CPL Theory
Aerodynamics (CADA)

CAE Oxford
Aviation Academy

CADA 8 – Control

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2. Related Documents

Related Documents	Document Identification

CAE Oxford Aviation Academy

CADA 8 – Control

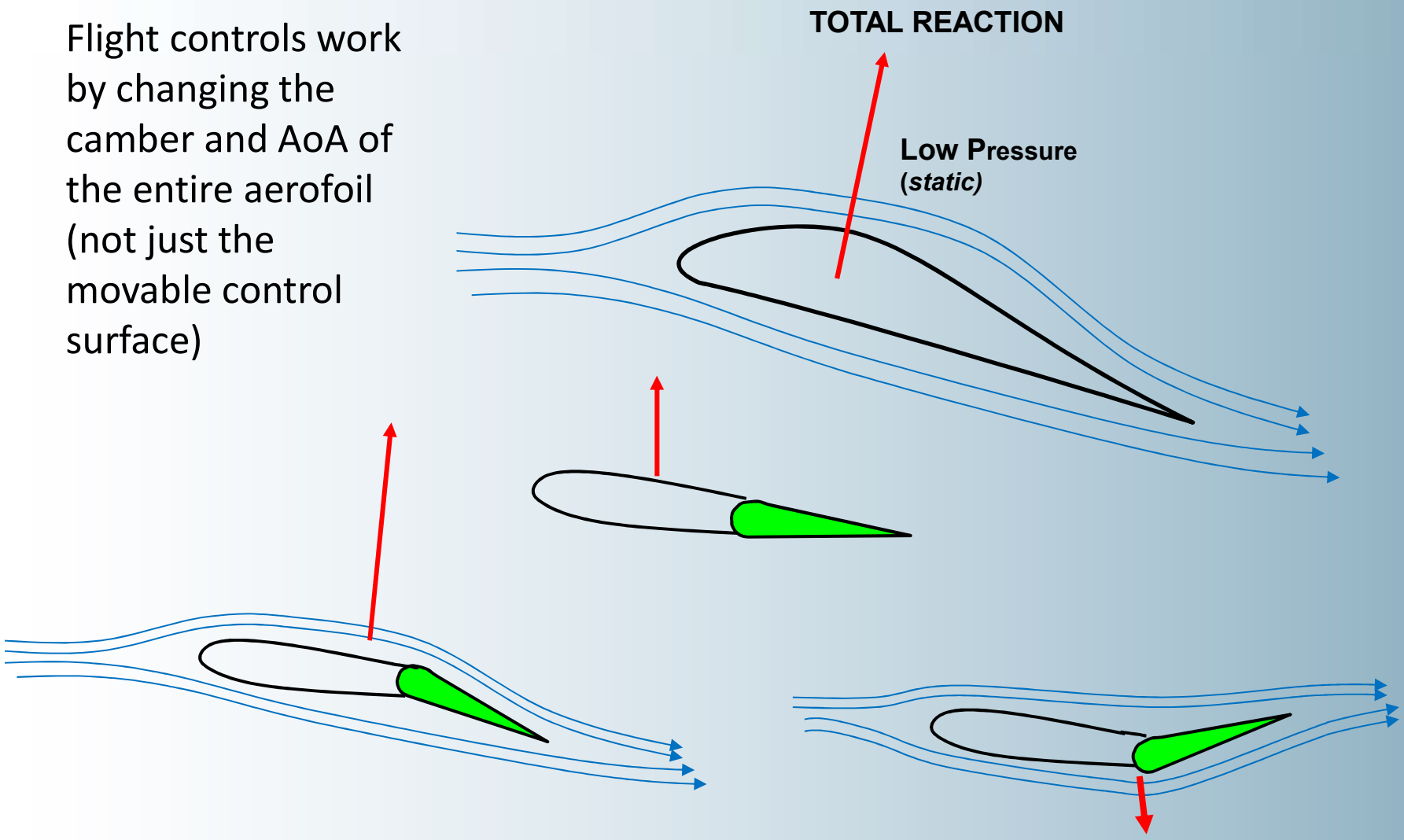
Amendments made to this document since the previous version are listed below. All amendments to this document have been made in accordance with CAE OAAM's document management procedure.

Slide	Changes

FLIGHT CONTROLS

Flight controls – Basic Principal

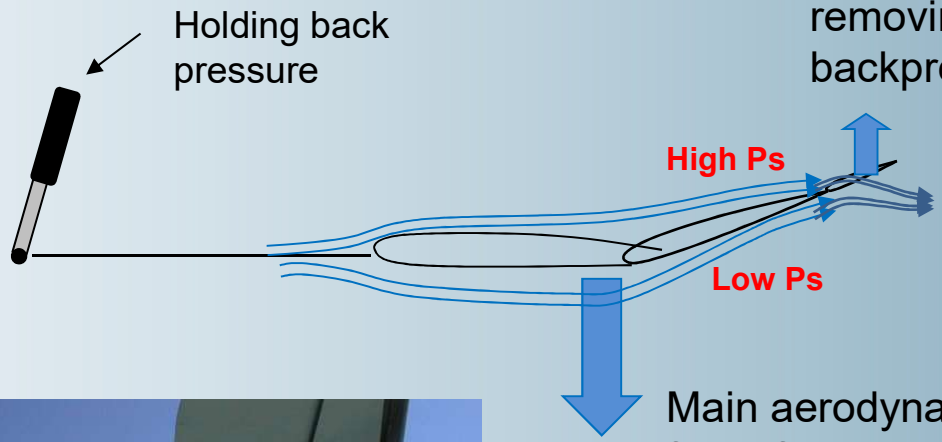
Flight controls work by changing the camber and AoA of the entire aerofoil (not just the movable control surface)



