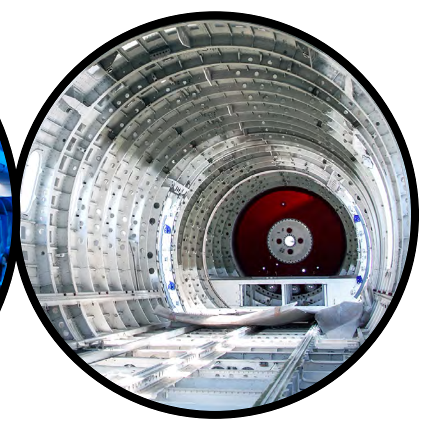
CAT-A

AVIATION MAINTENANCE TECHNICIAN CERTIFICATION SERIES

TURBINE AEROPLANE
STRUCTURES AND SYSTEMS

11



COMPLIANT WITH EASA European Aviation Safety Agency EASA PART 66/147

EASA 2023-989 COMPLIANT

REVISION LOG

Update notices for this book will be available online at www.actechbooks.com/revisions.html
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VERSION	EFFECTIVE DATE	DESCRIPTION OF REVISION(S)
001	2015.01	Module creation and release.
002	2024.06	Regulatory update for EASA 2023-989 Compliance.

Module was reorganized based upon the EASA 2023-989 subject criteria. Enhancements included in this version 002 are:

11.1.2 *High Speed Flight* - topic moved to Module 8 Basic Aerodynamics.
11.3.1 *Airborne Towing Devices* - topic added.
11.5.2 *Avionics Test Equipment* - topic added.
11.10 *Inert Gas Systems* - topic added.
11.11 *Tail Protection* - topic added.
11.16 *Pneumatic Pumps* - topic added.
Question and Answer updates for all Submodules.

TURBINE AEROPLANE STRUCTURES AND SYSTEMS

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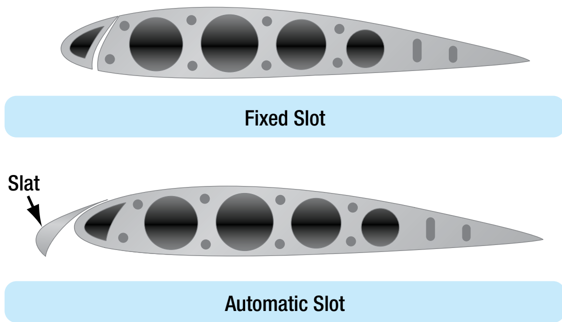

Figure 1-14. Wing slots.

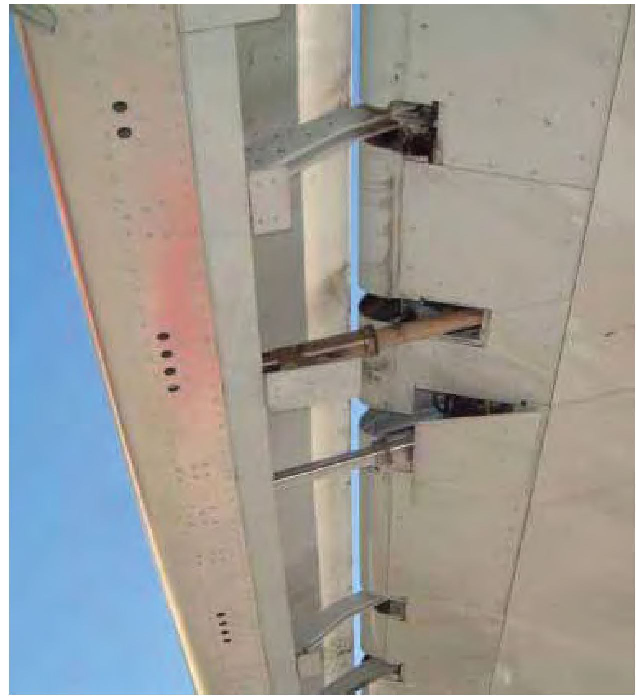

Figure 1-15. Air passing through the slot aft of the slat promotes boundary layer airflow on the upper surface at high angles of attack.

SLATS

Another leading edge device which extends wing camber is a slat. Slats can be operated independently of the flaps with their own switch in the cockpit. Slats not only extend out of the leading edge of the wing increasing camber and lift, but most often, when fully deployed leave a slot between their trailing edges and the leading edge of the wing. [**Figure 1-15**] This increases the angle of attack at which the wing will maintain its laminar airflow, resulting in the ability to fly the aircraft slower and still maintain control.

