AIRPLANE FLIGHT CONTROLS

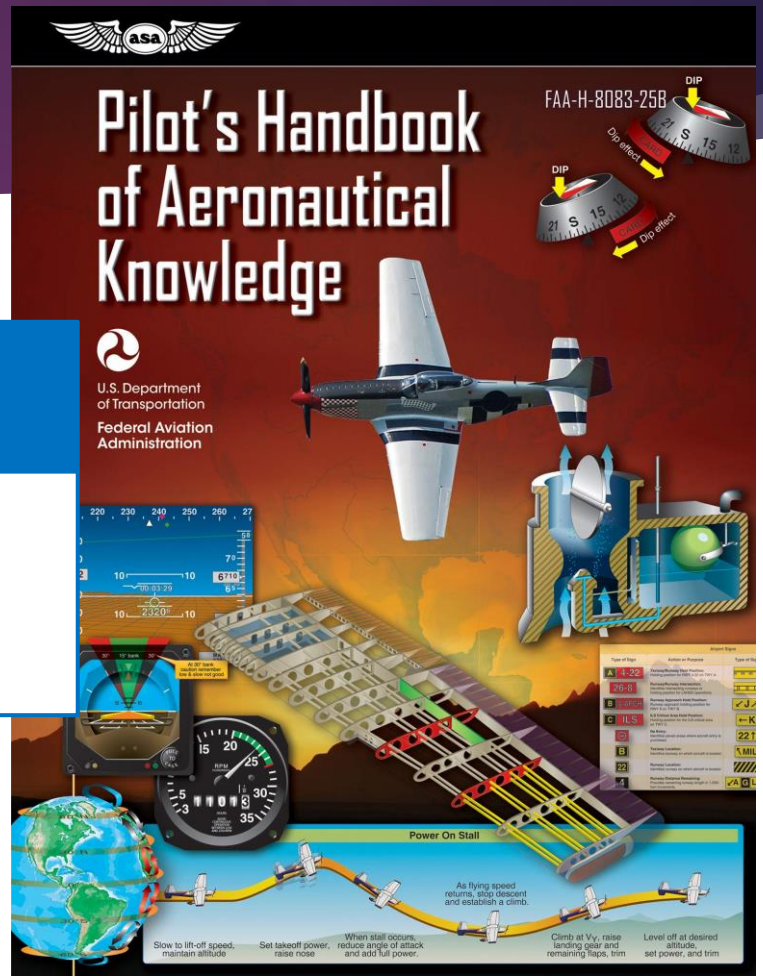
Lesson Outline

LESSON OBJECTIVE

To determine that the student exhibits proficient knowledge of the elements related to airplane flight controls by describing the elements on the following slide.

LESSON SOURCE(S)

Pilot's Handbook of Aeronautical Knowledge
FAA-H-8083-25



Lesson Outline

LESSON ELEMENTS	TIMEFRAME	EQUIPMENT/TOOLS
Primary Flight Controls Secondary Flight Controls Trim Controls	45 Minutes *approximately* Discuss Objectives Present and Review Material Student Questions Conclusion and Quiz	Lesson Presentation Whiteboard and Markers FAA Sources and References

Lesson Outline

INSTRUCTOR ACTIONS	STUDENT ACTIONS	COMPLETION STANDARDS
Present Objectives and Standards Teach Lesson from Presentation Ask and Answer Student Questions Assign Homework Check Student's Post Lesson Quiz	Participate in Lesson Take Notes Ask and Respond to Questions Pass the Post Lesson Quiz	Student is able to understand and differentiate between the different lesson elements. Student is further able to apply this acquired knowledge in flight training/flight operation scenarios effectively and appropriately.

Primary Flight Controls

Aircraft flight control systems consist of primary and secondary systems. The ailerons, elevator (or stabilator), and rudder constitute the primary control system and are required to control an aircraft safely during flight.

Ailerons

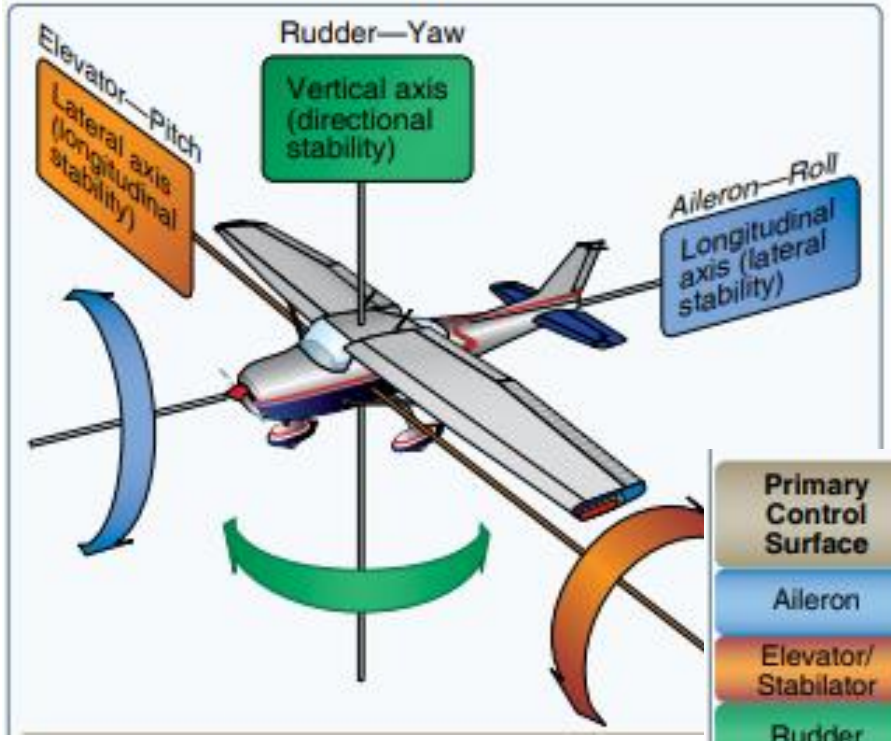
Ailerons control roll about the longitudinal axis.

Elevator

The elevator controls the pitch of the airplane about the lateral axis.

Rudder

The rudder controls the yaw of the airplane about the vertical axis.



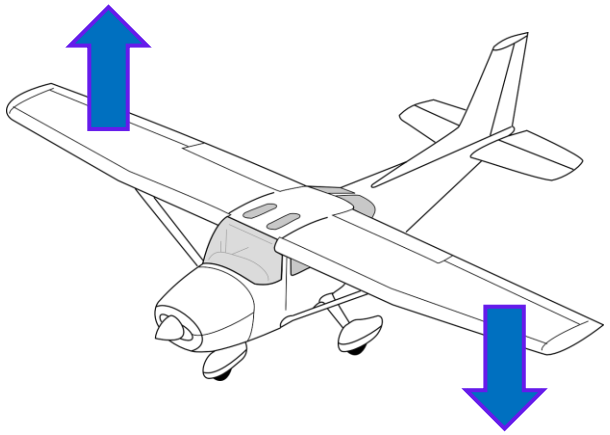
Primary Control Surface	Airplane Movement	Axes of Rotation	Type of Stability
Aileron	Roll	Longitudinal	Lateral
Elevator/ Stabilator	Pitch	Lateral	Longitudinal
Rudder	Yaw	Vertical	Directional

Primary Flight Controls

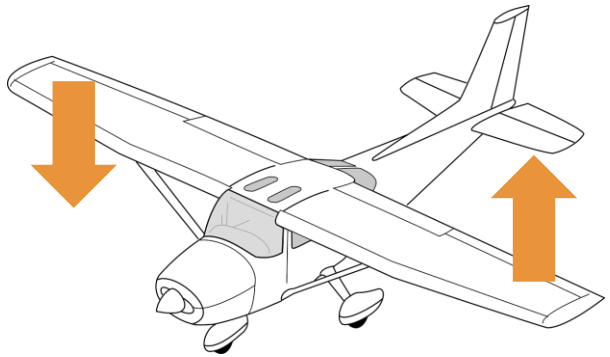
Ailerons

Ailerons control roll about the longitudinal axis. The ailerons are attached to the outboard trailing edge of each wing and move in the opposite direction from each other. Ailerons are connected by cables, bellcranks, pulleys, and/or push-pull tubes to a control wheel or control stick.

