Chapter 6
Initial Sizing
(actually the 2nd iteration)

Refined Sizing Methods

- Improved empty weight fraction using statistical weight equations
- Improved climb fuel burn
- Calculation of $(L/D)_{cruise}$ using drag polar
- Limitations of fixed engine sizing
- Tail and control surface sizing

Refined Sizing Methods

- Have first estimate of TOGW, T/W and W/S, horizontal and vertical tail volume coefficients
- Thus known values of fuselage dimension, wing area, engine thrust, and tail size

Improved W_e estimate

From statistical regression analysis

$$\frac{W_e}{W_0} = \left[a + b\, W_0^{C1}\, A^{C2} \left(\frac{T}{W_0} \right)^{C3} \left(\frac{W_0}{S} \right)^{C4} M_{max}^{C5} \right] K_{VS}$$

where (for a jet transport)

$a = 0.32 \quad b = 0.66$

$C1 = -0.13 \quad C2 = 0.30 \quad C3 = 0.06 \quad C4 = -0.05 \quad C5 = 0.05$

$K_{VS} = 1$

- This calculates MEW for aluminum aircraft. Must factor for
  - Composite construction, if applicable (0.92-0.97)
  - Operational items (i.e. 1.05 for transcontinental, 1.06 for intercontinental)

Improved climb fuel burn

Subsonic:

$$\frac{W_i}{W_{i-1}} = 1.0065 - 0.0325\,M$$

Supersonic:

$$\frac{W_i}{W_{i-!}} = 0.991 - 0.007M - 0.01M^2$$

Supersonic climb and acceleration is a strong function of transonic thrust pinch (should calculate acceleration time by stepwise integration through transonic region)

Improved climb and acceleration fuel burn

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Combat Duration

For x turns, with sustained turn rate $\dot{\psi}$, combat duration d given by:

$$d = \frac{2\pi x}{\dot{\psi}} = \frac{2\pi V x}{g\sqrt{n^2 - 1}}$$

where $n = \dfrac{\frac{T}{W}}{\frac{L}{D}}$ and $\dfrac{L}{D} = \dfrac{1}{\left(q\dfrac{C_{D_0}}{n\left(\frac{W}{S}\right)} + \dfrac{n\left(\frac{W}{S}\right)}{q\pi A e} \right)}$

- Aircraft velocity *V* and load factor *n*
- Oswald efficiency factor *e* is f(C_L) so solution has to be iterated

Section 6.6 Aeroelastic Effects

- On B-47, high aspect ratio thin wing subject to aileron reversal at high q

- A - Neutral aileron
- B - Deflected aileron, stiff wing
- C - Deflected aileron, flexible wing