FLAPS

Flaps are one such high lift device found on most aircraft. They are usually inboard on the wings' trailing edges adjacent to the fuselage. The flaps are lowered to increase the camber of the wings and provide greater lift and control at slow speeds. They enable landing at slower speeds and shorten the amount of runway required for takeoff and landing. The amount that the flaps extend and the angle they form with the wing can be selected from the cockpit. Typically, flaps can extend up to 45–50°. **Figure 1-16** shows various aircraft with flaps in the extended position.

There are various kinds of flaps. [**Figure 1-17**] Plain flaps form the trailing edge of the wing when the flap is in the retracted position. The airflow over the wing continues over the upper and lower surfaces of the flap, making the trailing edge of the flap essentially the trailing edge of the wing. The plain flap is hinged so that the trailing edge can be lowered. This increases wing camber and provides greater lift.

A split flap is normally housed under the trailing edge of the wing. It is usually just a braced flat metal plate hinged at several places along its leading edge. The upper surface of the wing extends to the trailing edge of the flap. When deployed, the split flap trailing edge lowers away from the trailing edge of the wing. Airflow over the top of the wing remains the same. Airflow under the wing now follows the camber created by the lowered split flap, increasing lift.

Fowler flaps not only lower the trailing edge of the wing when deployed but also slide aft, effectively increasing the area of the wing. This creates more lift via the increased surface area, as well as the wing camber. When stowed, the fowler flap typically retracts up under the wing trailing edge similar to a split flap. The sliding motion of a fowler flap can be accomplished with a worm drive and flap tracks.

Figure 1-16. Flap extension on large and small aircraft.

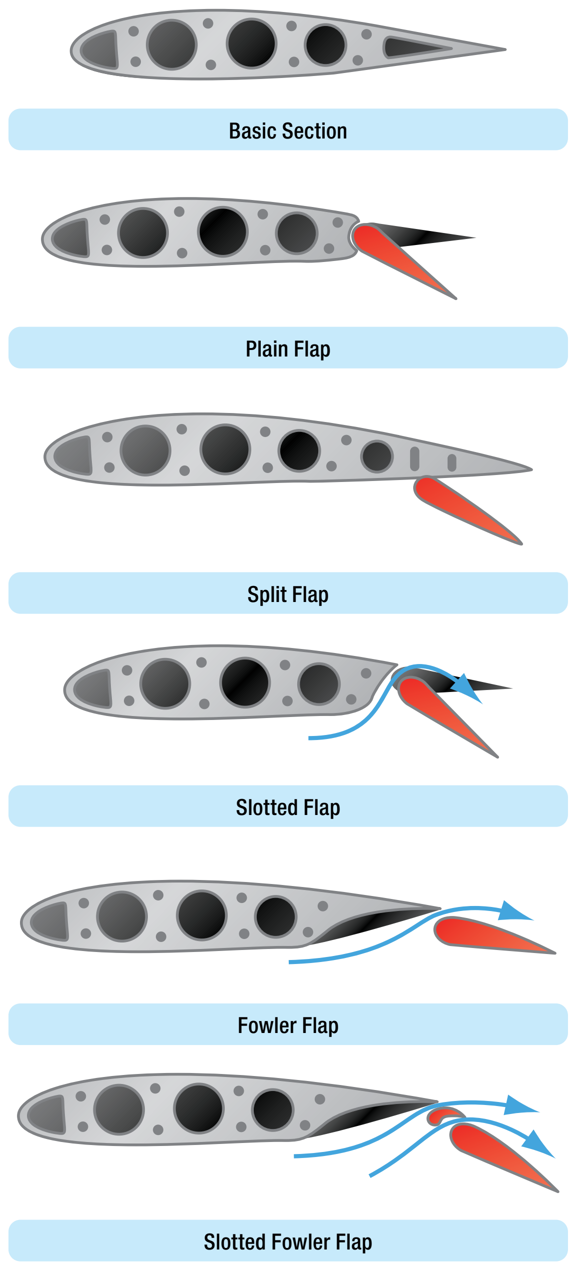

Figure 1-17. Types of flaps.

