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CONTROL SURFACES

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THE PRIMARY CONTROL SURFACES

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The Primary group of flight control surfaces includes

- Ailerons,
- Elevators, and
- Rudders.

AILERONS

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Description

- Ailerons are a primary flight control surface which **control movement about the longitudinal axis** of an aircraft. This movement is referred to as "roll".
- The ailerons are **attached to the outboard trailing edge** of each wing and, when a manual or autopilot control input is made, move in opposite directions from one another.
- In some large aircraft, two ailerons are mounted on each wing. In this configuration, both ailerons on each wing are active during slow speed flight. However, at higher speed, the outboard aileron is locked and only the inboard or high speed aileron is functional. The ailerons attach to the trailing edge of the wings.
- They **control the rolling** (or banking) motion of the aircraft. This action is known as longitudinal control

Function

- Moving the flight deck control wheel or control stick to the right results in the aileron mounted on the right wing to deflect upward while, at the same time, the aileron on the left wing deflects downward.
- The upward deflection of the right aileron reduces the camber of the wing resulting in decreased lift on the right wing. Conversely, the downward deflection of the left aileron results in an increase in camber and a corresponding increase in lift on the left wing. The differential lift between the wings results in the aircraft rolling to the right

Adverse Yaw

- In the functional example above, the increase in camber of the left wing results in an increase in lift but this, in turn, also causes an increase in drag. This added drag causes the wing to slow down slightly resulting in rotation, referred to as yaw, around the vertical axis. To overcome this yaw and thereby maintain coordinated flight, rudder input is required while entering and exiting a turn. To minimize the amount of adverse yaw produced during a turn, engineers have developed various aerodynamic and mechanical solutions including differential ailerons and coupled ailerons and rudder.

ELEVATOR

Description

- An Elevator is a primary flight control surface that controls **movement about the lateral axis** of an aircraft. This movement is referred to as "pitch".
- Most aircraft have two elevators, one of which is **mounted on the trailing edge** of each half of the horizontal stabilizer.
- When a manual or autopilot control input is made, the elevators move up or down as appropriate. In most installations, the elevators move symmetrically but, in some fly-by-wire controlled aircraft, they move differentially when required to meet the control input demands. Some aircraft types have provisions to "disconnect" the right and left elevators from one another in the event of a control surface jam while other types use different hydraulic systems to power the left and right elevator to ensure at least one surface is operational in the event of hydraulic system failure(s).

Function

- The elevators respond to a forward or aft movement of the control column or control stick.
- When the pilot **moves the controls forward**, the elevator surface is **deflected downwards**. This increases the camber of the horizontal stabilizer resulting in an increase in lift.
- The additional lift on the tail surface causes rotation around the lateral axis of the aircraft and results in a nose down change in aircraft attitude.

RUDDER

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Description

- The rudder is a primary flight control surface which **controls rotation about the vertical axis** of an aircraft. This movement is referred to as "yaw’’.
- The rudder is a movable surface that is **mounted on the trailing edge of the vertical stabilizer** or fin.
- Unlike a boat, the rudder is not used to steer the aircraft; rather, it is used to overcome adverse yaw induced by turning or, in the case of a multi-engine aircraft, by engine failure and also allows the aircraft to be intentionally slipped when required.

Function

- In most aircraft, the rudder is controlled through the flight deck rudder pedals which are linked mechanically to the rudder.
- Deflection of a rudder pedal causes a corresponding rudder deflection in the same direction; that is**, pushing the left rudder pedal will result in a rudder deflection to the left**. This, in turn, causes the rotation about the vertical axis moving the aircraft nose to the left. In large or high speed aircraft, hydraulic actuators are often used to help overcome mechanical and aerodynamic loads on the rudder surface.
- Rudder **effectiveness increases with aircraft speed**. Thus, at slow speed, large rudder input may be required to achieve the desired results. **Smaller rudder movement is required at higher speeds** and, in many more sophisticated aircraft, rudder travel is automatically limited when the aircraft is flown above Maneuvering Speed to prevent deflection angles that could potentially result in structural damage to the aircraft.