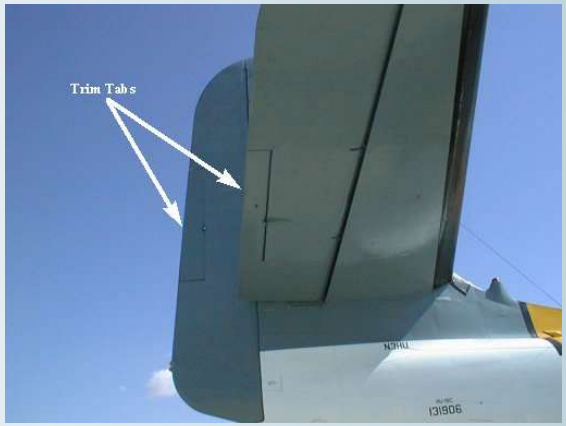
TRIM

Cockpit Adjustable Trim Tab

The cockpit adjustable trim tab is a simple device which can be used by the pilot to reduce and neutralise forces acting on the flight controls



- Cockpit adjustable trim tabs generally located on one of the elevators for pitch trim on small aeroplanes
- Bigger aeroplanes and multi-engine aeroplanes may include rudder trim or even aileron trim as well

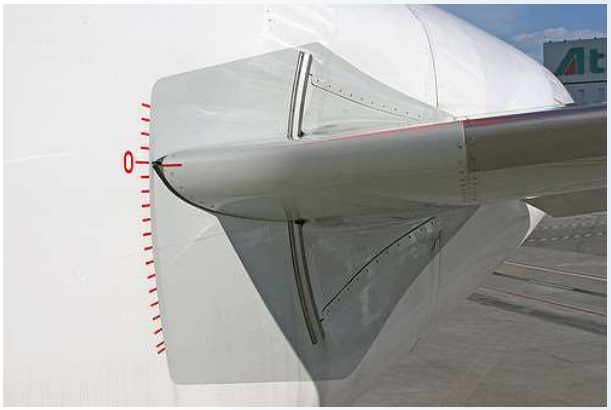


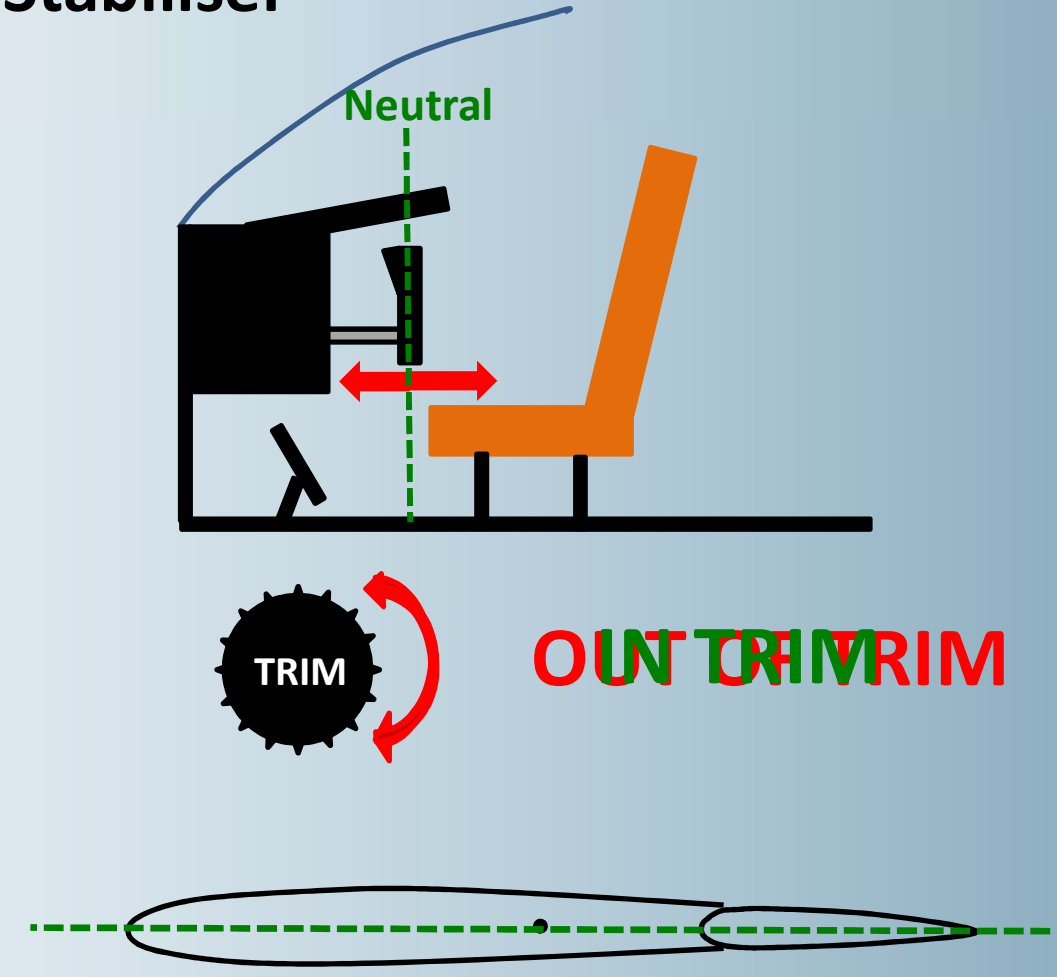
Ground Adjustable Trim Tab

- Ground adjustable trim tabs are tabs which are set by maintenance personnel on the ground and cannot be adjusted by the pilot in flight.
- Aerodynamically they work just like cockpit adjustable trim tabs
- They are positioned based on pilot feedback on how the aircraft behaves.

Trimmable Horizontal Stabiliser

- Elevator used for short term pitch control (like normal)
- For trim, the incidence of the entire horizontal stabiliser is adjusted