An enhanced version of the fowler flap is a set of flaps that actually contains more than one aerodynamic surface. **Figure 1-18** shows a triple slotted flap. In this configuration, the flap consists of a fore flap, a mid flap, and an aft flap. When deployed, each flap section slides aft on tracks as it lowers. The flap sections also separate leaving an open slot between the wing and the fore flap, as well as between each of the flap sections. Air from the underside of the wing flows through these slots. The result is that the flow on the upper surfaces is enhanced. The greater camber and effective wing area increase overall lift.

Heavy aircraft often have leading edge flaps that are used in conjunction with the trailing edge flaps. [**Figure 1-19**] While they are not installed or operate independently, their use with trailing edge flaps can greatly increase wing camber and lift. When stowed, leading edge flaps retract into the leading edge of the wing.

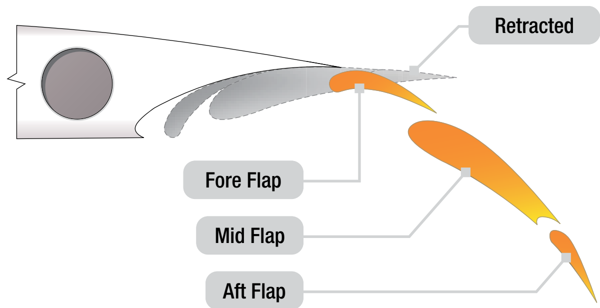

Figure 1-18. Triple slotted flap.

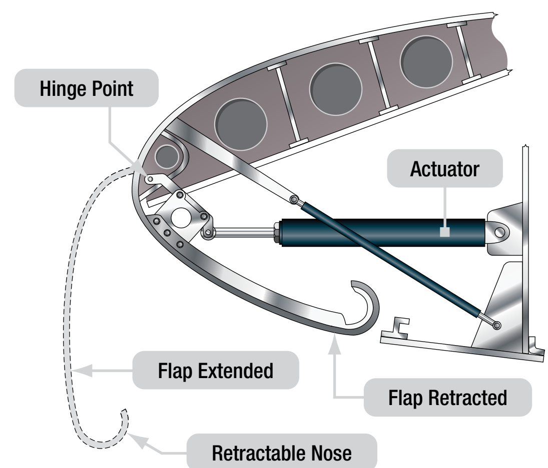

Figure 1-19. Leading edge flaps.

The differing designs of leading edge flaps essentially provide the same effect. Activation of the trailing edge flaps automatically deploys the leading edge flaps, which are driven out of the leading edge and downward, extending the camber of the wing.

FLAPERONS

Some aircraft are equipped with flaperons. [**Figure 1-20**] Flaperons are ailerons which can also act as flaps. 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. A mixer is used to combine the separate pilot inputs into this single set of control surfaces called flaperons.

Figure 1-20. Flaperons on a Boeing 787.

DRAG INDUCING DEVICES

The terms spoiler, lift dumper and speed brake are often used interchangeably. All are used to reduce lift and/or increase drag and have similar practical effects. One differentiation is that speed brakes are designed to create drag while spoilers and lift dumpers are designed to destroy lift. All have the effect of increasing rate of decent and of slowing an aircraft down, both in flight and after touchdown and thus assisting the aircraft ground brakes and helping to prevent their overheating.

Most often these devices are located on the upper surface of the wing. [**Figure 1-21**] An exception is the BAe146 where speed brakes operating exclusively as drag creation device deploys from the rear fuselage. [**Figure 1-22**]

In most airplanes the speed brake/ground spoiler function deploys automatically upon touchdown or upon deployment of the thrust reversers. However, some airplanes still require a manual deployment by the pilot.

SECONDARY AND AUXILIARY CONTROL SURFACES

TRIM TABS

The force of the air against a control surface during the high speed of flight can make it difficult to move and hold that control surface in the deflected position. Several different tabs are used to aid with these types of problems. [**Figure 1-23**] The table in **Figure 1-24** summarizes the various tabs and their uses. While in flight, it is desirable for the pilot to be able to take his or her hands and feet off of the controls and have the aircraft maintain its flight condition.

Trim tabs are designed to allow this. Most trim tabs are small movable surfaces located on the trailing edge of a primary flight control surface. A small movement of the tab in the direction opposite of the direction the flight control surface is deflected, causing air to strike the tab, in turn producing a force that aids in maintaining the flight control surface in the desired position. Through linkage set from the cockpit, the tab can be positioned so that it is actually holding the control surface in position rather than the pilot. Therefore, elevator tabs are used to maintain the speed of the aircraft since they assist in maintaining the selected pitch. Rudder tabs can be set to hold yaw in check and maintain heading. Aileron tabs can help keep the wings level.