THE SECONDARY CONTROL SURFACES

The secondary group includes the

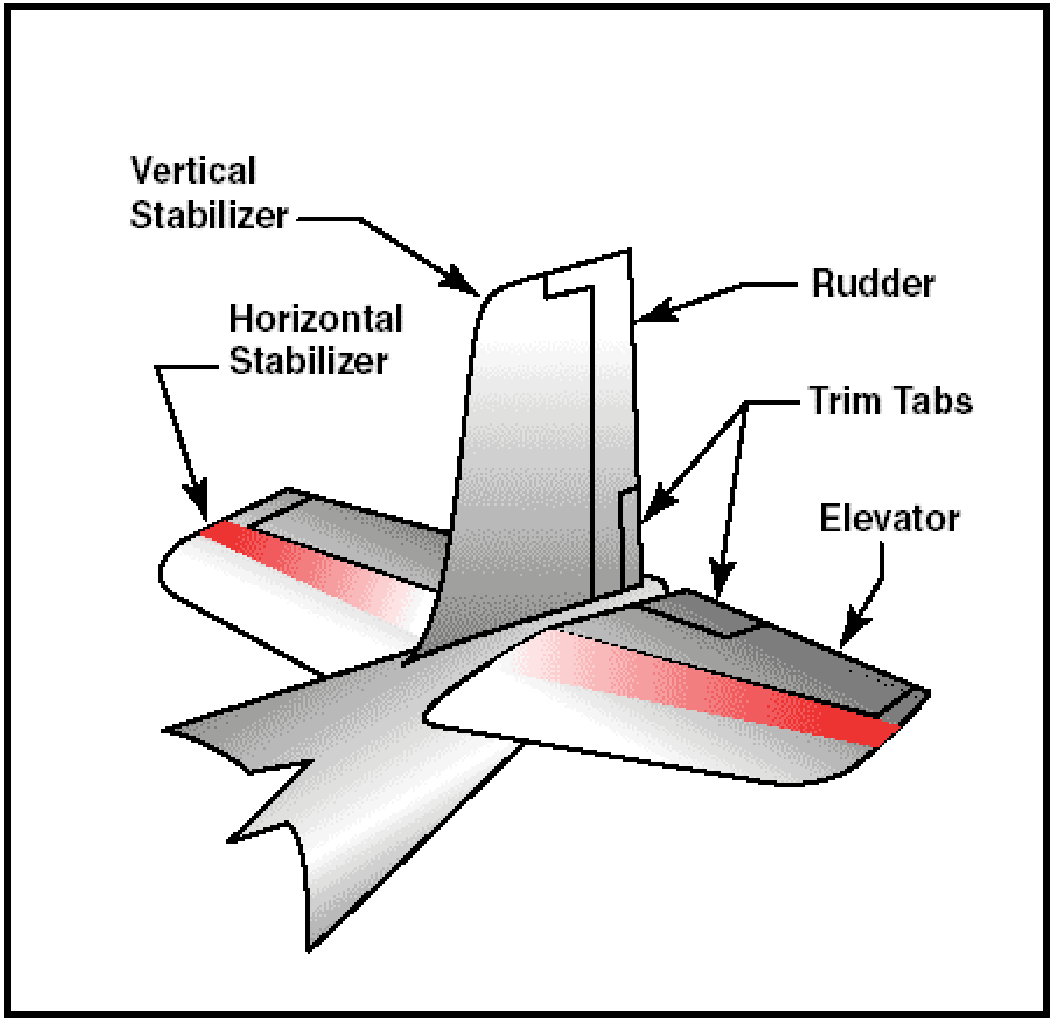
1.Trim tabs

2.Spring tabs.