Control Wheel To the Right



Control Wheel To the Left



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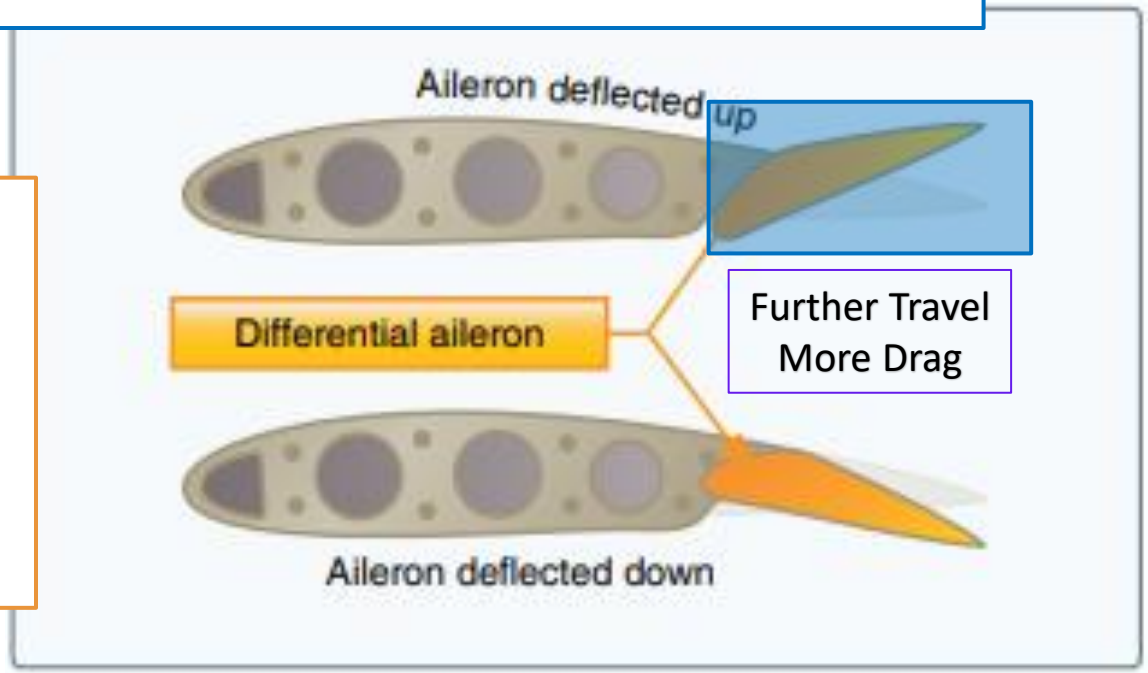
Differential Ailerons

With differential ailerons, one aileron is raised a greater distance than the other aileron and is lowered for a given movement of the control wheel or control stick. This produces an increase in drag on the descending wing. The greater drag results from deflecting the up aileron on the descending wing to a greater angle than the down aileron on the rising wing. This helps to reduce adverse yaw.



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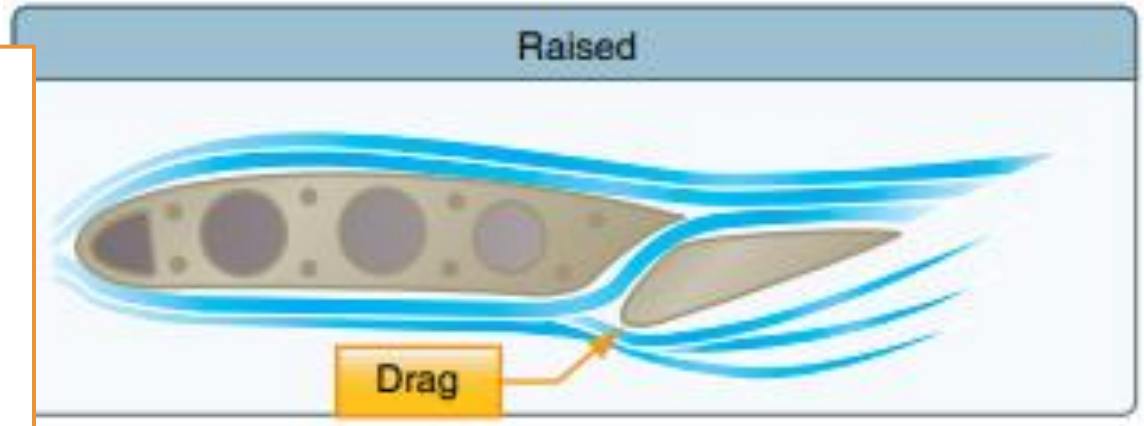
Frise-Type Ailerons

When pressure is applied to the control wheel, or control stick, the aileron that is being raised pivots on an offset hinge. This projects the leading edge of the aileron into the airflow and creates drag. It helps equalize the drag created by the lowered aileron on the opposite wing and reduces adverse yaw.



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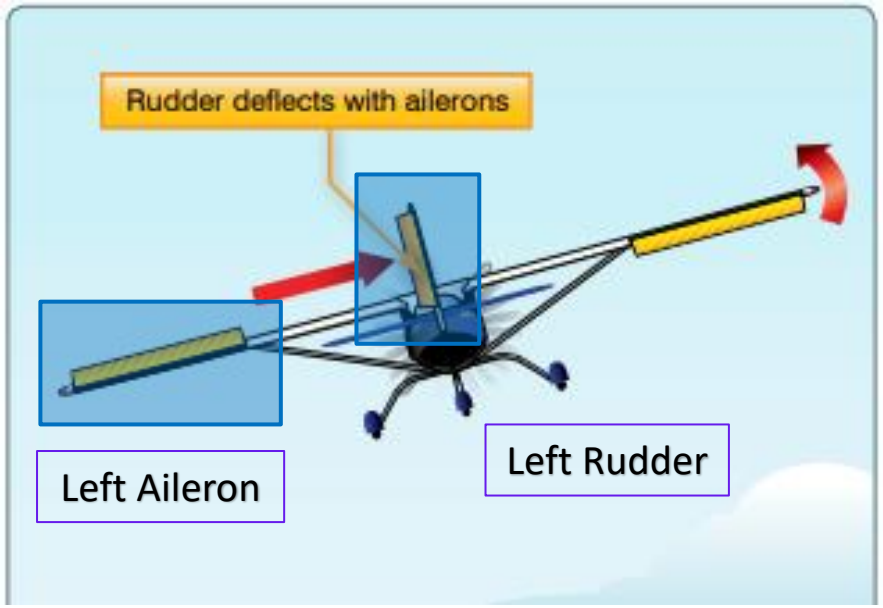
Coupled Ailerons and Rudder

Coupled ailerons and rudder are linked controls. This is accomplished with rudder-aileron interconnect springs, which help correct for aileron drag by automatically deflecting the rudder at the same time the ailerons are deflected. For example, a left aileron input will also be accompanied by left deflection of the elevator to help reduce adverse yaw.



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Flaperons

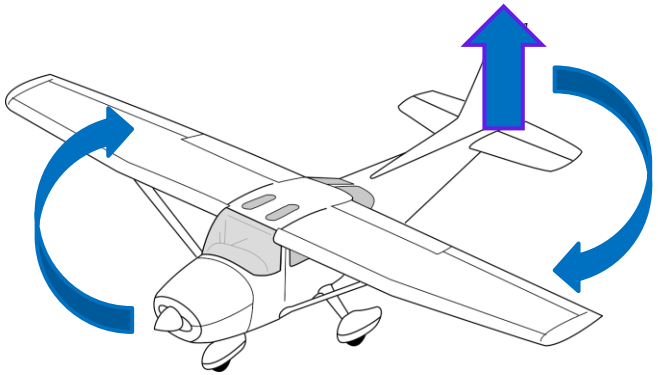
Flaperons combine both aspects of flaps and ailerons. In addition to controlling the bank angle of an aircraft like conventional ailerons, flaperons can be lowered together to function much the same as a dedicated set of flaps. The pilot retains separate controls for ailerons and flaps.