Occasionally, a simple light aircraft may have a stationary metal plate attached to the trailing edge of a primary flight control, usually the rudder. This is also a trim tab as shown in **Figure 1-25**. It can be bent slightly on the ground to trim the aircraft in flight to a hands off condition when flying straight and level. The correct amount of bend can be determined only by flying the aircraft after an adjustment. Note that a small amount of bending is usually sufficient.


Figure 1-21. Spoilers fully deployed as speed brakes on an Embraer 190.


Figure 1-22. The BAe146 speed brake system can be deployed both in flight and after touchdown.

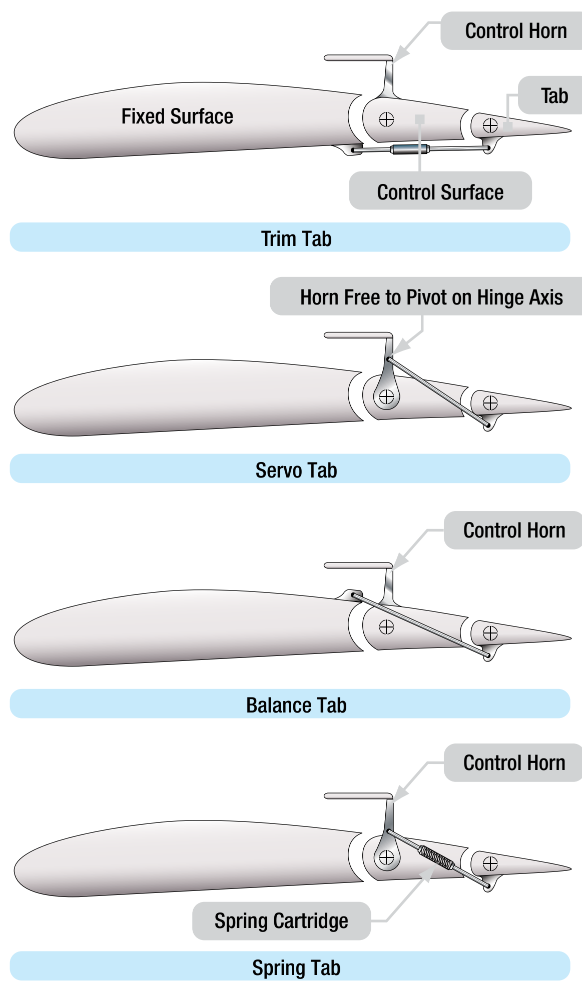

Figure 1-23. Types of trim tabs.

SERVO TABS

A servo tab is similar to a balance tab in location and effect, but it is designed to operate the primary flight control surface, not just reduce the force needed to do so. It is usually used as a means to back up the primary control of the flight control surfaces. [**Figure 1-26**]

On heavy aircraft, large control surfaces require too much force to be moved manually and are usually deflected out of the neutral position by hydraulic actuators. These power control units are signaled via a system of hydraulic valves connected to the yoke and rudder pedals. On fly by wire aircraft, the hydraulic actuators that move the flight control surfaces are signaled by electric input. In the case of hydraulic system failure(s), manual linkage to a servo tab can be used to deflect it. This, in turn, provides an aerodynamic force that moves the primary control surface.

CONTROL SURFACE BIAS

When a control surface is in the neutral position, it is faired with the wing rudder or horizontal stabilizer and no effect on the aircrafts aerodynamic surfaces. Some aircraft are designed with control surface bias.

This means that a control surface is not naturally in the neutral position. It is designed to impart a force on the airfoil at all times. The force is generally used to counter balance a design imbalance and alter the aircraft's aerodynamics for easy hands off flight.

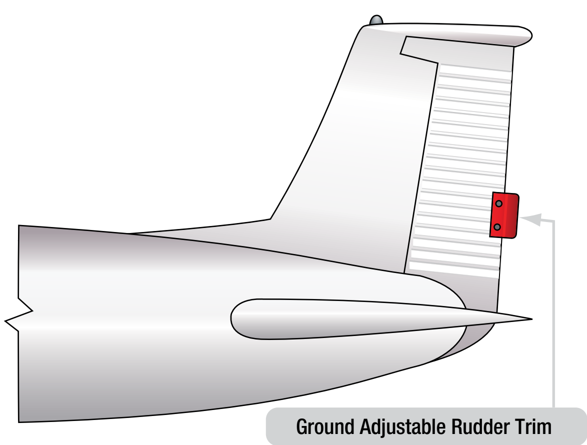

Figure 1-25. Example of a trim tab.