1.Trim tabs

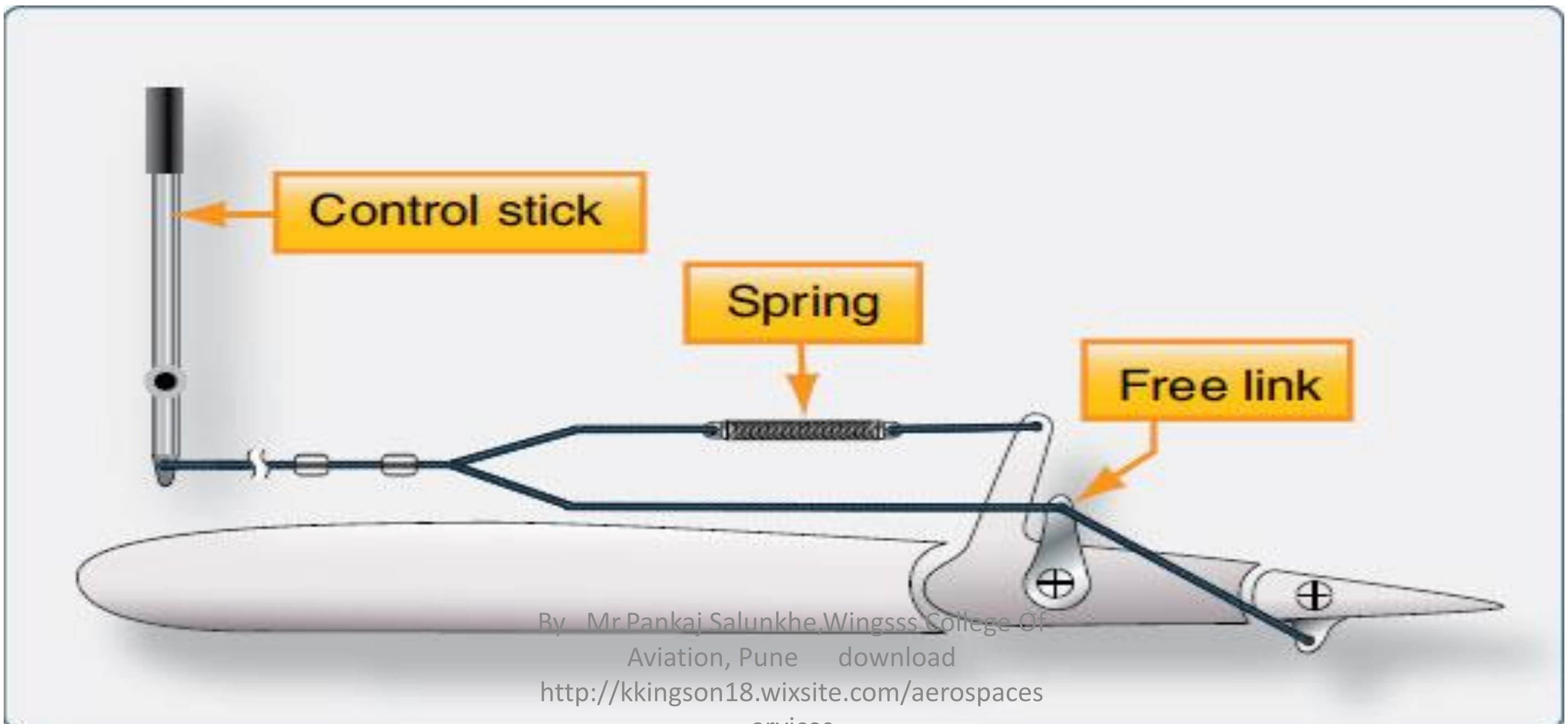
Trim tabs are small airfoils recessed into the trailing edges of the primary control surface.

Each trim tab hinges to its parent primary control surface, but operates by an **independent control**. Trim tabs let the pilot trim out an unbalanced condition without exerting pressure on the primary controls.



2.Spring tabs

Spring tabs are similar in appearance to trim tabs but serve an entirely different purpose. Spring tabs are used for the same purpose as hydraulic actuators. They aid the pilot in moving a larger control surface, such as the ailerons and elevators.



AUXILIARY GROUP

- **The auxiliary group includes**

1. **Wing flaps,**
2. **Spoilers,**
3. **Speed brakes,**
4. **Slats.**

FLAPS

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Wing Flaps

- Wing flaps give the aircraft extra lift.
- Their purpose is to reduce the landing speed.
- Reducing the landing speed shortens the length of the landing rollout.
- Flaps help the pilot land in small or obstructed areas by increasing the glide angle without greatly increasing the approach speed.
- The use of flaps during takeoff serves to reduce the length of the takeoff run.

TYPES OF FLAPS

1.Plain Flap

PLAIN FLAP (maximum increment in Lift coefficient occurs at 80° deflection angle)

Geometry Alteration effect: Increases the effective camber of the airfoil.

Boundary Layer Control: There is no effect over the behavior of the boundary layer.