Primary Flight Controls

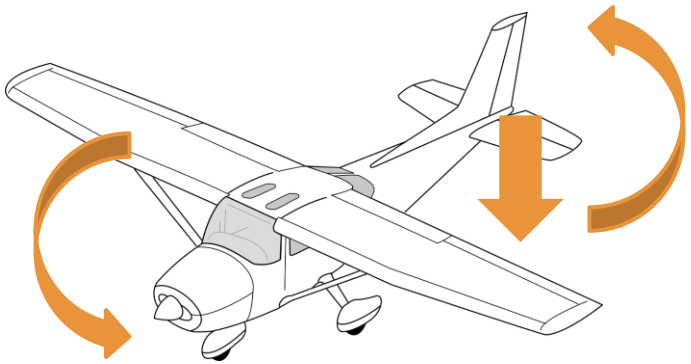
The Elevator

The elevator controls pitch about the lateral axis. Like the ailerons on small aircraft, the elevator is connected to the control column in the flight deck by a series of mechanical linkages.

Control Wheel Aft



Control Wheel Forward



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T-Tail Elevator

In a T-tail configuration, the elevator is above most of the effects of downwash from the propeller, as well as airflow around the fuselage and/or wings during normal flight conditions. Operation of the elevators in this undisturbed air allows control movements that are consistent throughout most flight regimes.

Primary Flight Controls

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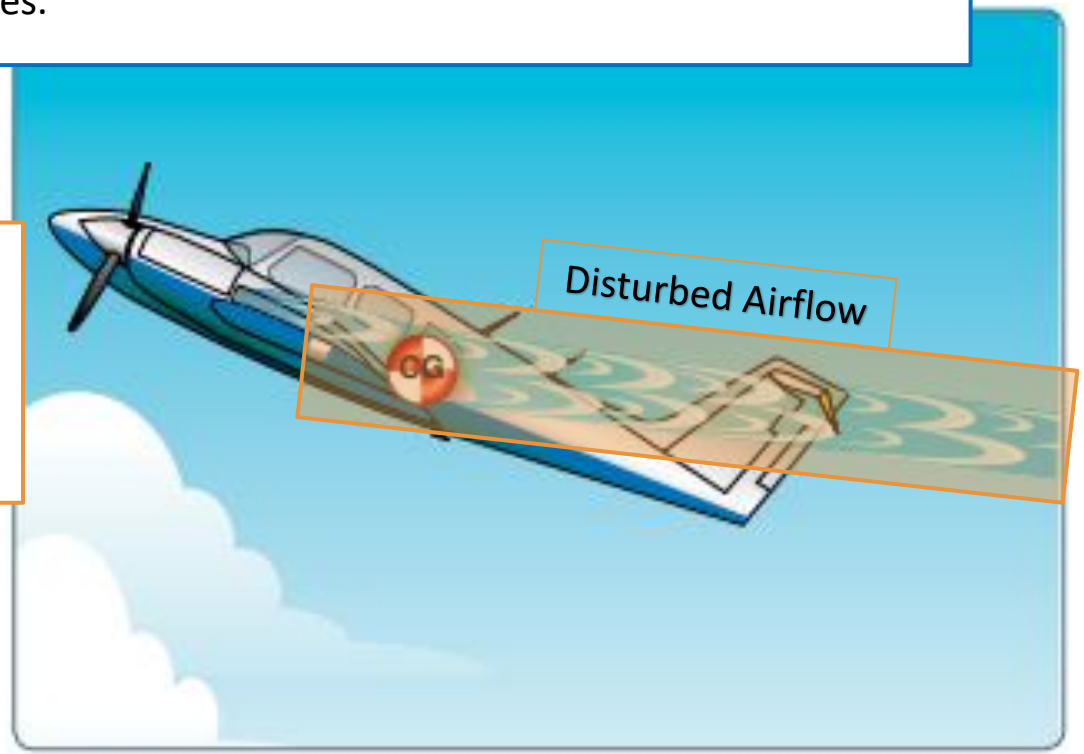
T-Tail Elevator

When flying at a very high AOA with a low airspeed and an aft CG, the T-tail aircraft may be more susceptible to a deep stall. In this condition, the wake of the wing impinges on the tail surface and renders it almost ineffective.



Primary Flight Controls

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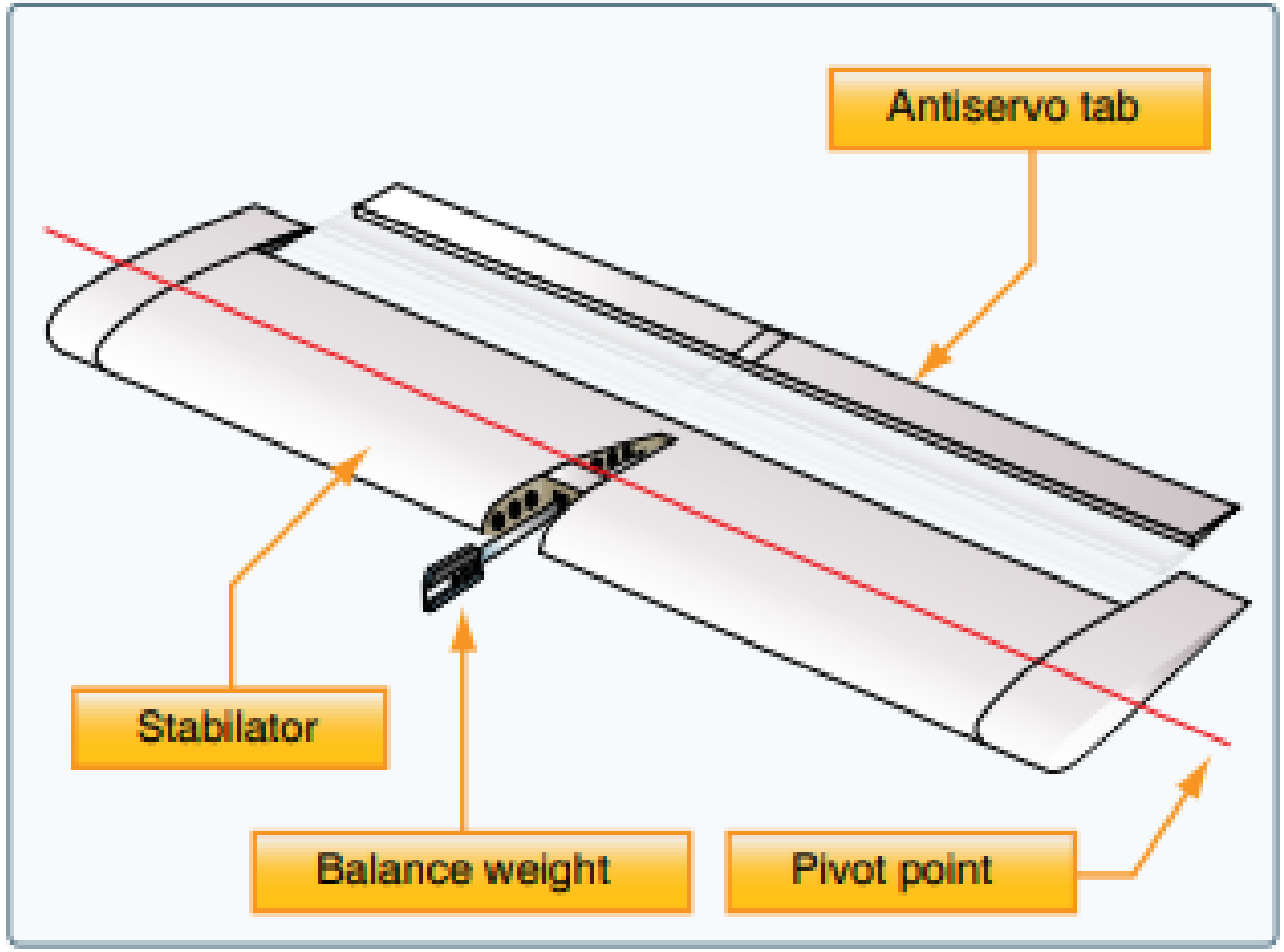
Stabilator

A stabilator is essentially a one-piece horizontal stabilizer that pivots from a central hinge point. When the control column is pulled back, it raises the stabilator's trailing edge, pulling the nose of the aircraft. Because stabilators pivot around a central hinge point, they are extremely sensitive to control inputs and aerodynamic loads. Antiservo tabs are incorporated on the trailing edge to decrease sensitivity.


