Etkin, Dynamics of Atmospheric Flight, p108

- Earth-fixed frame, E: zE along gravity (down), xE North, yE East
- Body frame, B: xB upstream, yB right wing, zB down
- Wind frame, W: w/body@CM, xW along the velocity vector of the vehicle V, zW in the plane of symemetry
- Stability frame, S: w/body, xS symmetry plane w/body, rotated and beta from Wind frame
- NOTE:
  - V is the velocity of the craft relative to the atmosphere, or -vrel

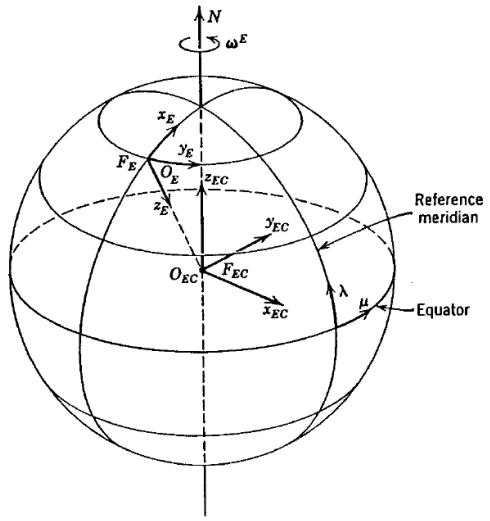


FIG. 4.2 Earth axes. (λ, μ) = latitude, longitude.

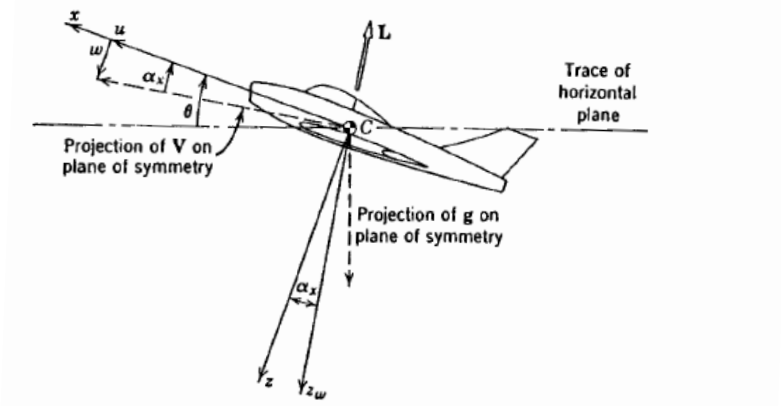


FIG. 4.4 Plane of symmetry—Cxz; L = lift vector.

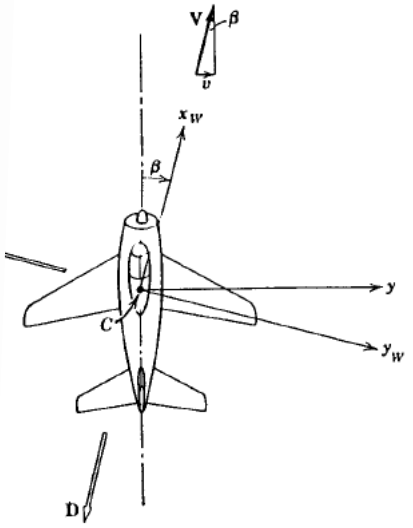


FIG. 4.5 Plane Cx_Wy_W: D, C = drag and cross-wind force vectors.