Plain Flap

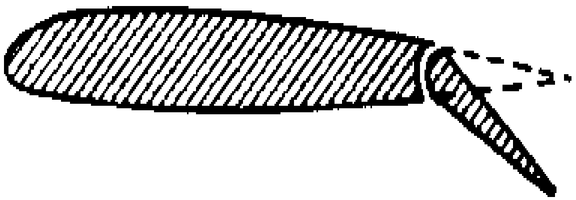


Figure 1-21

EFFECTS

- Reduces the zero lift angle of attack to a much lower point increases the coefficient of lift compared to unflapped airfoil. C_{Lmax} is obtained at much lower angle of attack.
- Reduction in the stall angle of incidence helps in low nose up attitude flight during landing and take-off maneuver advantageous in pilot's perspective for he can have a good visibility.
- Coefficient of Pressure is varied in the presence of flap effecting an aft movement of the centre of pressure, causing a nose down moment requiring adjustment by the pilot. (for pressure plot look at Aerodynamics by L J Clancy)

2.SPLIT FLAP

Geometry Alteration effect: Increases the effective camber of the airfoil as plain flap.

Boundary Layer Control: No special effect.

To overcome the separation effect in the plain flap a split flap is adapted with curvature of the airfoil being unaffected even at the time of deflection of the flap.

Split Flap

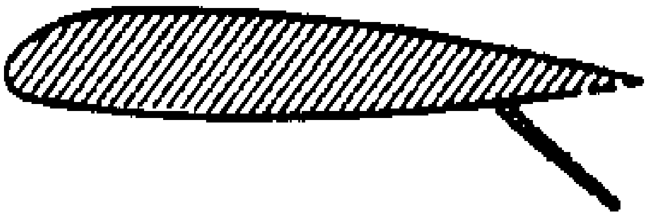


Figure 1-22

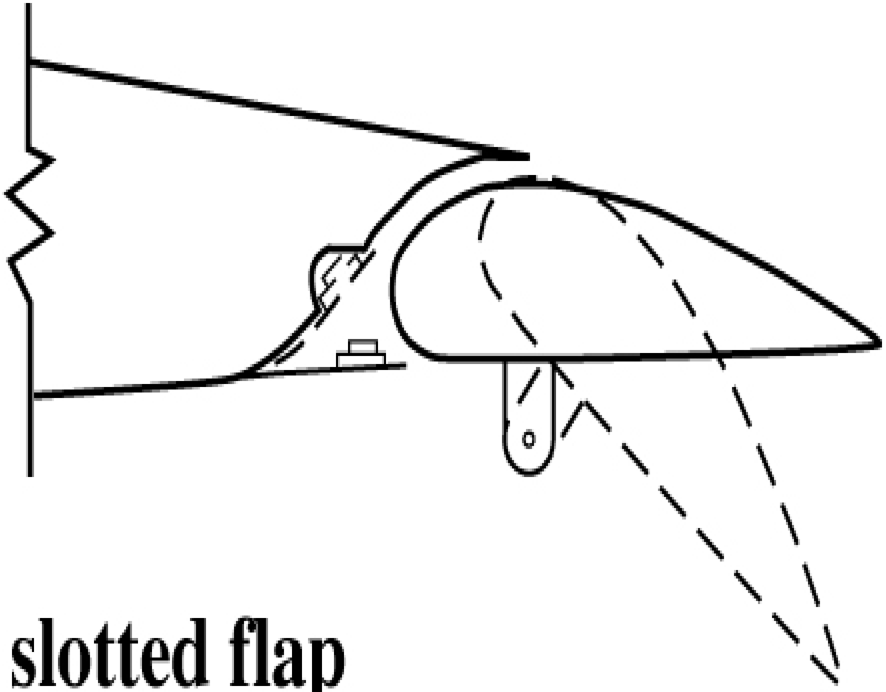
EFFECTS

- ***The lift slope curve is slightly increased, because the flap performs better at high than at low incidence***
- ***The zero lift angle is reduced, but not by quite so much as is the case with a plain flap.***
- ***The stalling angle is less than with flap neutral, but higher than the corresponding value for a plain flap.***
- ***The increment in maximum lift coefficient is bigger than with a plain flap.***
- ***The effect on pitching moment is similar but less marked.***
- ***Bigger Increase in drag than with a plain flap because of the large wake.***

3.THE SLOTTED FLAP

Geometry: Increases the effective camber of the airfoil.