- Aeroplane is correctly trimmed when the elevator is faired with the stabiliser





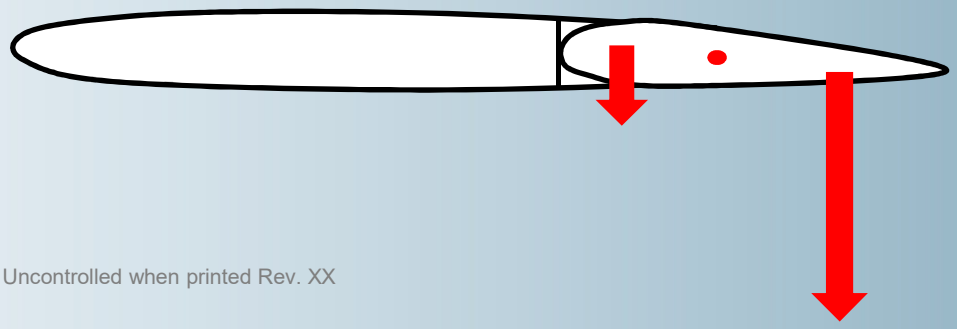
CONTROL BALANCE

Aerodynamic Balancing

- Large control surfaces experience large aerodynamic forces
- Aerodynamic balancing may be needed to keep control forces to a manageable level
- Aerodynamic balance may be achieved through several means

Control Horn Balance

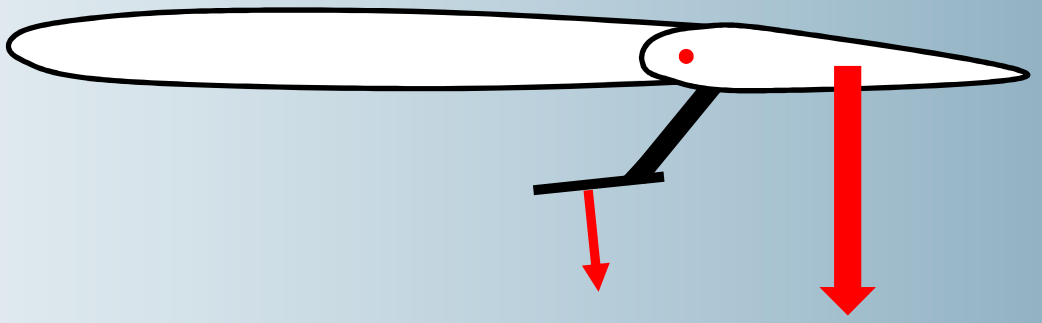
- A section of the control surface called the control horn is placed in front of the hinge line
- When the surface is deflected the horn will provide a small force which tries to increase the deflection
- This reduces the force required to be input by the pilot



Aileron Spades

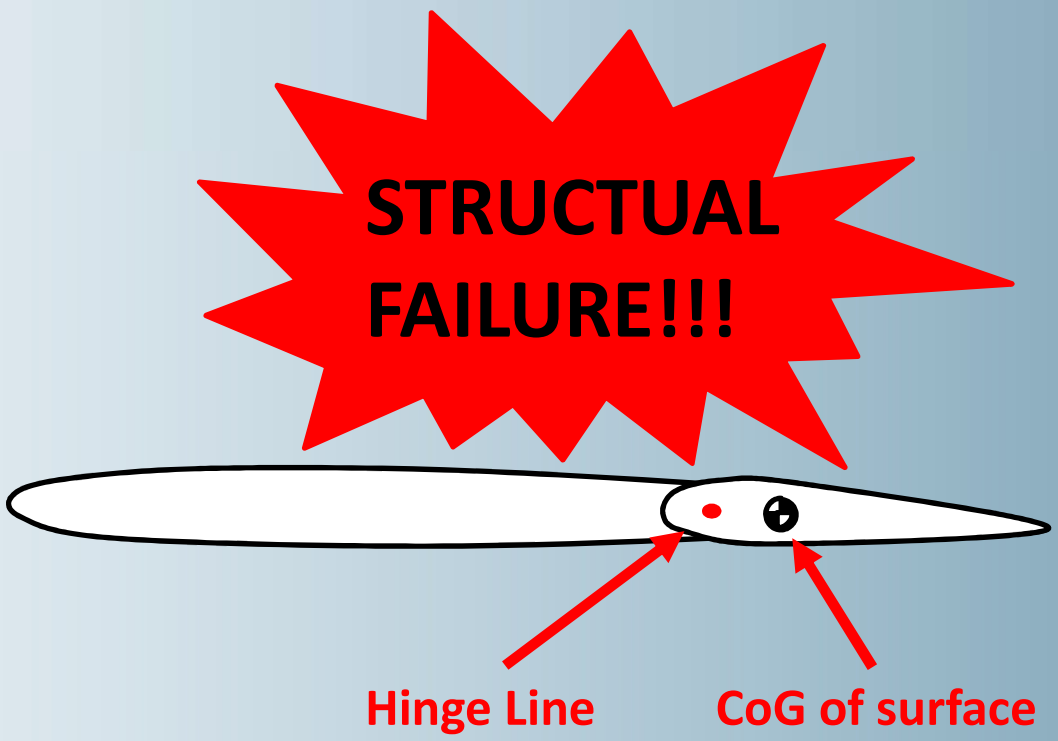
- Similar to a horn, a spade sticks out into the airflow when the surface is deflected
- When the surface is deflected the spade will provide a small force which tries to increase the deflection
- This reduces the force required to be input by the pilot