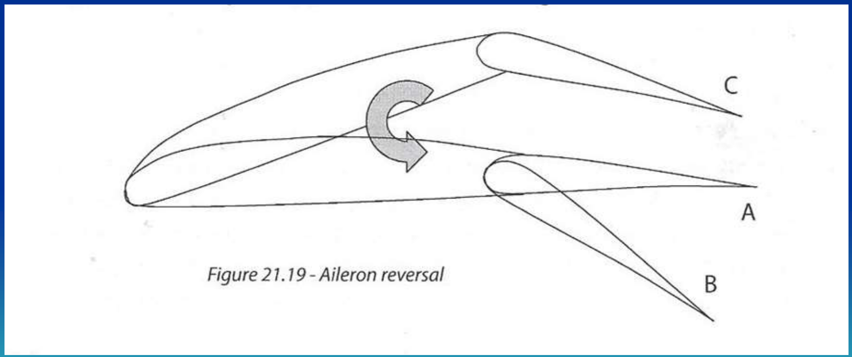
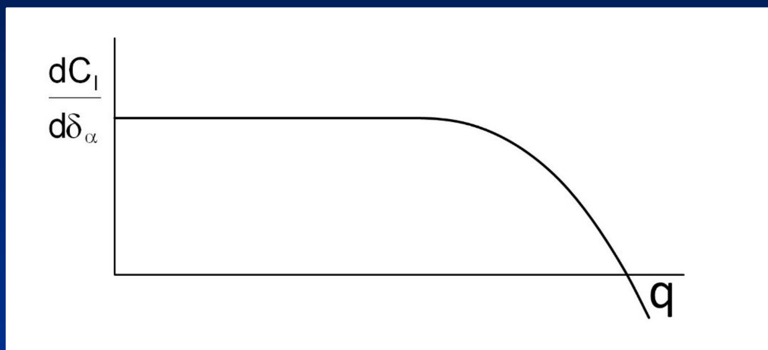
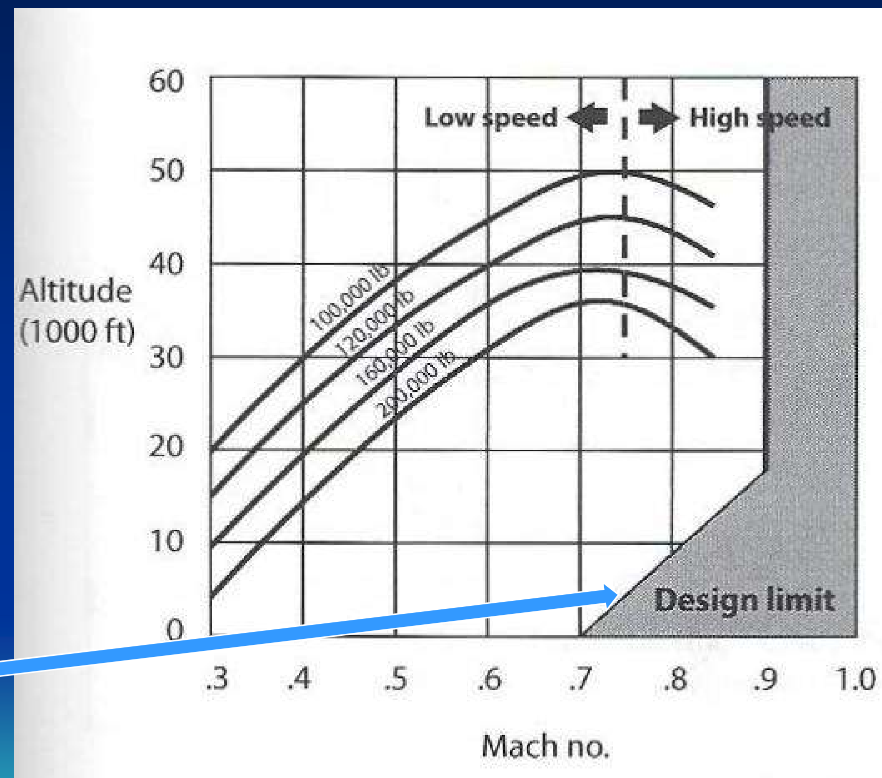