BL Control: The air passing through the slot re-energizes the boundary layer and prevents separation.



slotted flap

EFFECT:

- **Zero lift angle is still reduced. Maximum lift coefficient is appreciably bigger than that in the previous cases**
- **Drag is much lesser since it prevents separation. (Pressure drag is reduced)**
- **Moment is still large.**

4.LEADING EDGE SLOT

LEADING EDGE SLOT

Geometry alteration: Negligible or unnoticed alteration in the geometry of the airfoil.

B L Control: The BL is re-energized by the air flow.

EFFECTS:

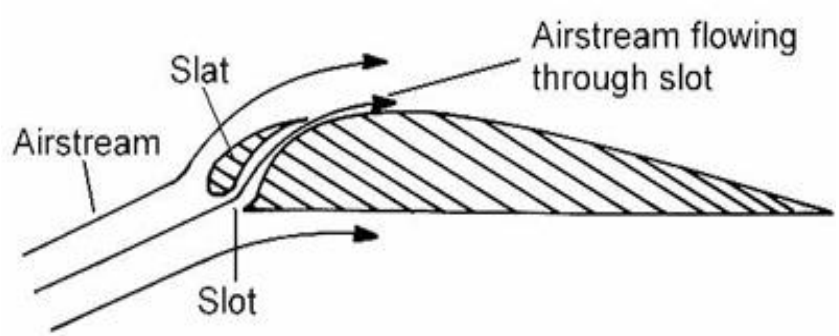
The stall angle is increased from, say, 15 to 25 degree

The maximum lift coefficient is increased by about 60%.

At low incidence slat ahead of the airfoil affects the flow over the rest of the wing and there is an appreciable increase in drag coefficient. Thus this device gives increase in the drag at wrong end of the speed range.

Maximum lift coefficient is obtained only at high incidence, so requires high nose up attitude at take-off and landing affecting the visibility of the pilot.

Drag at low speed is reduced which is again a disadvantage during landing where L/D should be too low as possible.



5.LEADING EDGE FLAP(Droop Snoot)

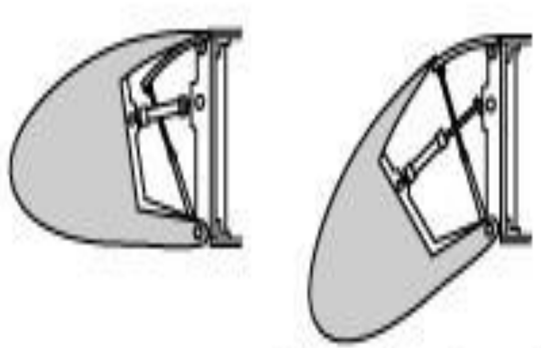
Another device which produces lift increments by helping to prevent flow separation is the leading edge flap, often colloquially referred to as the ‘droop-snoot’.

EFFECTS:

Same as that of the leading edge slot.

Effective at low speeds, thought the objective or design point is high speed purpose.

Lift curve is similar to that of the leading edge slot, but there is a small camber effect as well, and this causes the reduction in the zero lift angle (though not too large).