Aileron spade



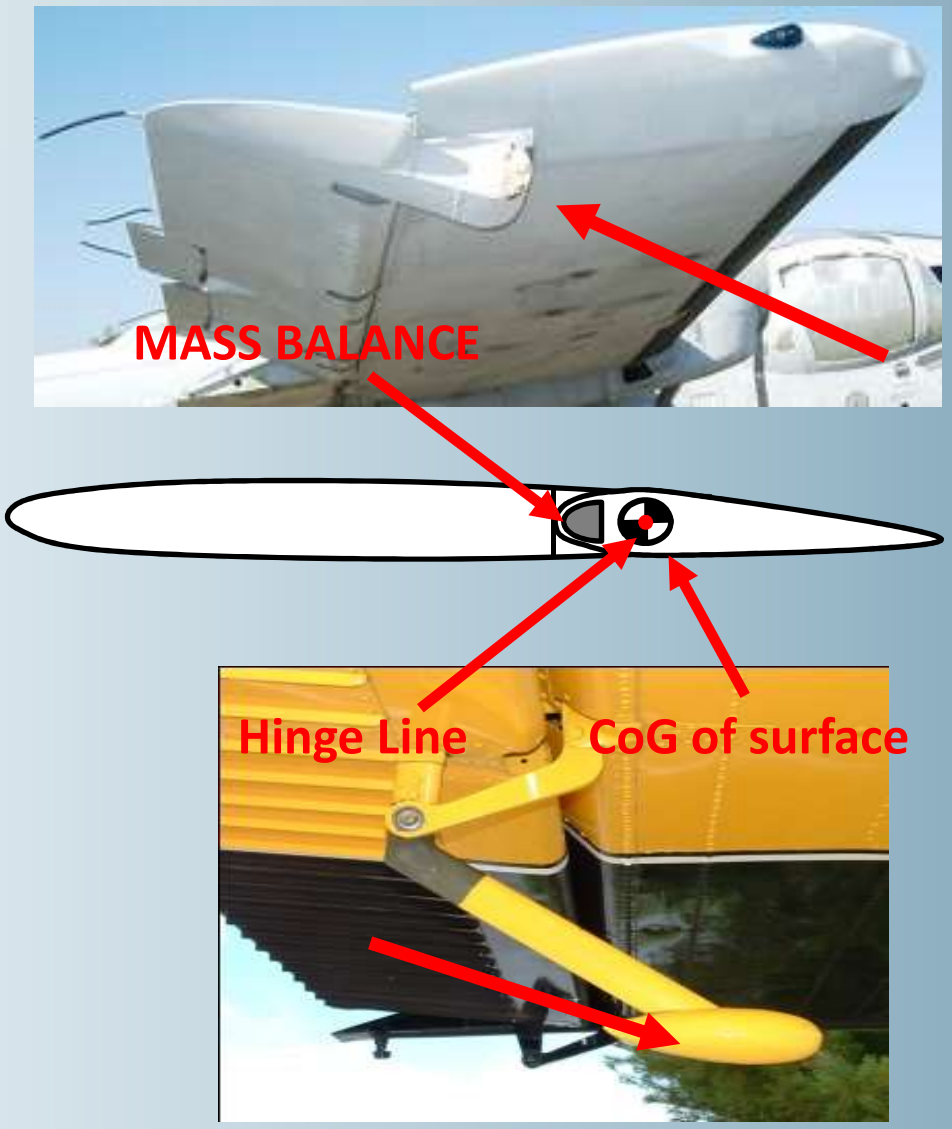
Mass Balancing

- With the CoG of the control surface behind the hinge line, vibrations in the fixed surface can cause the control surface to deflect
- These deflections cause aerodynamic forces which can couple with the vibrations
- At high airspeeds the aerodynamic forces can become stronger than the structure's natural damping ability
- In this case structural vibrations may become large enough that failure is likely to occur
- This is known as **flutter**