Figure 21.19 - Aileron reversal

Source: Obert

Section 6.6 Aeroelastic Effects

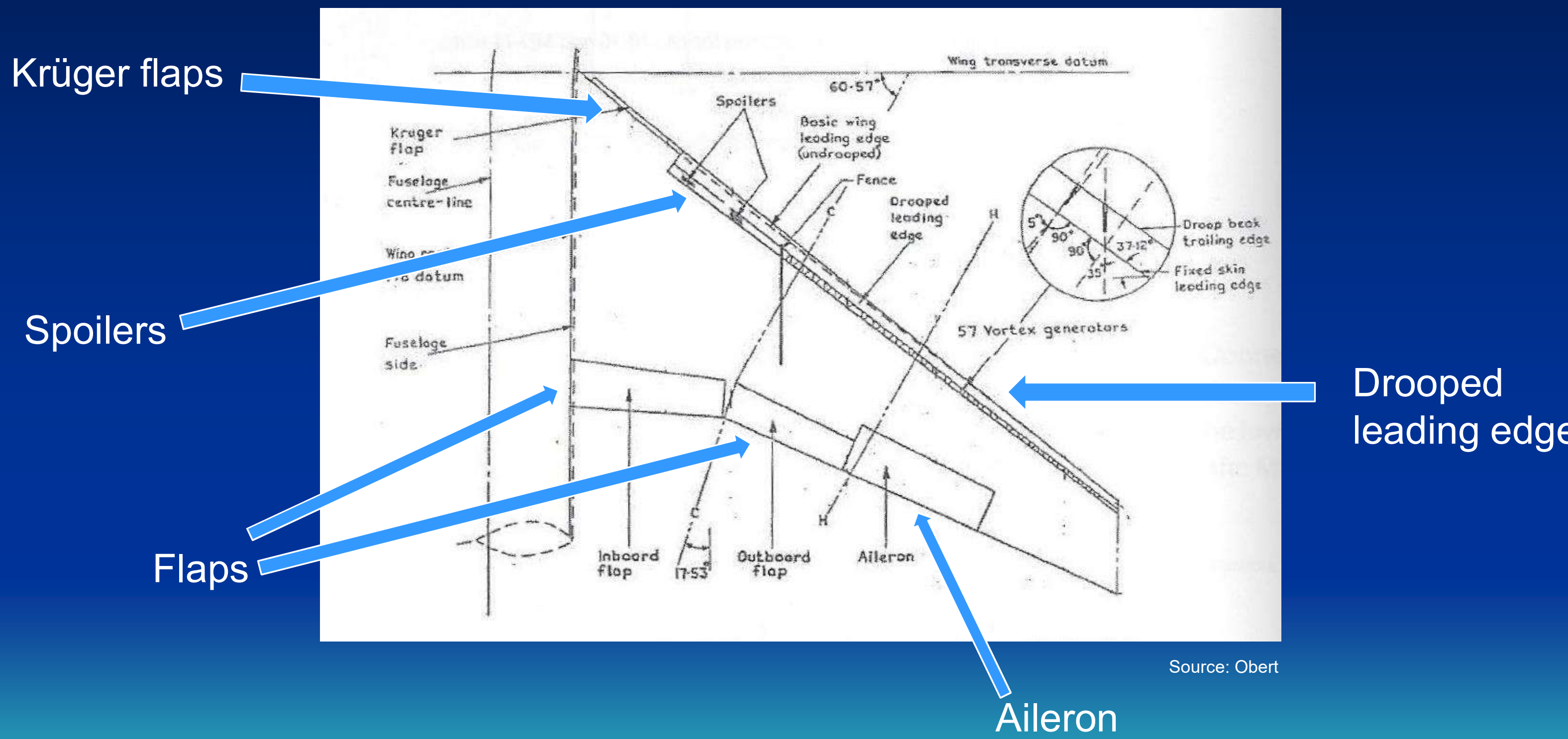




Source: Obert

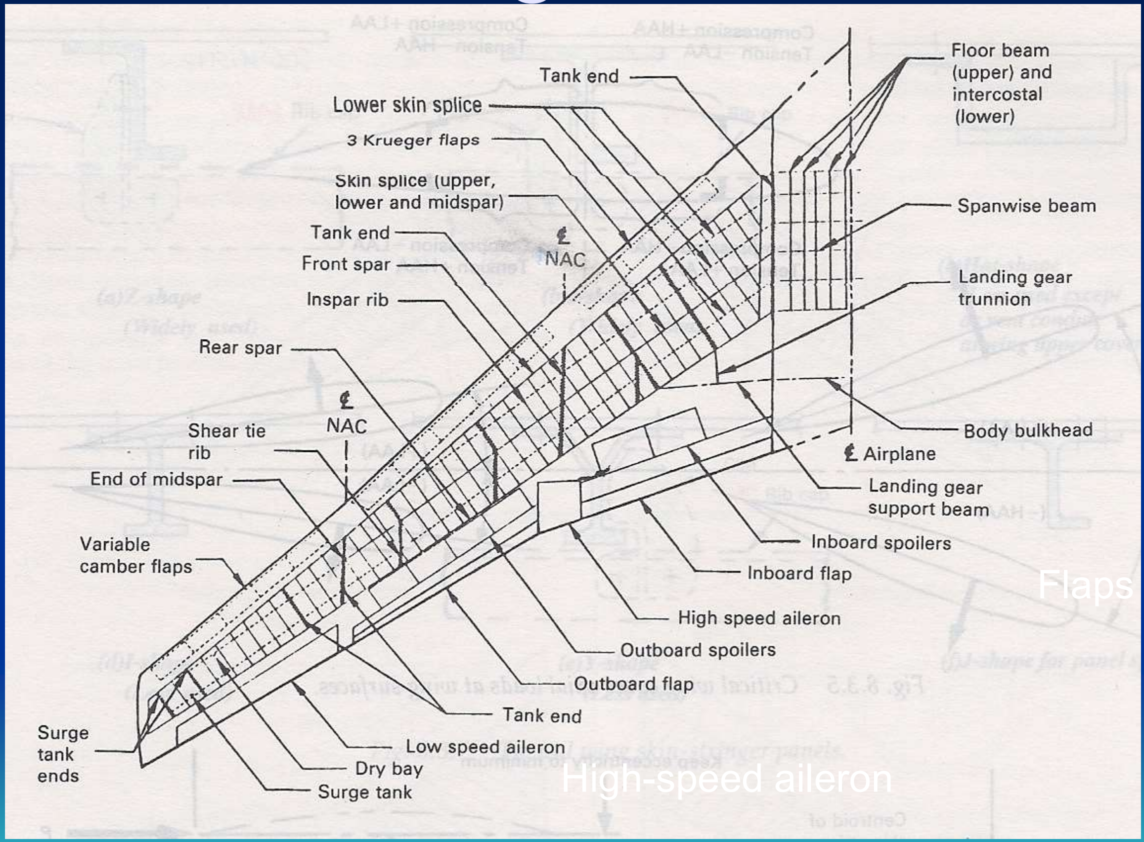
- Spoiler ailerons tested but not used on production aircraft
- q-limited flight envelope