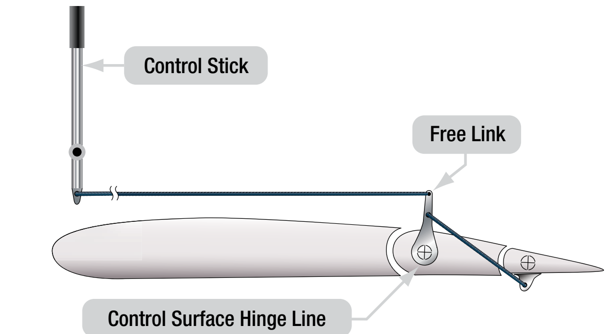

Figure 1-26. Servo tabs can be used to position flight control surfaces in case of hydraulic failure.

SECTION B

AEROPLANE: OTHER AERODYNAMIC DEVICES

OPERATION AND EFFECTS

BALANCE TABS

The aerodynamic phenomenon of moving a trim tab in one direction to cause the control surface to experience a force moving in the opposite direction is exactly what occurs with the use of balance tabs. [**Figure 1-27**] Often, it is difficult to move a primary control surface due to its surface area and the speed of the air rushing over it. Deflecting a balance tab hinged at the trailing edge of the control surface in the opposite direction of the desired control surface movement causes a force to position the surface in the proper direction with reduced force to do so. Balance tabs are usually linked directly to the control surface linkage so that they move automatically when there is an input for control surface movement. They also can double as trim tabs if adjustable on the flight deck.

ANTI-SERVO/ANTI-BALANCE TABS

Anti-servo tabs, as the name suggests, are like servo tabs but move in the same direction as the primary control surface. On some aircraft, especially those with a movable horizontal stabilizer, the input to the control surface can be too sensitive. An Anti-servo tab tied through the control linkage creates an aerodynamic force that increases the effort needed to move the control surface. This makes flying the aircraft more stable for the pilot. **Figure 1-28** shows an Anti-servo tab in the near neutral position. Deflected in the same direction as the desired stabilator movement, it increases the required control surface input. Anti-servo tabs are also known as anti-balance tabs.

SPRING TABS

A control surface may require excessive force to move only in the final stages of travel. When this is the case, a spring tab can be used. This is essentially a servo tab that does not activate until an effort is made to move the control surface beyond a certain point. When reached, a spring in line of the control linkage aids in moving the control surface through the remainder of its travel. [**Figure 1-29**]

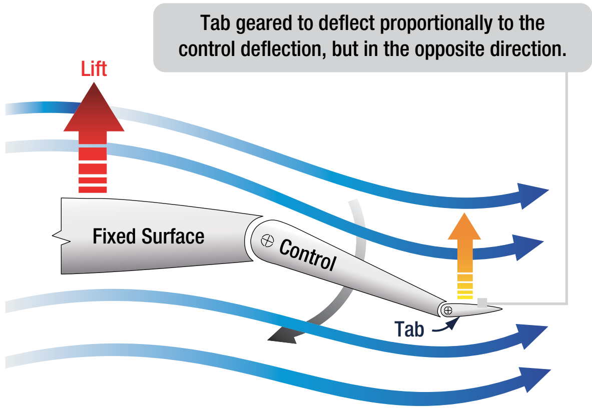

Figure 1-27. Balance tabs assist with forces needed to position control surfaces.

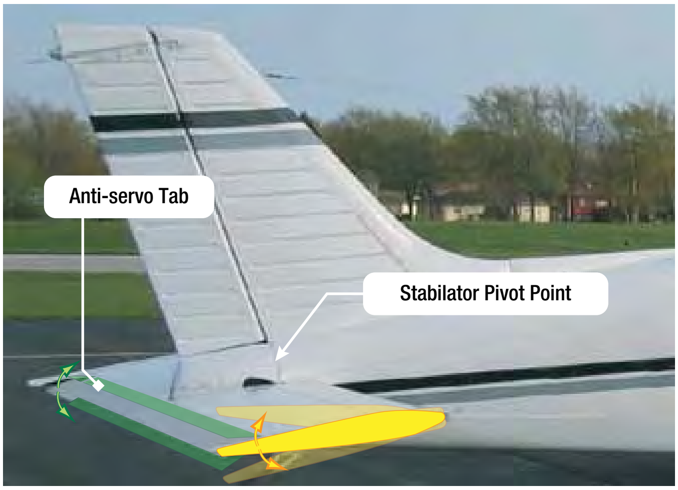

Figure 1-28. An Anti-servo tab moves in the same direction as the control tab. Shown here on a stabilator, it desensitizes the pitch control.