Antiservo tab
Stabilator
Balance weight
Pivot point

Primary Flight Controls

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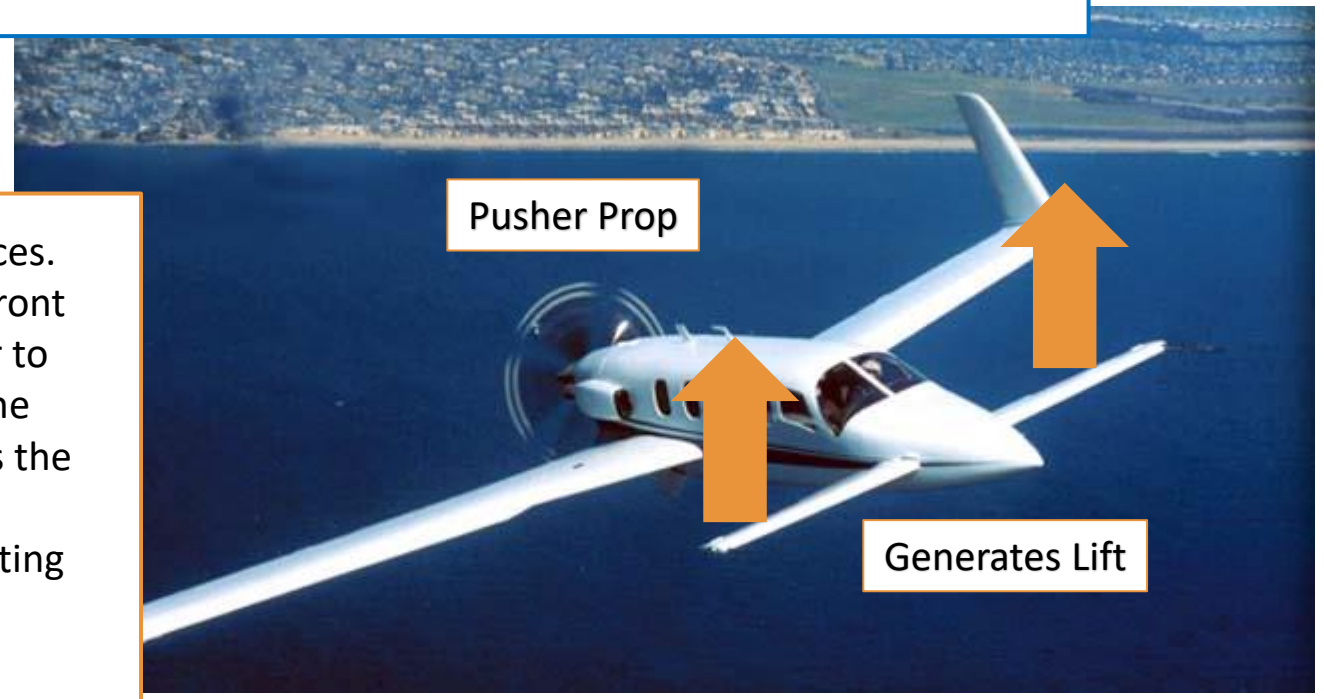
Canard

The canard design utilizes the concept of two lifting surfaces. The canard functions as a horizontal stabilizer located in front of the main wings. In effect, the canard is an airfoil similar to the horizontal surface on a conventional aft-tail design. The difference is that the canard actually creates lift and holds the nose up, as opposed to the aft-tail design which exerts downward force on the tail to prevent the nose from rotating downward.

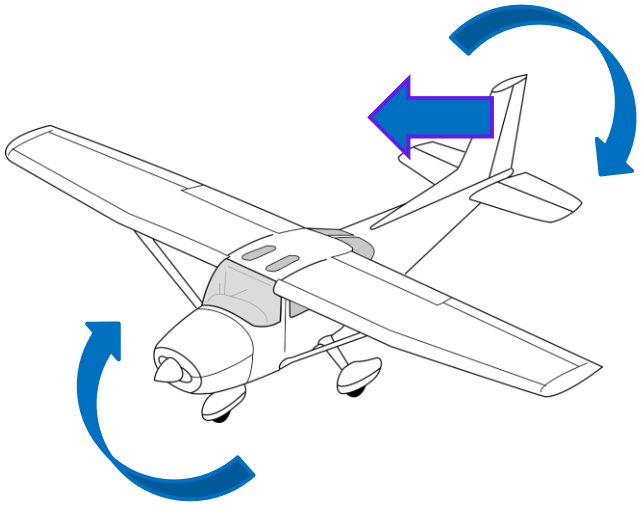


Primary Flight Controls

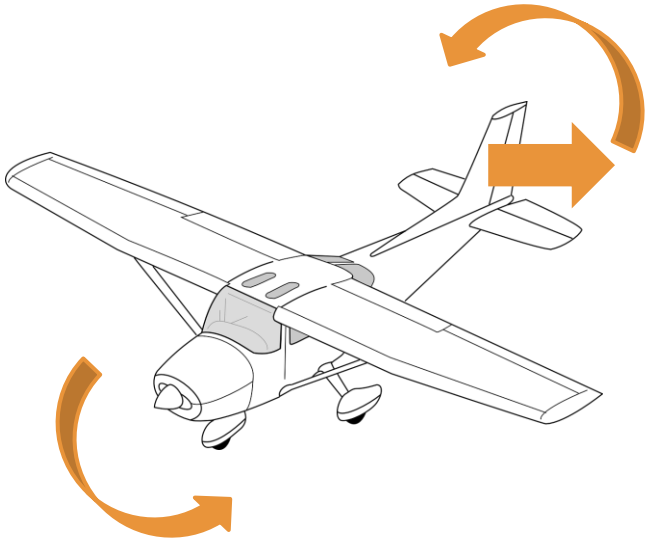
The Rudder

The rudder controls movement of the aircraft about its vertical axis. This motion is called yaw. Like the other primary control surfaces, the rudder is a movable surface hinged to a fixed surface in this case, to the vertical stabilizer or fin.

Right Rudder



Left Rudder



Primary Flight Controls

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The V-Tail Design

The V-tail design utilizes two slanted tail surfaces to perform the same functions as the surfaces of a conventional elevator and rudder configuration. The fixed surfaces act as both horizontal and vertical stabilizers. These ruddervators are connected through a special linkage that allows the control wheel to move both surfaces simultaneously. On the other hand, displacement of the rudder pedals moves the surfaces differentially, thereby providing directional control.

Secondary Flight Controls

Secondary flight control systems may consist of wing flaps, leading edge devices, spoilers, and trim systems.