De Havilland Trident Wing Planform



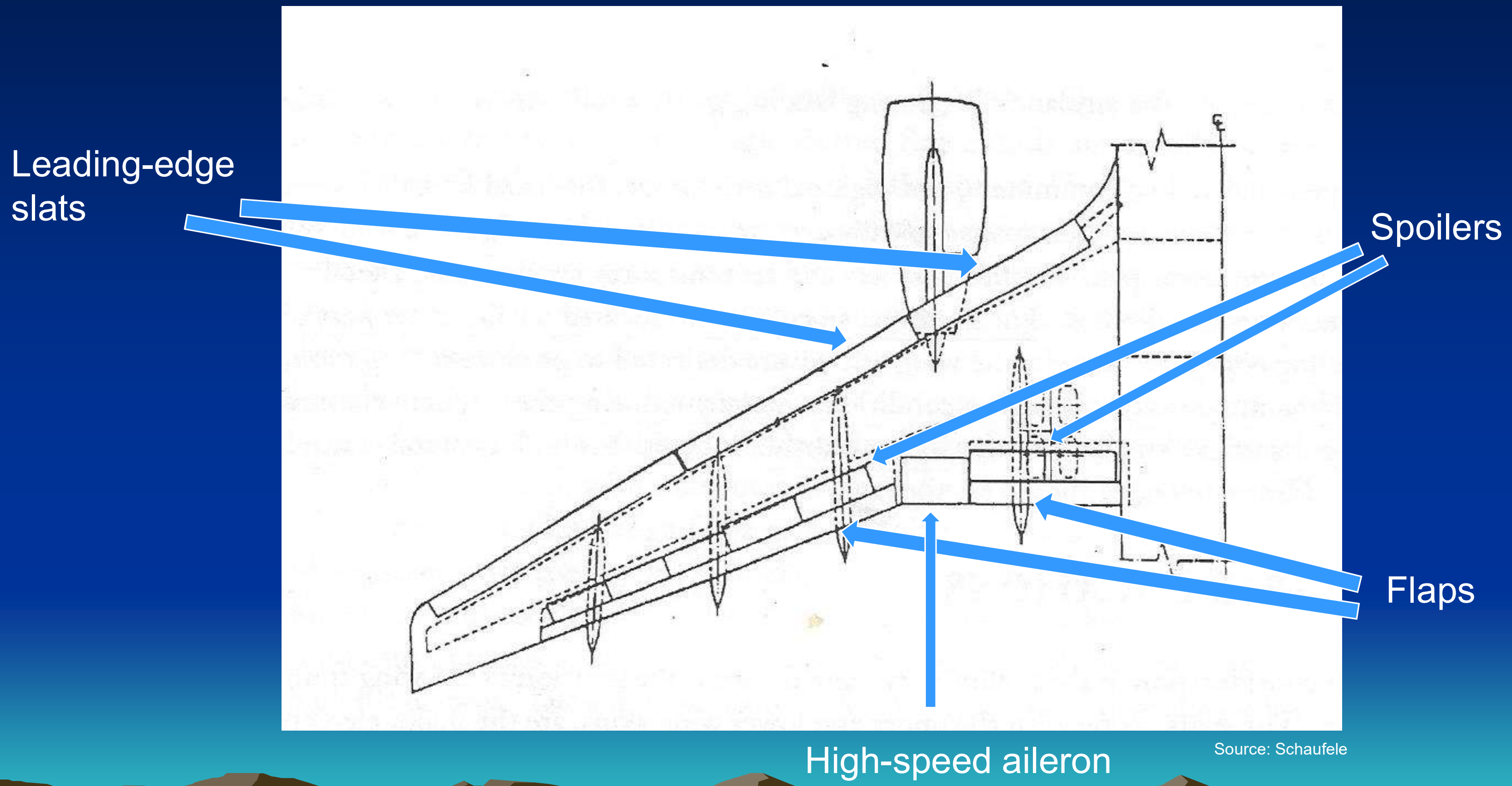
Source: Obert

747 Wing Planform