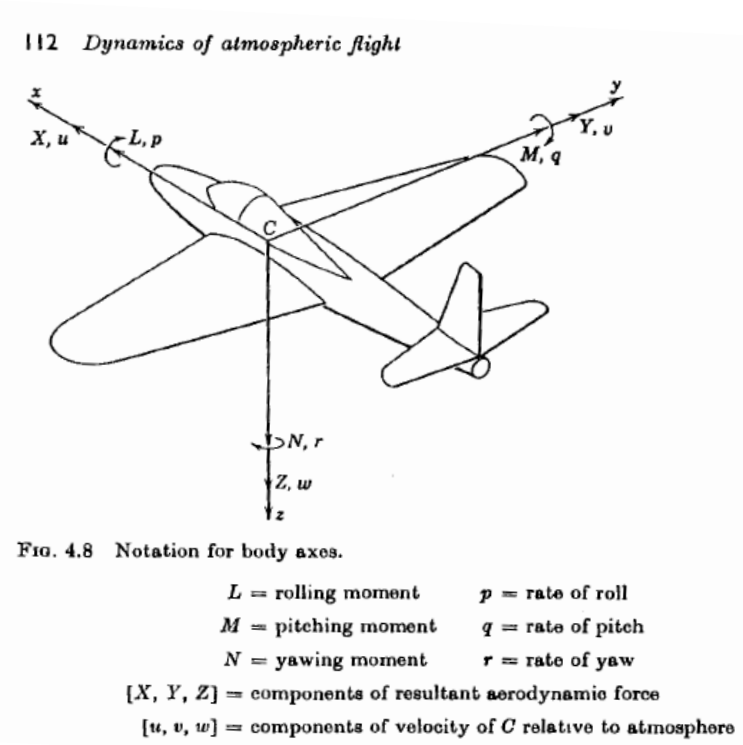


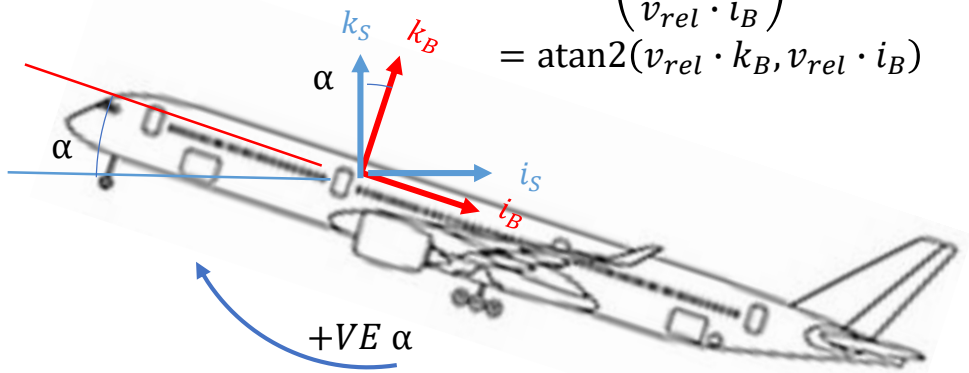
FIG. 4.8 Notation for body axes.

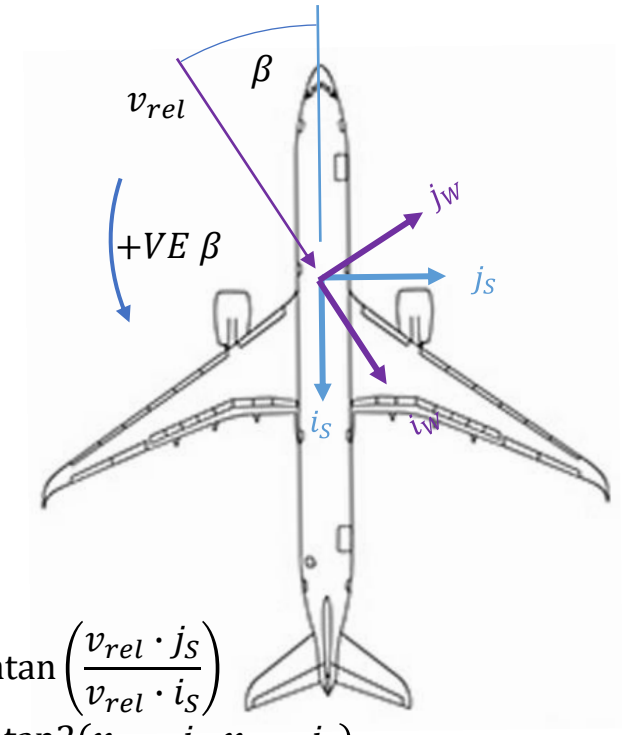
L = rolling moment — p = rate of roll
M = pitching moment — q = rate of pitch
N = yawing moment — r = rate of yaw
$[X, Y, Z]$ = components of resultant aerodynamic force
$[u, v, w]$ = components of velocity of C relative to atmosphere

AVL,

- AVL file frame, A: w/body@LE xA downstream, yA out the right wing, zA up
- Body frame, XYZ (B): w/body@CM xA downstream, yA out the right wing, zA up
- Stability frame xyz (S): w/body@CM tilted up by angle alpha from body frame (OCB = [])
- Wind frame, W: w/body@CM,
- NOTE:
  - Forces and moments are +VE in stability frame:
    - Drag +VE xS, Side +VE yS, Lift +VE zS

$$\alpha = \text{atan}\left(\frac{v_{rel}\cdot k_B}{v_{rel}\cdot i_B}\right) = \text{atan2}(v_{rel}\cdot k_B, v_{rel}\cdot i_B)$$





$$\beta = \text{atan}\left(\frac{v_{rel}\cdot j_S}{v_{rel}\cdot i_S}\right) = \text{atan2}(v_{rel}\cdot j_S, v_{rel}\cdot i_S)$$

$$^{XYZ\ (B)}[C]^{xyz\ (S)} = \begin{bmatrix} c\alpha & 0 & -s\alpha \\ 0 & 1 & 0 \\ s\alpha & 0 & c\alpha \end{bmatrix}$$

$$^{S}[C]^{W} = \begin{bmatrix} c\beta & -s\beta & 0 \\ s\beta & c\beta & 0 \\ 0 & 0 & 1 \end{bmatrix}$$

$$^{S}[C]^{B} = \begin{bmatrix} c\alpha & 0 & s\alpha \\ 0 & 1 & 0 \\ -s\alpha & 0 & c\alpha \end{bmatrix}$$

$$^{W}[C]^{S} = \begin{bmatrix} c\beta & s\beta & 0 \\ -s\beta & c\beta & 0 \\ 0 & 0 & 1 \end{bmatrix}$$