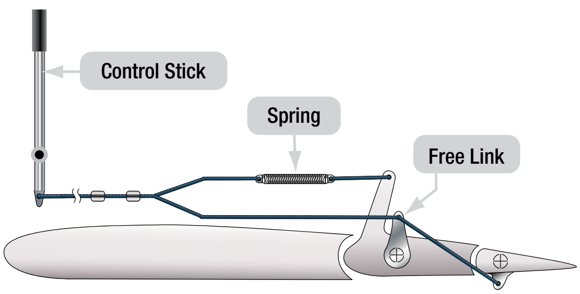

Figure 1-29. Many tab linkages have a spring tab that kicks in as the forces needed to deflect a control increase with speed and the angle of desired deflection.

MASS BALANCE

Flutter is an undesirable oscillation of an aircraft control surface which can have catastrophic effect on controllability of the aircraft. The center of lift on a control surface should be aft of the control surface center of gravity to prevent control surface flutter. Often, the addition of weight to the forward surface of an aileron is sufficient to move the CG of the airfoil forward and prevent flutter. Some aircraft designs place the weight on a lever arm that extends forward of the control surface. This is known as a mass balance. Mass balances help prevent flutter and also reduce the required control stick pressure used to move a control surface. [**Figure 1-30**]

Figure 1-30. An aileron mass balance.

AERODYNAMIC BALANCE PANELS

Figure 1-31 shows another way of assisting the movement of an aileron on a large aircraft. It is called an aileron balance panel. Not visible when approaching the aircraft, it is positioned in the linkage that hinges the aileron to the wing. Balance panels have been constructed typically of aluminum skin covered frame assemblies or aluminum honeycomb structures. The trailing edge of the wing just forward of the leading edge of the aileron is sealed to allow controlled airflow in and out of the hinge area where the balance panel is located.

WING FENCES

A chordwise barrier on the upper surface of the wing, called a wing fence or stall fence, is used to halt the spanwise flow of air along the wing. During low speed flight, this can maintain proper chordwise airflow reducing the tendency for the wing to stall. [**Figure 1-32**]

SAW TOOTH LEADING EDGE

A few aircraft have a sawtooth leading edge where, rather than being a smooth continuous surface, the leading edge juts out slightly at a point(s) determined to be beneficial by design engineers. The purpose of the sawtooth wing is to utilize the vortex created by an inboard section of the wing to improve boundary layer flow over an outboard section. This increases lift and resistance to stall. Sawtooth wing leading edges are most common on high performance military aircraft.

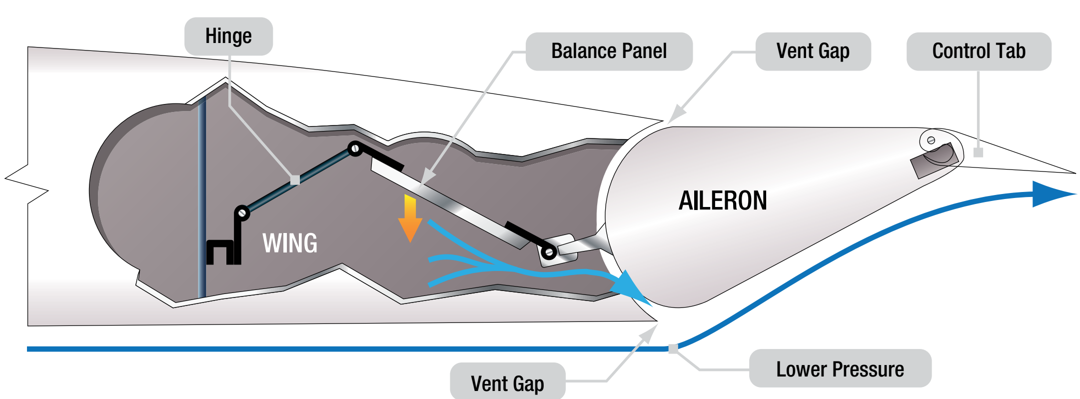

Figure 1-31. An aileron balance panel and linkage uses varying air pressure to assist in control surface positioning.