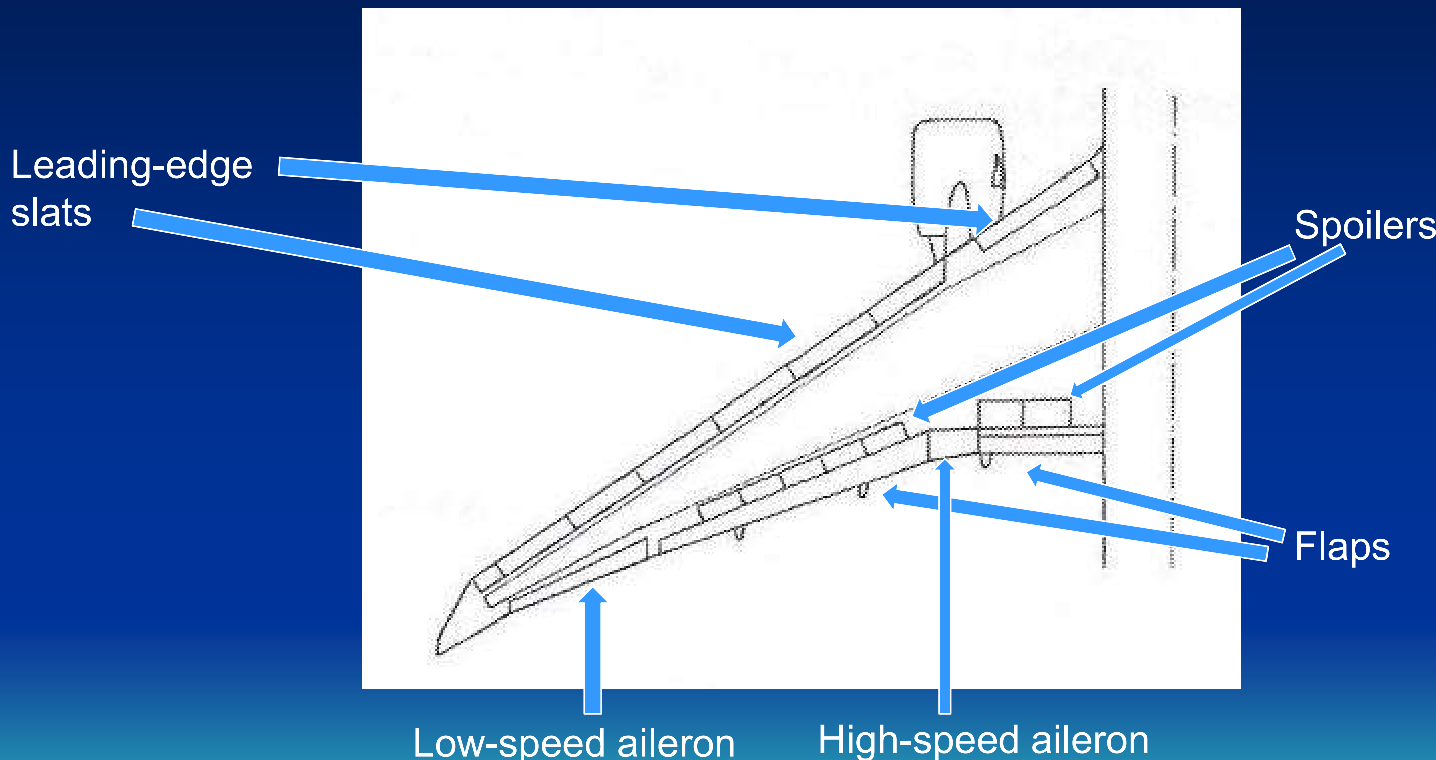
Source: Niu

A310 Wing Planform



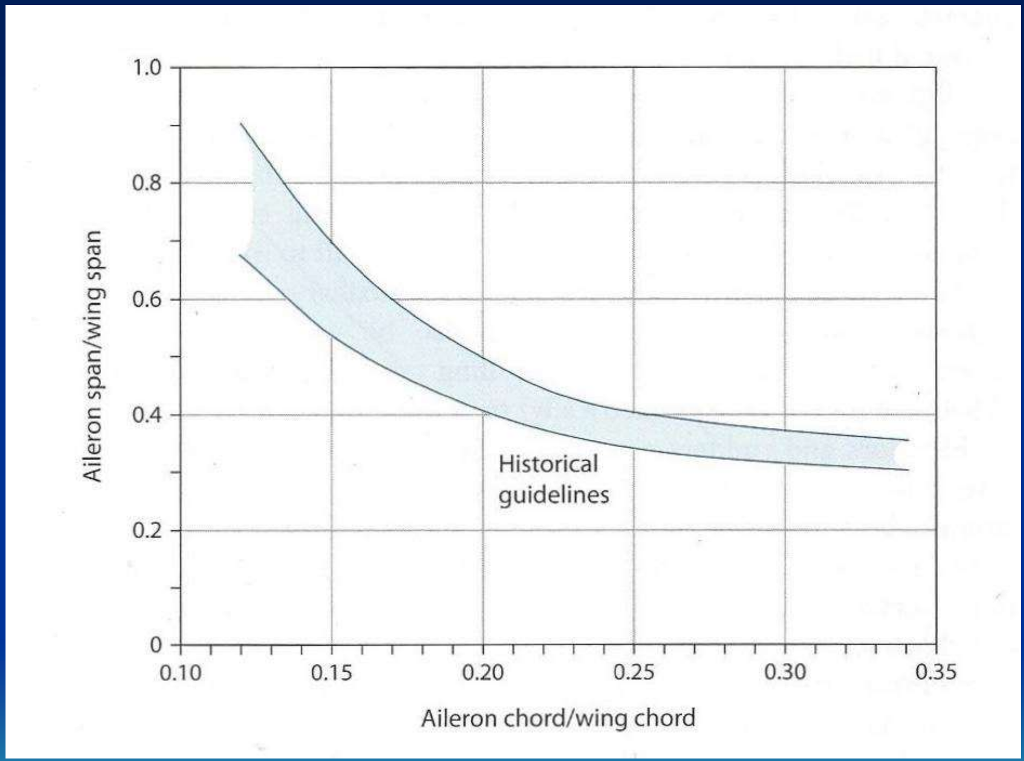
Source: Schaufele

777 Wing Planform