Droop leading edge

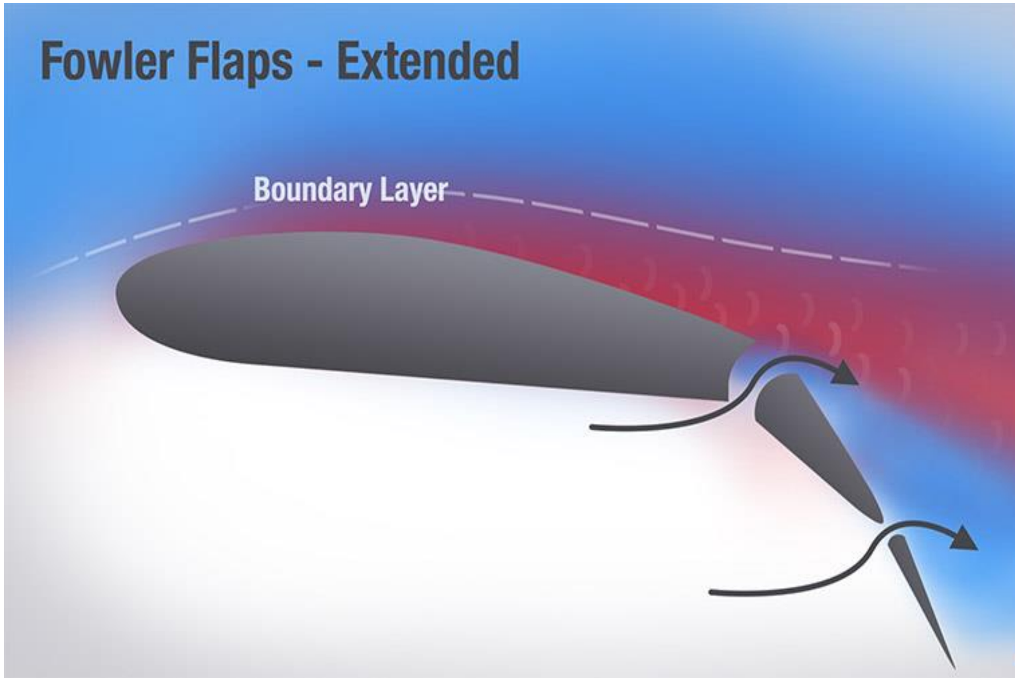
6.FOWLER FLAP

Geometry Alteration: Increases the camber, and also the effective area by deflecting backwards and downwards.

BL Control: B L is re-energized as in the case of slotted flap.

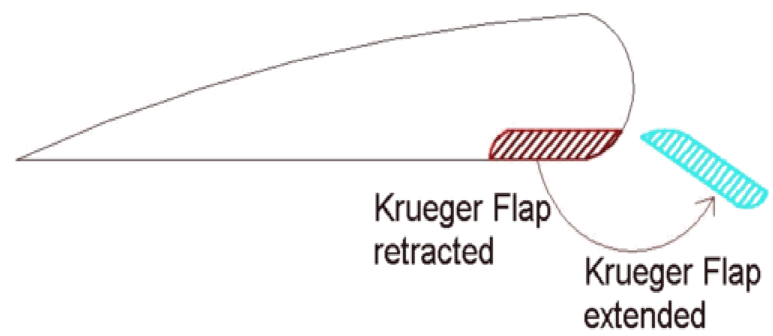
EFFECTS

- High lift increment compared to any of the flap considered.
- Reduction in the effective chord to thickness ratio, making the wing to stall earlier.
- Moment effect is large, because of high contribution of the flap,
- Drag Increment is small because of the slot effect and reduces t/c ratio.



7.Krueger flap

Krueger flaps are high lift devices that are fitted to all or part of the leading edge of the wings of some aircraft types. The aerodynamic effect of Krueger flaps is similar to that of slats; however, they are deployed differently. Krueger flaps are mounted on the bottom surface of the wing and are hinged at their leading edges. Actuators extend the flap down and forwards from the under surface of the wing thus increasing the wing camber which, in turn, increases lift.



8.Zap Flap

Flaps on the trailing edges of the wings. These increase the camber as well as the effective wing area. This results in much higher maximum lift and drag values than with camber or split flaps. Also called *zapp flaps*.

9.SLATS

- Slats are movable control surfaces that attach to the leading edge of the wing.
- **When the slat is retracted, it forms the leading edge of the wing. When the slat is open (extended forward), a slot is created between the slat and the wing leading edge.**
- High-energy air is introduced into the boundary layer over the top of the wing. At low airspeeds, this action improves the lateral control handling characteristics. This allows the aircraft to be controlled at airspeeds below normal landing speed. The high-energy air that flows over the top of the wing is known as boundary layer control air.
- Boundary layer control is intended primarily for use during operations from carriers. Boundary layer control air aids in catapult takeoffs and arrested landings. Boundary control air can also be accomplished by directing high-pressure engine bleed air across the top of the wing or flap surface.