Mass Balancing

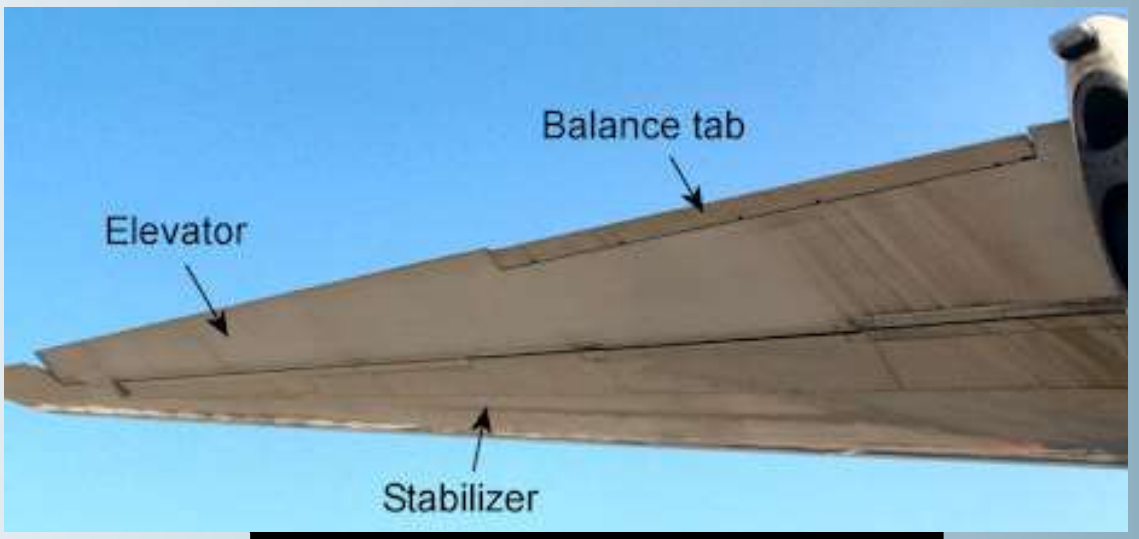
- Mass balancing is used to help prevent high speed control surface flutter
- A mass balance Placed on the control surface ahead of the hinge line to move the CoG of the control surface as close as practical to the hinge line
- Vibrations in the airframe will no longer cause deflection of the balanced control surface
- This can prevent aerodynamic forces from exciting vibrations, which are now dampened by the structure



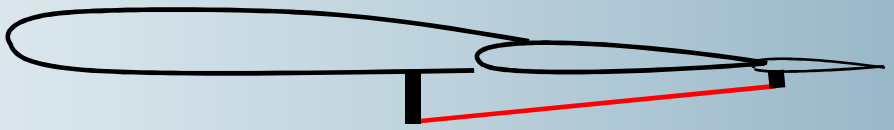
CONTROL SURFACE TABS

Balance Tabs

- A balance tab is designed to reduce the force required deflect a control surface
- Can be thought of as artificial aerodynamic balancing
- The balance tab is linked to the control surface so that as the pilot moves the control surface, the balance tab automatically moves in the **opposite** direction to the surface
- This 'balances' the forces acting on the surface to make it easier to move

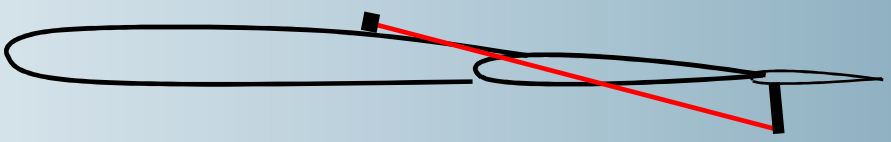


A **spring balance tab** is similar, except that the linkage contains springs so the tab will only begin to move once a pre-set control force is reached