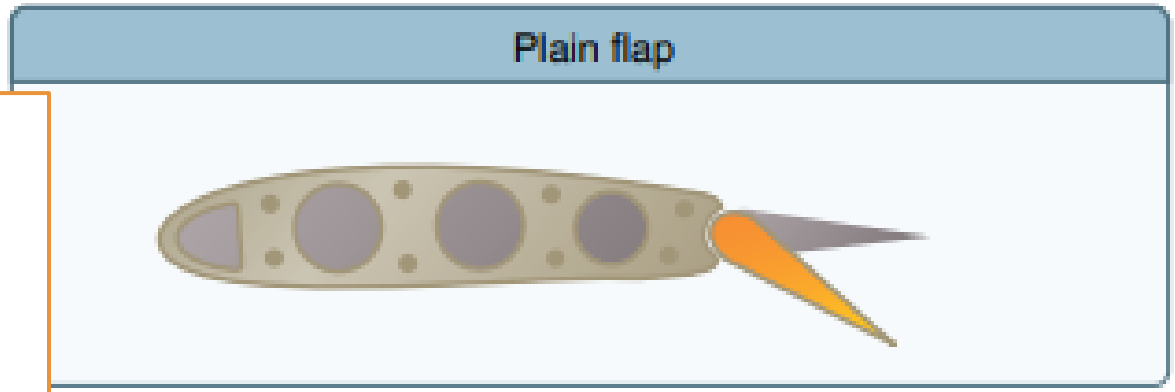
Secondary Flight Controls

Flaps

Flaps are the most common high-lift devices used on aircraft. These surfaces, which are attached to the trailing edge of the wing, increase both lift and induced drag for any given AOA. Flaps allow a compromise between high cruising speed and low landing speed because they may be extended when needed and retracted into the wing's structure when not needed.

Plain Flaps

The plain flap is the simplest of the four types. It increases the airfoil camber, resulting in a significant increase in the coefficient of lift (CL) at a given AOA. At the same time, it greatly increases drag and moves the center of pressure (CP) aft on the airfoil, resulting in a nose-down pitching moment.



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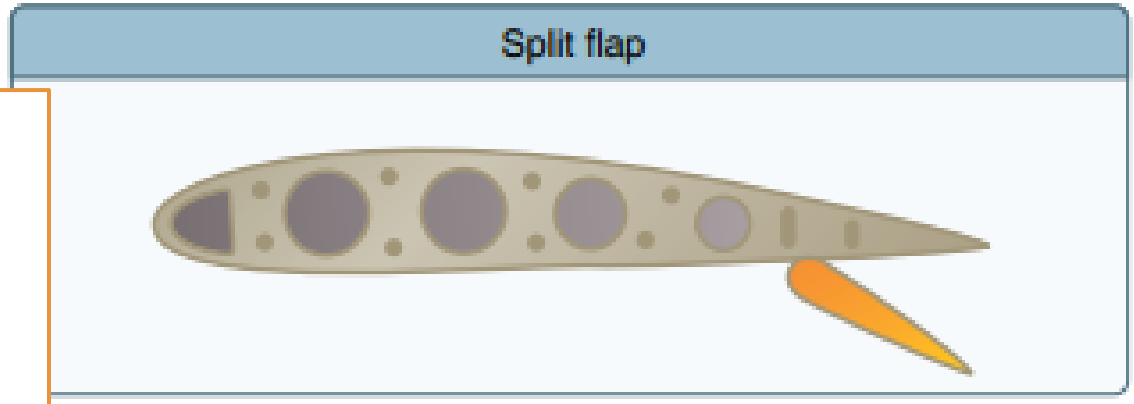
Split Flaps

The split flap is deflected from the lower surface of the airfoil and produces a slightly greater increase in lift than the plain flap. More drag is created because of the turbulent air pattern produced behind the airfoil. When fully extended, both plain and split flaps produce high drag with little additional lift.



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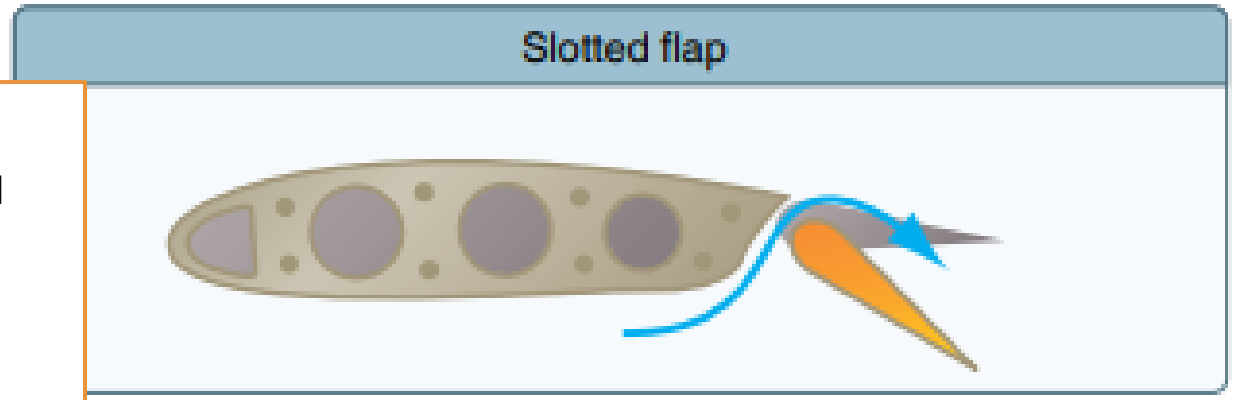
Slotted Flaps

Slotted flaps increase the lift coefficient significantly more than plain or split flaps. On small aircraft, the hinge is located below the lower surface of the flap, and when the flap is lowered, a duct forms between the flap well in the wing and the leading edge of the flap. When it is lowered, high energy air from the lower surface is ducted to the flap's upper surface.



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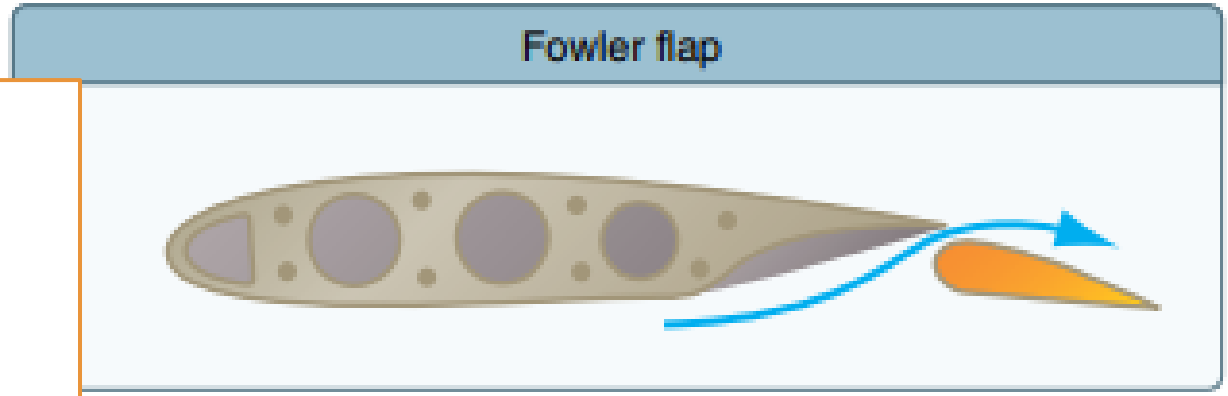
Fowler Flaps

Fowler flaps are a type of slotted flap. This flap design not only changes the camber of the wing, it also increases the wing area. Instead of rotating down on a hinge, it slides backwards on tracks. In the first portion of its extension, it increases the drag very little, but increases the lift a great deal as it increases both the area and camber. During the last portion of its travel, the flap increases the drag with little additional increase in lift.