CL vs angle of attack

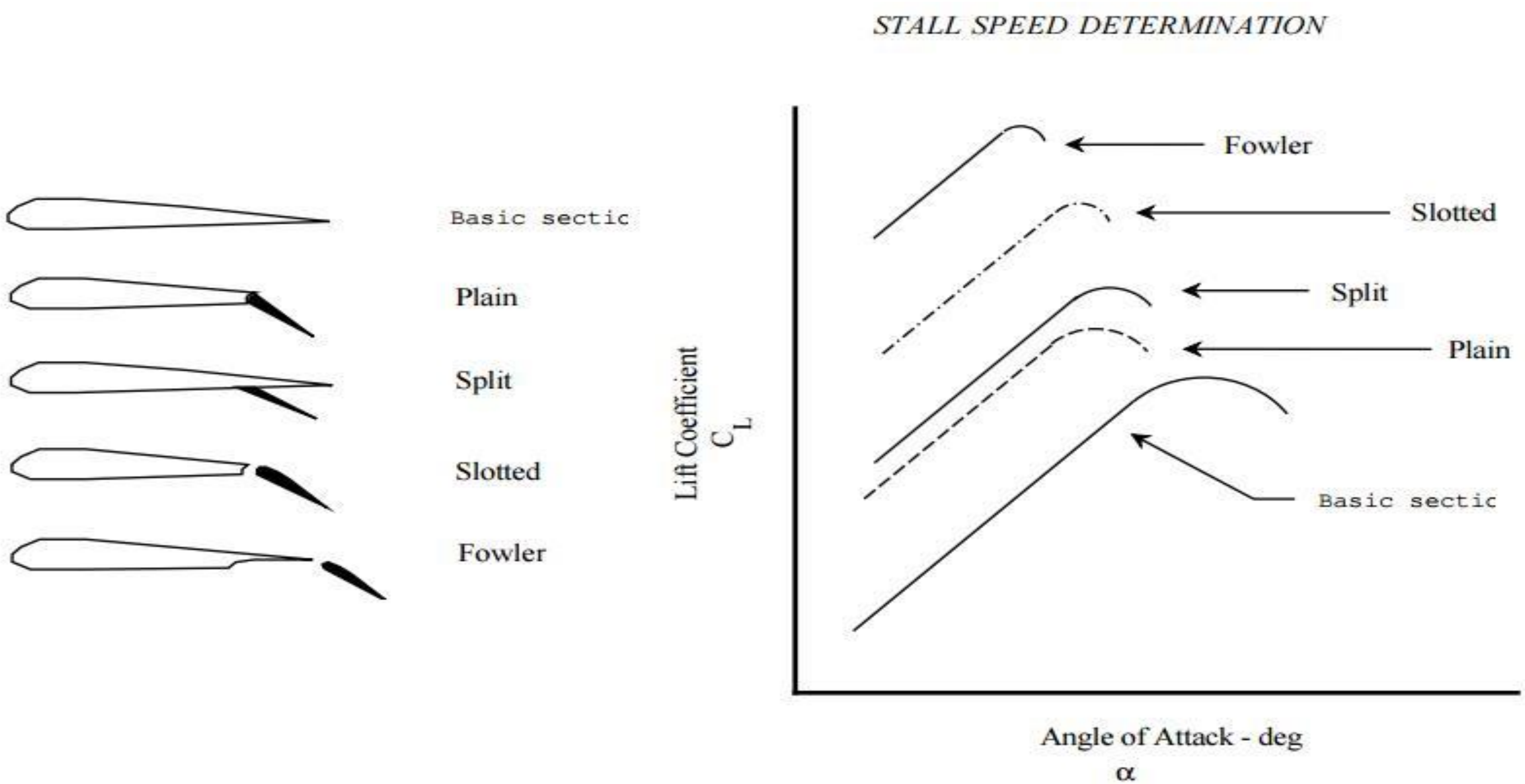


Figure 3.7

2.SPEED BRAKES

SPEED BRAKES

- Speed brakes are movable control surfaces used for reducing the speed of the aircraft. Some manufacturers refer to them as dive brakes; others refer to them as dive flaps. On some aircraft, they're hinged to the sides or bottom of the fuselage. Regardless of their location, speed brakes serve the same purpose—to keep the airspeed from building too high when the aircraft dives. Speed brakes slow the aircraft's speed before it lands. Speedbrakes are purely drag devices while spoilers simultaneously increase drag and reduce lift.
- . In most cases, speedbrakes are fuselage mounted panels which, when selected by the pilot, extend into the airstream to produce drag.
- Speedbrakes may be used during the final approach to touchdown as well as after landing