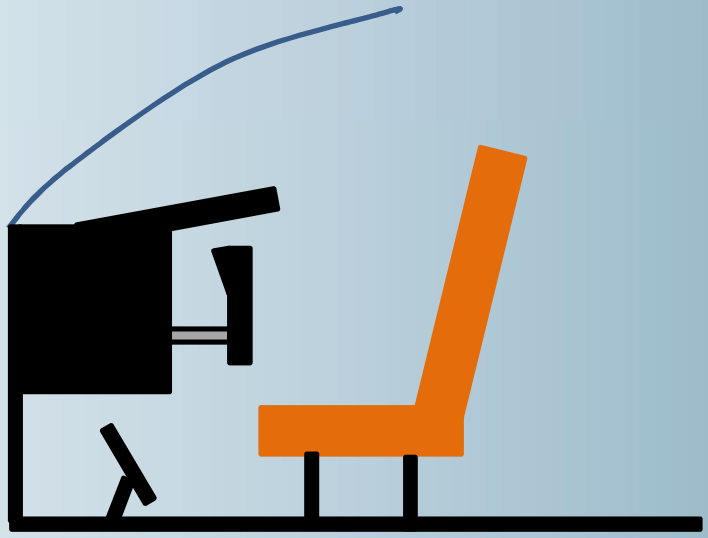
Anti-Balance Tabs

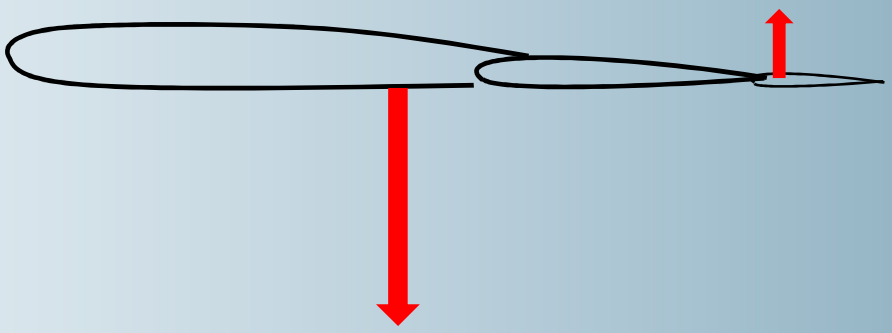
- Anti-balance tabs work in the opposite sense to a balance tab
- Linked to the control surface so they move in the **same** direction as the control surface
- They resist control input and increase control forces
- Used to help stop the pilot from over-controlling the aircraft



Servo Tabs

- Also called "**Control Tabs**"
- Pilot does not directly control the control surface (e.g elevator)
- Instead the pilot controls a servo tab on the surface
- Deflection of the servo tab provides an aerodynamic force which drives the control surface in the opposite direction to the correct position

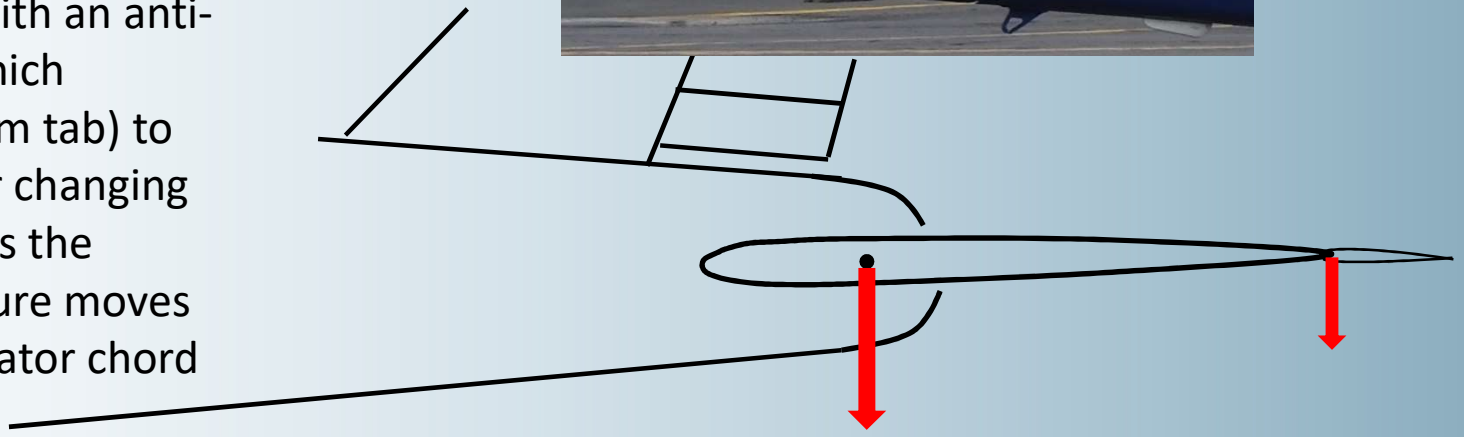




STABILATORS

Stabilator

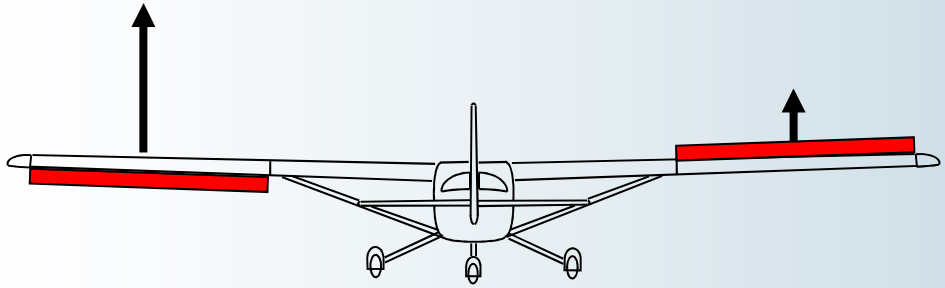
- Also called an “all flying tail”
- This is where the entire horizontal stabiliser is used for pitch control, rather than a separate elevator surface
- Usually fitted with an anti-balance tab (which doubles as a trim tab) to compensate for changing control forces as the centre of pressure moves along the stabilator chord

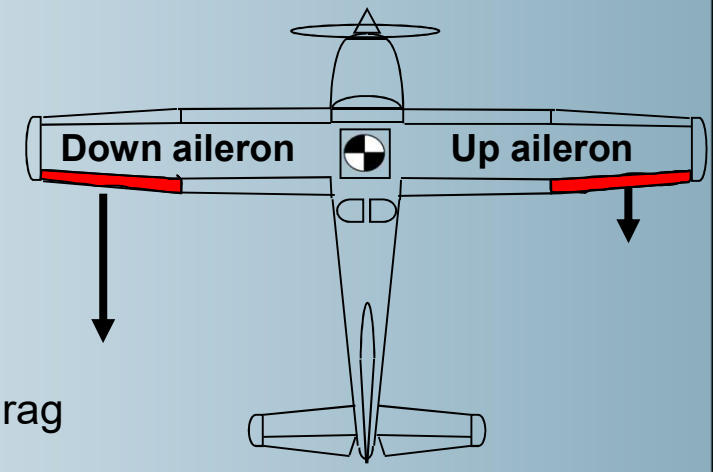


ADVERSE YAW

Adverse Yaw

- Tendency for the aircraft to yaw in the opposite direction of the roll.
- Caused by increase in induced drag on the down-going aileron.