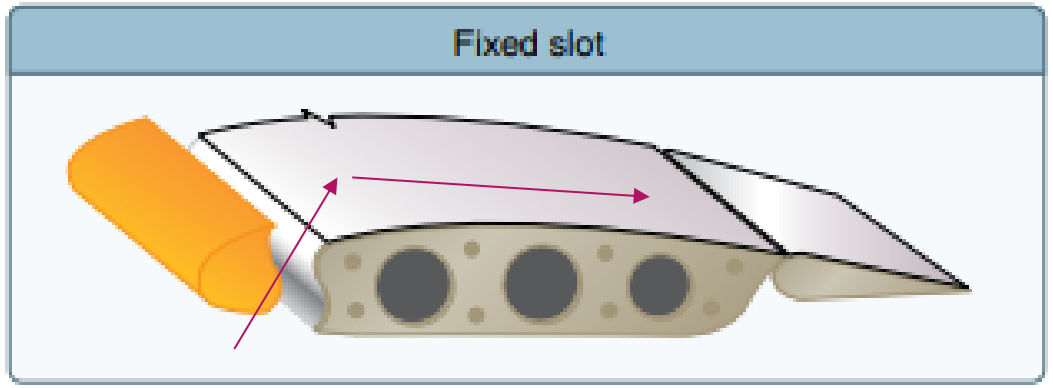
Secondary Flight Controls

Leading Edge Devices

High-lift devices also can be applied to the leading edge of the airfoil. The most common types are fixed slots, movable slats, leading edge flaps, and cuffs.

Fixed Slots

Fixed slots direct airflow to the upper wing surface and delay airflow separation at higher angles of attack. The slot does not increase the wing camber, but allows a higher maximum lift coefficient because the stall is delayed until the wing reaches a greater AOA.



Delayed Airflow Separation

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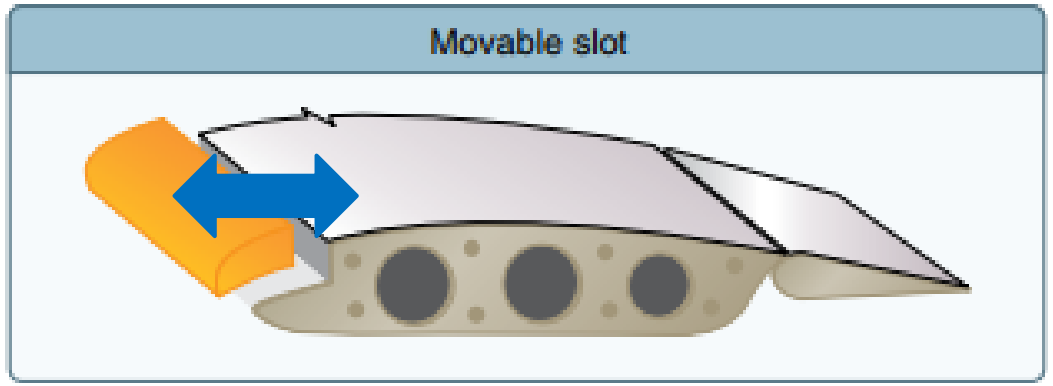
Movable Slats

Movable slats consist of leading edge segments that move on tracks. At low angles of attack, each slat is held flush against the wing's leading edge by the high pressure that forms at the wing's leading edge. As the AOA increases, the high pressure area moves aft below the lower surface of the wing, allowing the slats to move forward.



Move In and Out

Secondary Flight Controls

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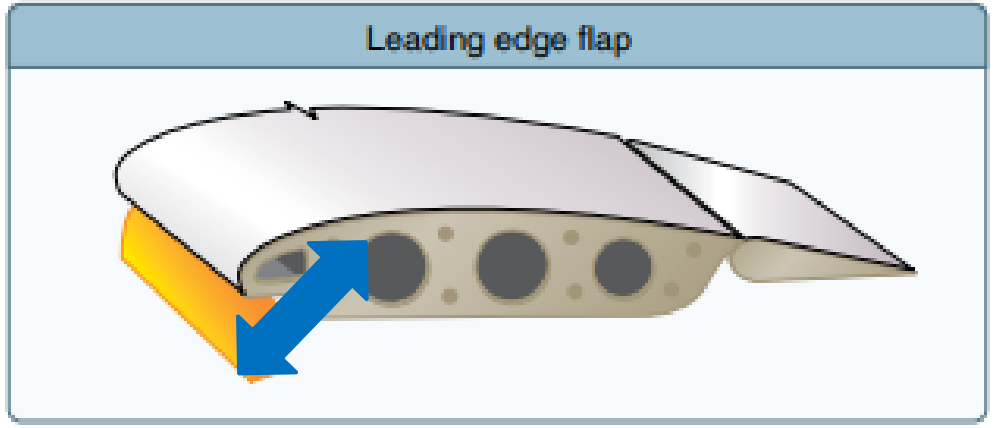
Leading Edge Flaps

This type of leading edge device is frequently used in conjunction with trailing edge flaps and can reduce the nose-down pitching movement produced by the latter. As is true with trailing edge flaps, a small increment of leading edge flaps increases lift to a much greater extent than drag. As flaps are extended, drag increases at a greater rate than lift.



Extend and Retract

Secondary Flight Controls

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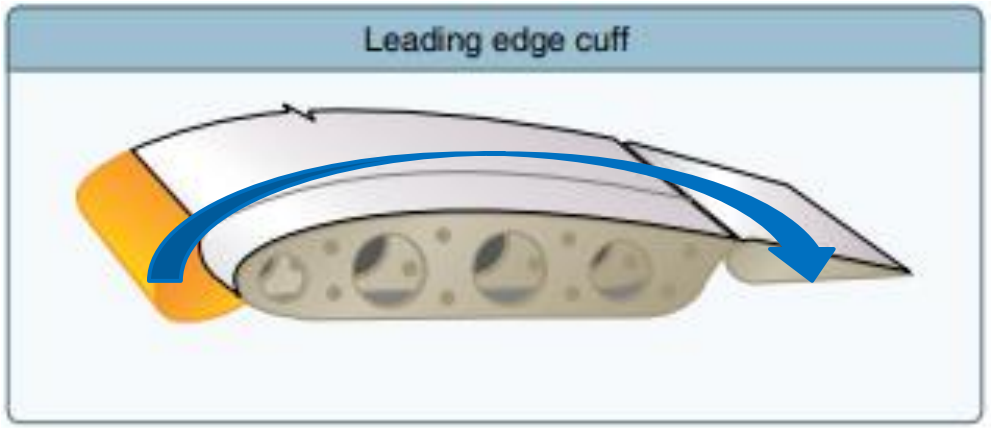
Leading Edge Cuffs

Leading edge cuffs are fixed aerodynamic devices. In most cases, leading edge cuffs extend the leading edge down and forward. This causes the airflow to attach better to the upper surface of the wing at higher angles of attack, thus lowering an aircraft's stall speed.