Low-speed Aileron Guidelines

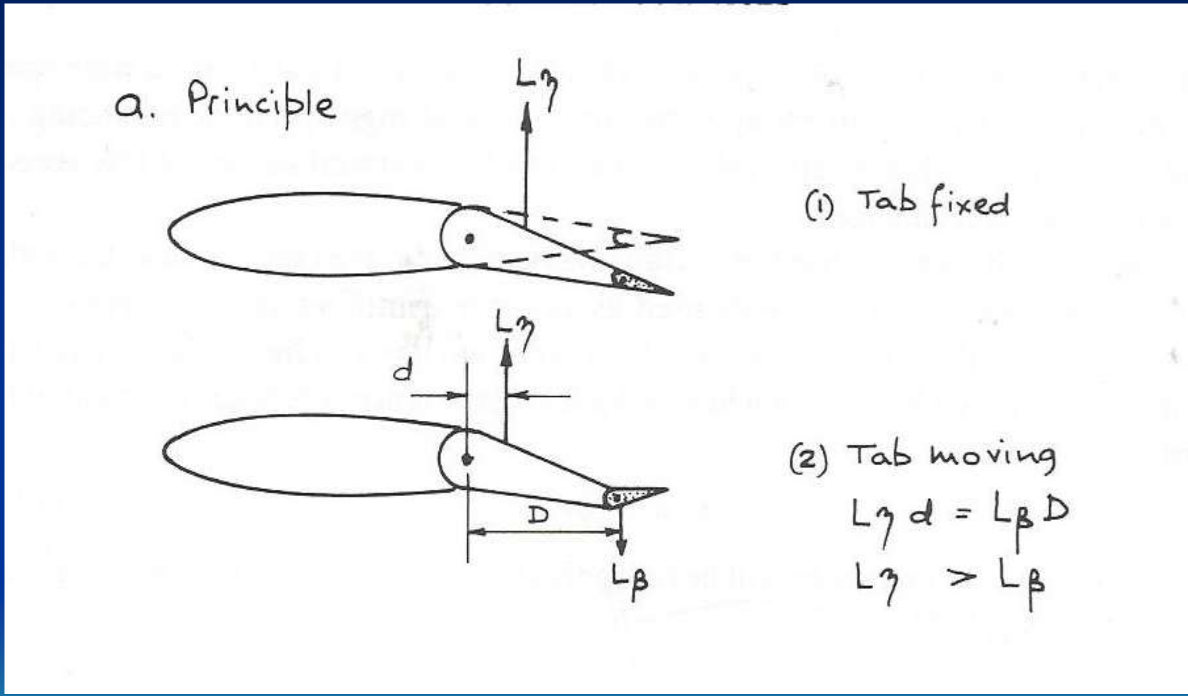
- Typically (aileron chord)/(wing chord) = 15% to 25%