The increased drag causes adverse aileron yaw.

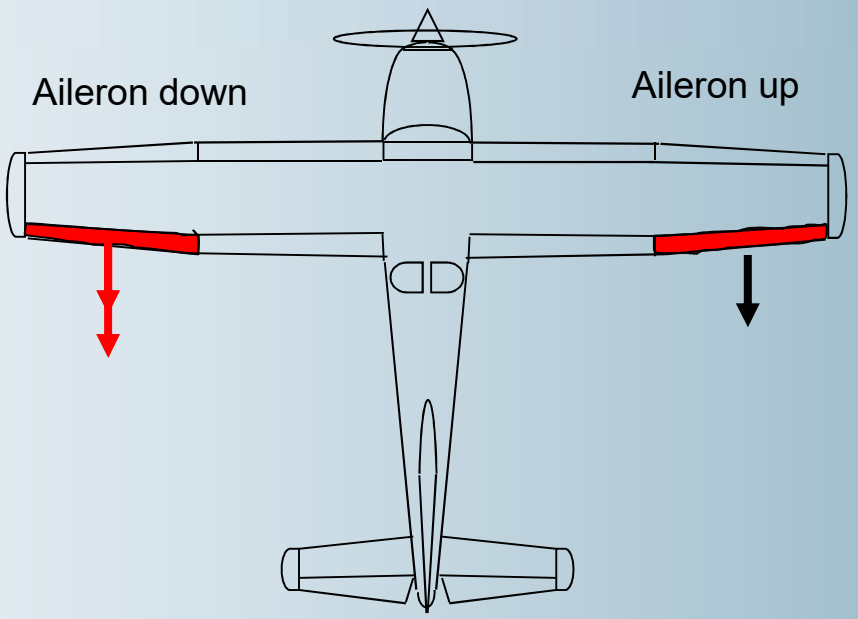
Adverse Yaw

The affect of adverse aileron yaw is minimised using;

- Differential ailerons
- Frise - type ailerons
- Coupling the rudder

Differential Ailerons

- The down-going aileron travels less distance.
- This reduces induced drag on the down-going aileron, reducing adverse aileron yaw.

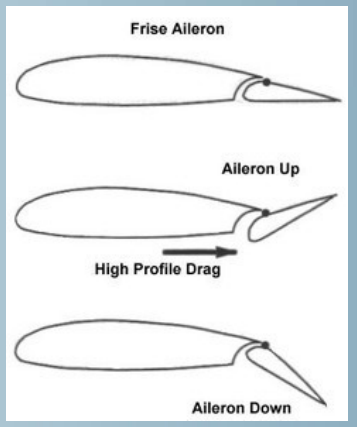


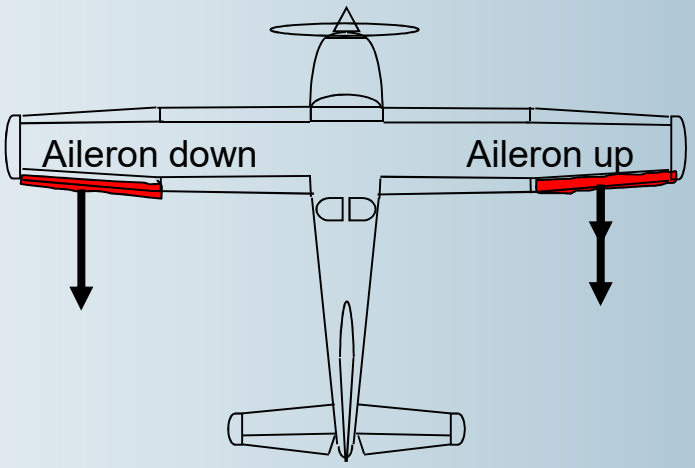
Decreased deflection <u>decreases</u> induced drag