Increased Wing Camber

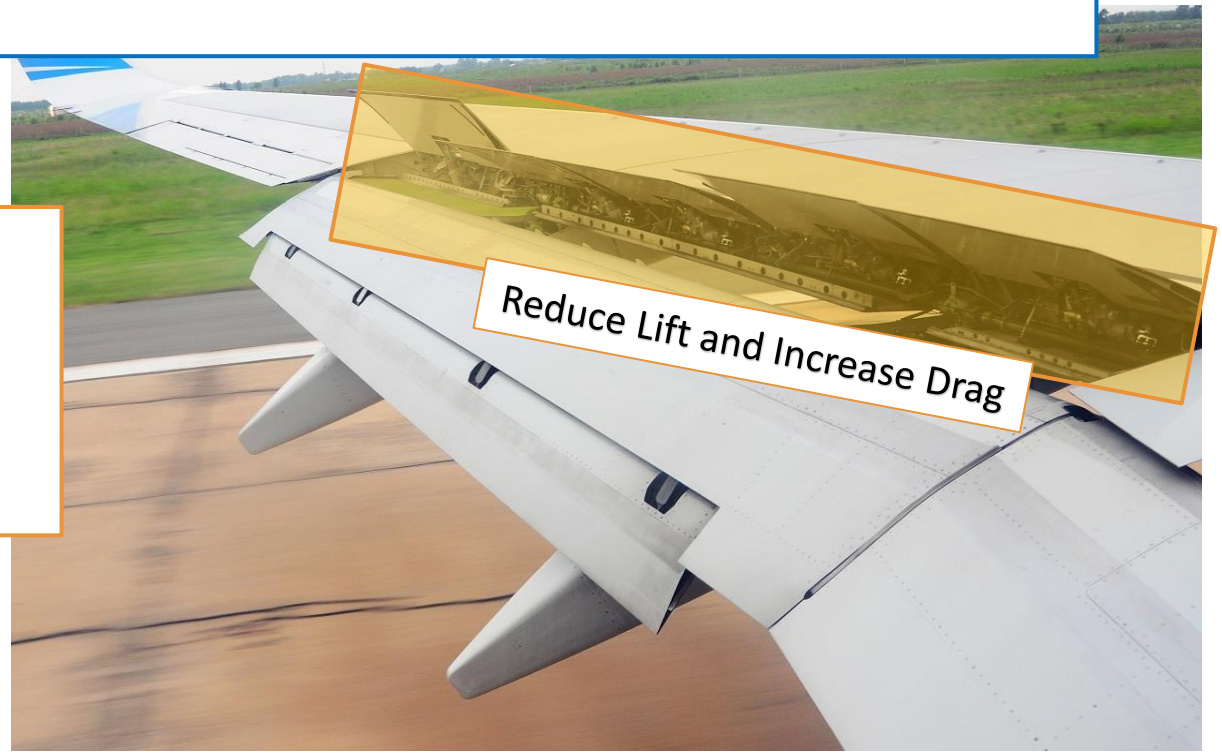
Secondary Flight Controls

Spoilers

Found on some fixed-wing aircraft, high drag devices called spoilers are deployed from the wings to spoil the smooth airflow, reducing lift and increasing drag.

Spoiler Uses

Spoilers are often used for roll control, an advantage of which is the elimination of adverse yaw. Spoilers are also deployed to help reduce ground roll after landing. By destroying lift, they transfer weight to the wheels, improving braking effectiveness.



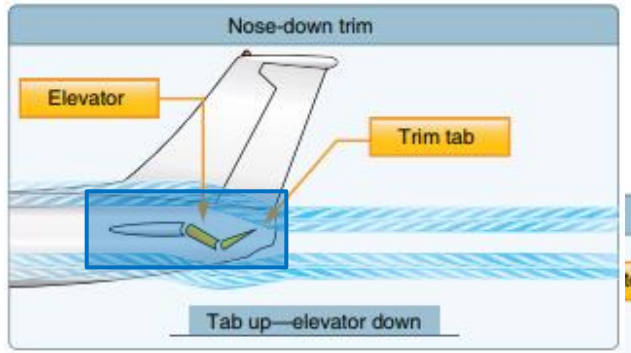
Secondary Flight Controls

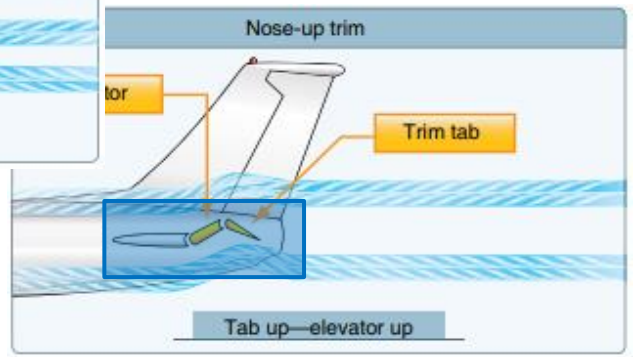
Trim Systems

Trim systems are used to relieve the pilot of the need to maintain constant pressure on the flight controls, and usually consist of flight deck controls and small hinged devices attached to the trailing edge of one or more of the primary flight control surfaces.

Trim Tabs

The most common installation on small aircraft is a single trim tab attached to the trailing edge of the elevator. Most trim tabs are manually operated by a small, vertically mounted control wheel. However, a trim crank may be found in some aircraft.





Travel In Opposite Direction of Elevator

Secondary Flight Controls

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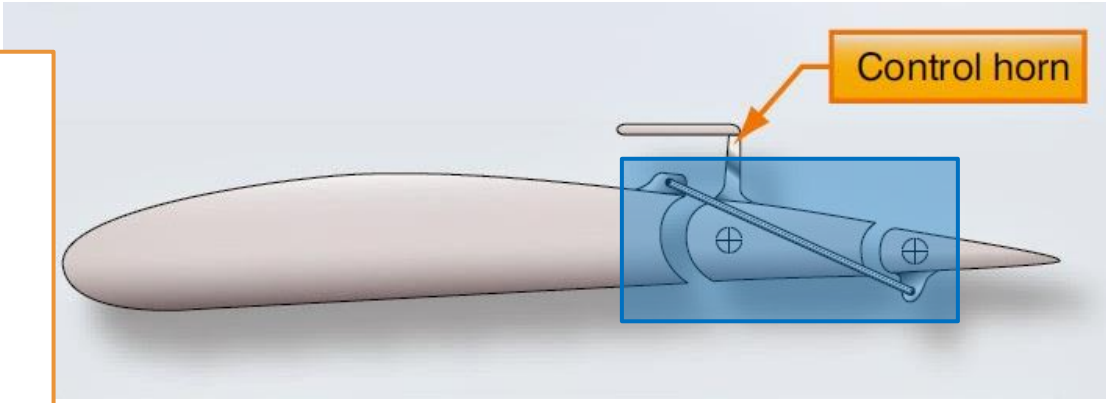
Balance Tabs

The control forces may be excessively high in some aircraft, and, in order to decrease them, the manufacturer may use balance tabs. They are coupled to the control surface rod so that when the primary control surface is moved in any direction, the tab automatically moves in the opposite direction.



Mechanical Linkage With Control Surface

Secondary Flight Controls

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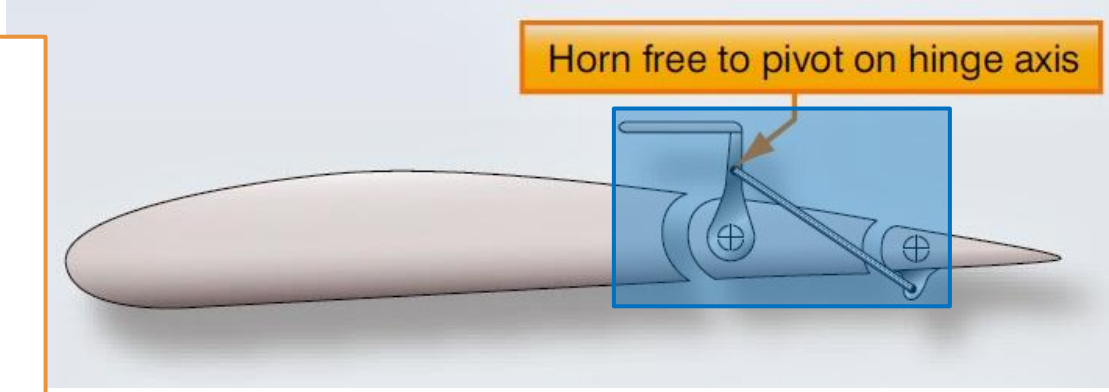
Servo Tabs

A servo tab is a small portion of a flight control surface that deploys in such a way that it helps to move the entire flight control surface in the direction that the pilot wishes it to go. A servo tab is a dynamic device that deploys to decrease the pilots work load and de-stabilize the aircraft. Usually found on large aircraft.