3.SPOILER

Spoilers

- Spoilers are panels mounted on the upper surface of the wing that, when extended, both increase drag and decrease lift by disrupting the airflow over the wing. Dependent upon the aircraft type, spoilers can serve as many as three distinct primary functions:

1. **Ground spoilers**
2. **Roll spoilers**
3. **(Flight) spoilers or Speed brakes**

1.Ground Spoilers

- All spoiler equipped aircraft have a ground spoiler function. During the landing ground roll or during a rejected takeoff, all spoiler panels are extended to their maximum angle.
- **The primary purpose of the ground spoilers is to maximize wheel brake efficiency by "spoiling" or dumping the lift generated by the wing and thus forcing the full weight of the aircraft onto the landing gear.**
- The spoiler panels also help slow the aircraft by producing aerodynamic drag. Depending upon aircraft type, the ground spoiler extension may be fully automatic when the system is armed provided that other deployment criteria such as weight on wheels, airspeed or throttle lever position are met.
- Other aircraft may require the pilot to manually select the ground spoilers after landing or in the event of a rejected takeoff.

2.Roll Spoilers

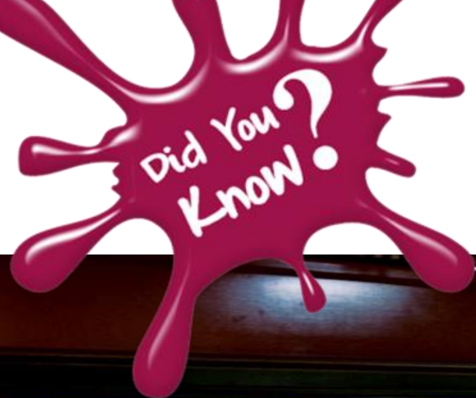
- On many spoiler equipped aircraft, one or more of the spoiler panels will deflect in harmony with the aileron on the associated wing **to enhance roll** authority and response.
- Roll commands normally take priority over a speed brake command and spoiler panels will extend or retract accordingly.

3.Speed brakes

- On many spoiler equipped aircraft, some of the spoiler panels have a flight spoiler function which is often referred to as "speed brakes".
- **In this application, the wing panels are symmetrically extended by pilot selection. The maximum deflection of the panels while airborne is normally limited to an angle which is less than the deflection achieved in ground spoiler mode.**
- Various aircraft have built in protections that will automatically command speed brake retraction below a certain airspeed, with flaps selected beyond a given position or with thrust levers set above a specific angle.
- Wing spoilers should not be deployed during the final phase of the approach to landing as the induced loss of lift will result in a higher than normal stall speed and could result in a hard landing.

Secondary/Auxiliary Flight Control Surfaces		
Name	**Location**	**Function**
Flaps	Inboard trailing edge of wings	Extends the camber of the wing for greater lift and slower flight. Allows control at low speeds for short field takeoffs and landings.
Trim tabs	Trailing edge of primary flight control surfaces	Reduces the force needed to move a primary control surface.
Balance tabs	Trailing edge of primary flight control surfaces	Reduces the force needed to move a primary control surface.
Anti-balance tabs	Trailing edge of primary flight control surfaces	Increases feel and effectiveness of primary control surface.
Servo tabs	Trailing edge of primary flight control surfaces	Assists or provides the force for moving a primary flight control.
Spoilers	Upper and/or trailing edge of wing	Decreases (spoils) lift. Can augment aileron function.
Slats	Mid to outboard leading edge of wing	Extends the camber of the wing for greater lift and slower flight. Allows control at low speeds for short field takeoffs and landings.
Slots	Outer leading edge of wing forward of ailerons	Directs air over upper surface of wing during high angle of attack. Lowers stall speed and provides control during slow flight.
Leading edge flap	Inboard leading edge of wing	Extends the camber of the wing for greater lift and slower flight. Allows control at low speeds for short field takeoffs and landings.

Any questions ?????????



Today's Amazing Fact???

At the time of WW II US manufactured average 130 planes per day

धन्यवाद

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