Source: Raymer

Tab-assisted Controls

- Balance moments about hinge of main control surface

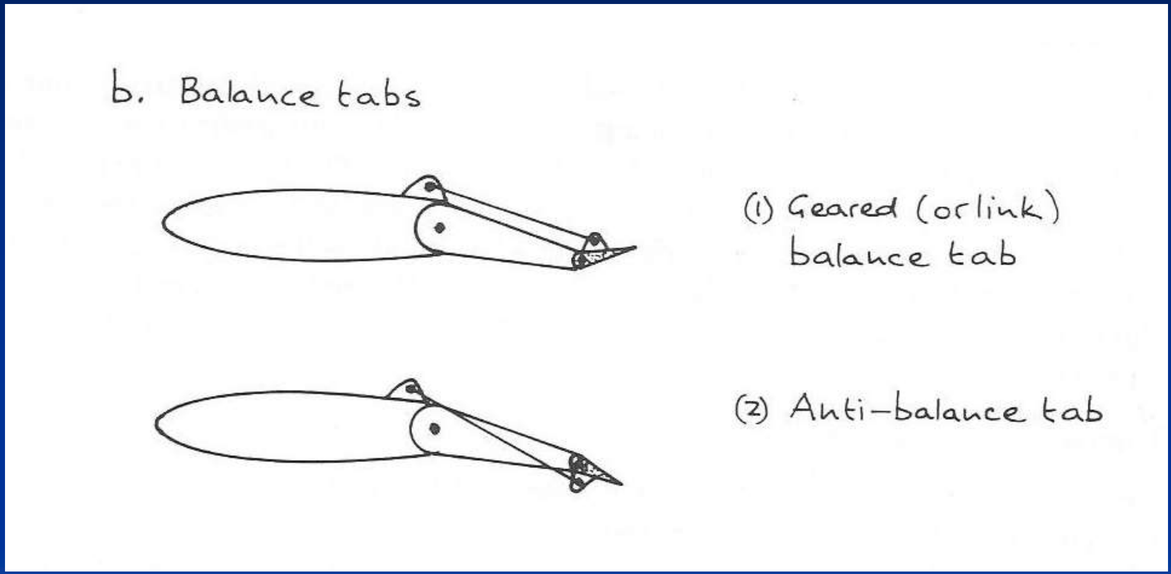


Source: Stinton

Tab-assisted Controls

- Usually balance tab to reduce pilot's control forces

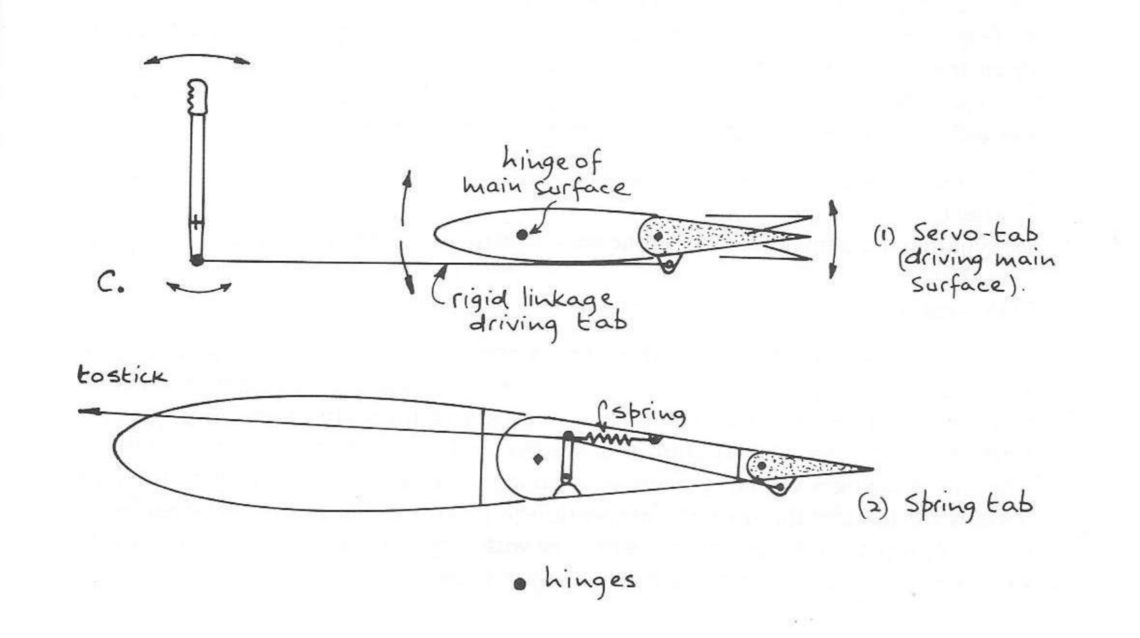
- Occasionally anti-balance to increase aerodynamic forces



Source: Stinton

Tab-operated Controls

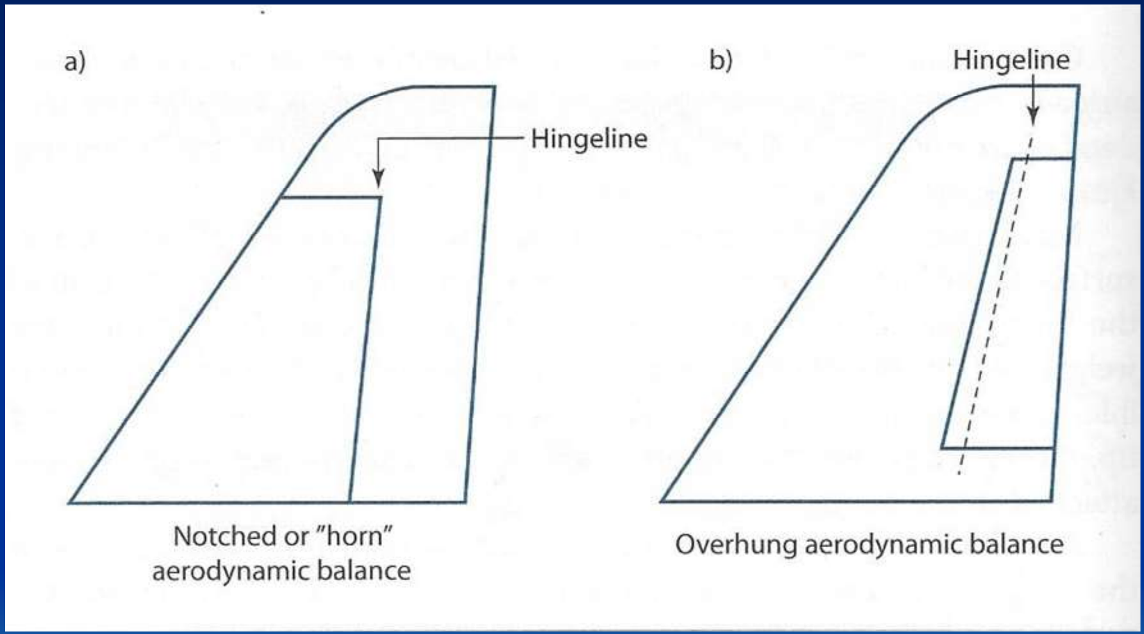
- No applied moment at control surface hinge
- Spring tab reduces required input control forces
  - Effectiveness at low speed
  - Effectiveness at stall
  - Tab damage when main controls hit stops during taxiing
  - Prevention of flutter



Source: Stinton

Rudder Balance

- Horn balance usually on an unpowered control surface (including elevator)



Source: Raymer

Initial Sizing
The End