Assists the Pilot in
Moving a Large Control Surface

Secondary Flight Controls

Trim Systems

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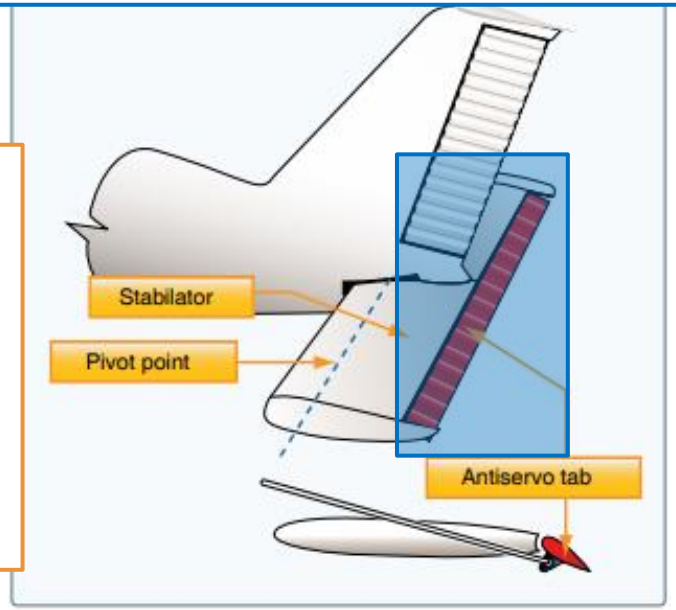
Antiservo Tabs

Antiservo tabs work in the same manner as balance tabs except, instead of moving in the opposite direction, they move in the same direction as the trailing edge of the stabilator. In addition to decreasing the sensitivity of the stabilator, an antiservo tab also functions as a trim device to relieve control pressure and maintain the stabilator in the desired position.



Moves in the Same Direction as the Stabilator To Decrease Sensitivity

Secondary Flight Controls

Trim Systems

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Ground Adjustable Tabs

Many small aircraft have a non-movable metal trim tab on the rudder. This tab is bent in one direction or the other while on the ground to apply a trim force to the rudder. The correct displacement is determined by trial and error.

Secondary Flight Controls

Trim Systems

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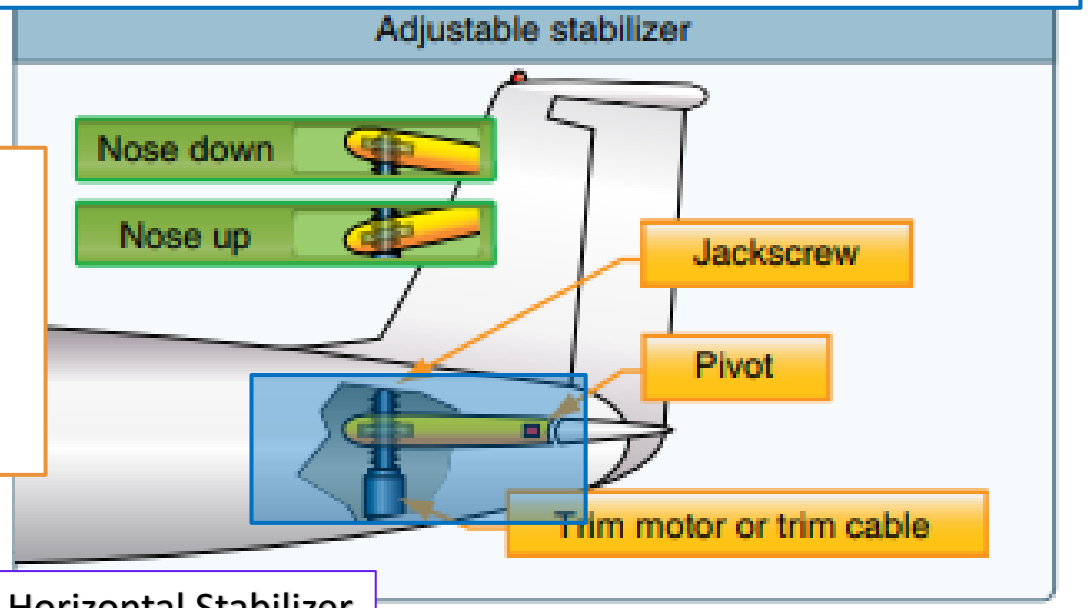
Adjustable Stabilizer

Rather than using a movable tab on the trailing edge of the elevator, some aircraft have an adjustable stabilizer. With this arrangement, linkages pivot the horizontal stabilizer about its rear spar. This is accomplished by the use of a jackscrew mounted on the leading edge of the stabilator.



Jackscrew moves the Horizontal Stabilizer

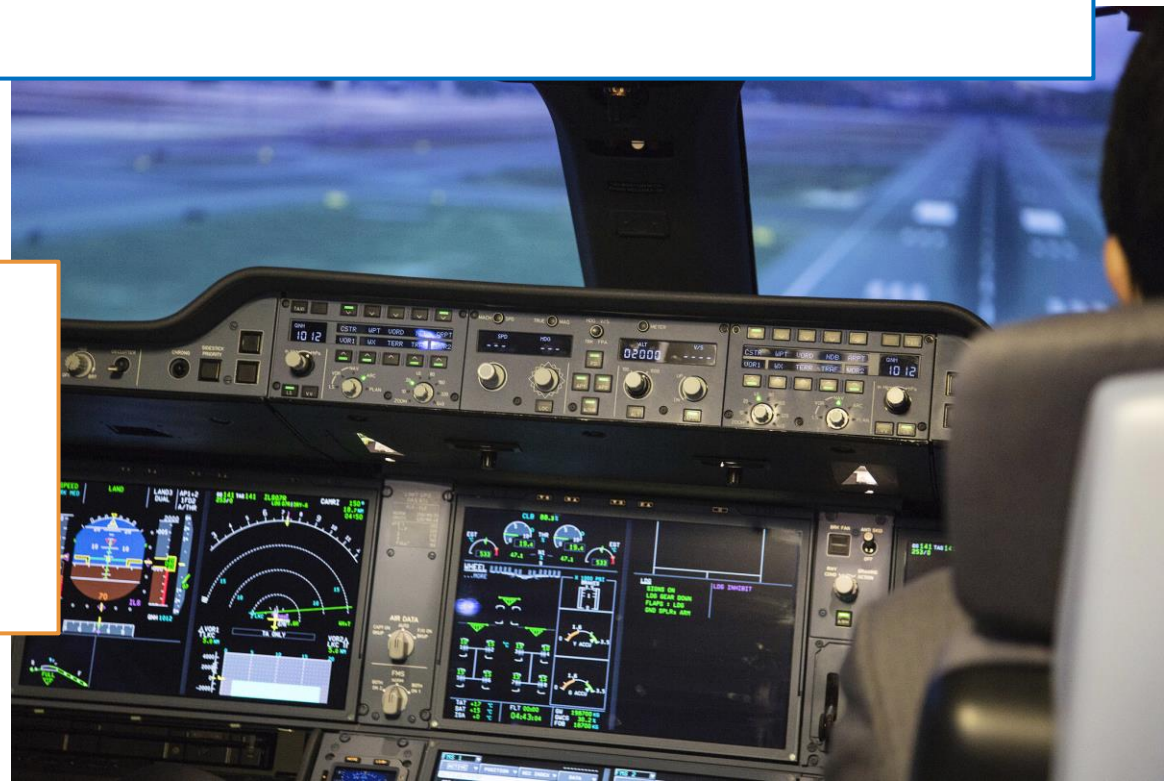
Secondary Flight Controls

Autopilot

Autopilot is an automatic flight control system that keeps an aircraft in level flight or on a set course. It can be directed by the pilot, or it may be coupled to a radio navigation signal.

How it Works

The simplest systems use gyroscopic attitude indicators and magnetic compasses to control servos connected to the flight control system. The number and location of these servos depends on the complexity of the system. A three-axis autopilot controls the aircraft about the longitudinal, lateral, and vertical axes.



Lesson Summary

In this lesson we discussed the primary and secondary flight controls that included: ailerons, elevator, rudder, flaps, leading edge devices, spoilers, trim, and auto pilot.