flight-controls

[2] **control surface:** WordNet 1.7.1. Princeton University, 2001. Answers.com GuruNet Corp. 25 Sep. 2005. http://www.answers.com/topic/flight-controls

[3] **control surface:** Wikipedia. Wikipedia, 2005. Answers.com GuruNet Corp. 25 Sep. 2005. http://www.answers.com/topic/flight-controls