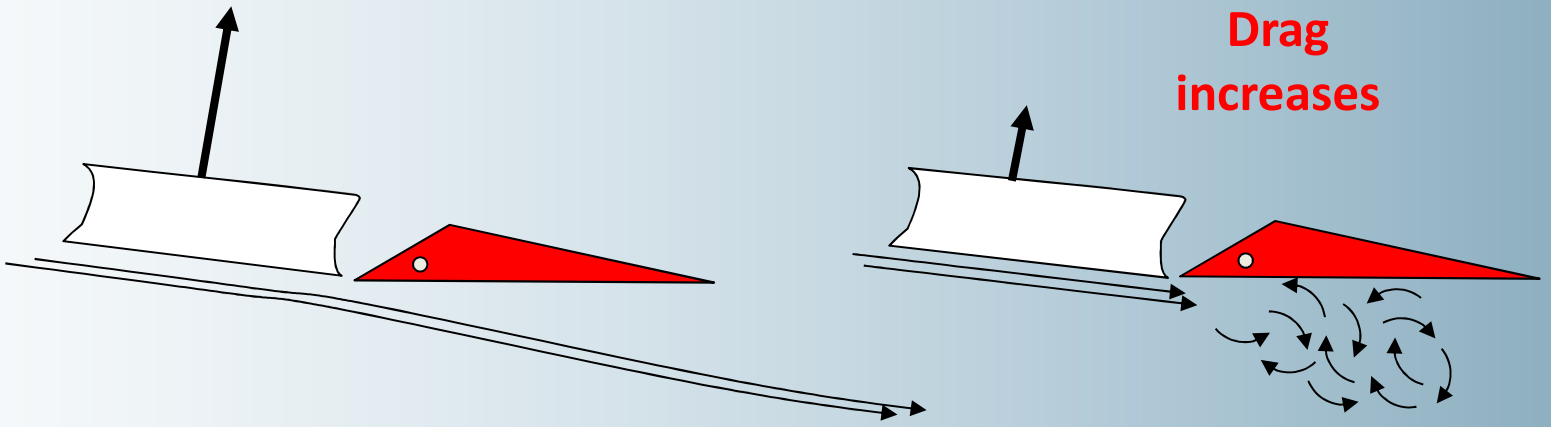
This does not completely eliminate adverse yaw

Frise Ailerons

- Uses offset hinges to deflect part of the up-going aileron into the air.
- This creates extra drag on the up going aileron which balances the drag on the down going aileron



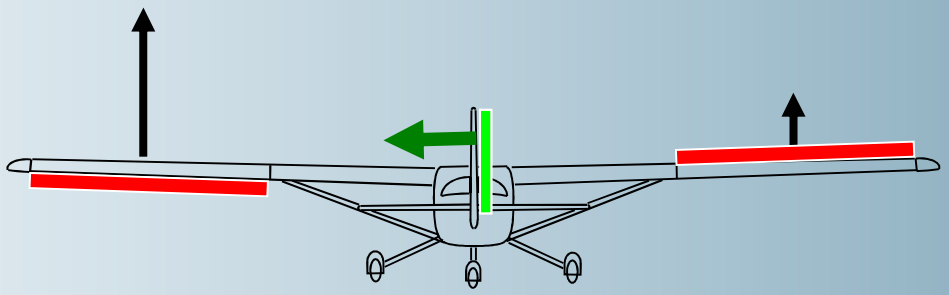




Drag increases

Aileron – Rudder coupling

- The wheel/stick is also linked to the rudder
- As the ailerons are deflected the rudder automatically moves to counteract the adverse yaw.



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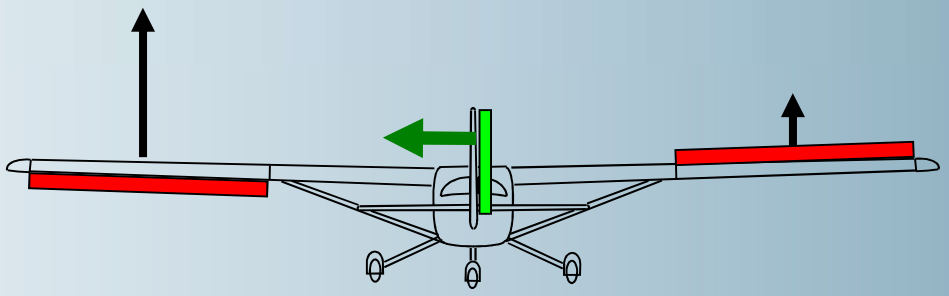

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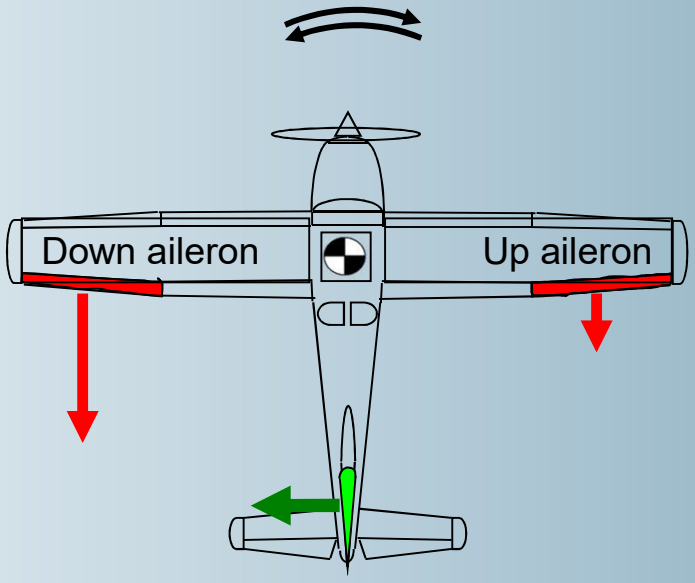

Note: These are all designer considerations, so the pilot has no control over these

SPOILERS

Spoilers

- Spoilers are small panels on the upper surface of the wing which can deflect into the airflow
- When deployed they decrease lift and increase drag on the wing
- Can be used symmetrically on each wing as speed breaks
- Can be used asymmetrically to aid in roll control