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ASEN 3128
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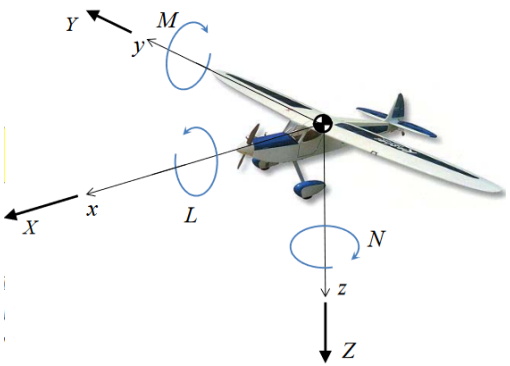
Nomenclature



$\mathbf{V}_B^E$ = velocity in intertial frame written in body coordinate system
$\mathbf{F}_B^{aero} = X\mathbf{e}_x + Y\mathbf{e}_y + Z\mathbf{e}_z = [X; Y; Z]$
$\mathbf{M}_B^{aero} = \mathbf{G}_B^{aero} = L\mathbf{e}_x + M\mathbf{e}_y + N\mathbf{e}_z = [L; M; N]$
$\mathbf{V}_B^E = u^E\mathbf{e}_x + v^E\mathbf{e}_y + w^E\mathbf{e}_z = [u^E; v^E; w^E]$
$V_g = |\mathbf{V}_B^E| = \mathbf{V}_E^E = \sqrt{(u^E)^2 + (v^E)^2 + (w^E)^2}$
$\omega_B^E = p^E\mathbf{e}_x + q^E\mathbf{e}_y + r^E\mathbf{e}_z = [p; q; r]$

Four Control Surfaces

Rudder: $+\delta_r$ = towards -y = negative moment & positive force
Elevator: $+\delta_e$ = down = negative moment & negative force
Aileron: $+\delta_a$ = right (+y) down = negative moment
Throttle: $+\delta_t$ = no moment, positive force.

Wind

Background Wind: $\mathbf{V}^E = \mathbf{V} + \mathbf{W}$ **Wind Angles**:
$V = |\mathbf{V}_B|$
$a = \arctan\frac{w}{u}$, $\beta = \arcsin\frac{v}{V}$
$u = V\cos\beta\cos\alpha$, $v = V\sin\beta$, $w = V\cos\beta\sin\alpha$
α = angle of attack, β = sideslip angle

Euler Angles

$R_E^B(\phi,\theta,\psi) = R_{v2}^B(\phi)R_{v1}^{v2}(\theta)R_E^{v1}(\psi)$
Body to Inertial Frame Transformation:
$\mathbf{p}_B = R_E^B\mathbf{p}_E \rightarrow \mathbf{p}_E = R_B^E\mathbf{p}_B$
$R_B^E = (R_E^B)^T$
Stability Frame: $\mathbf{p}_s = R_B^s\mathbf{p}_B$

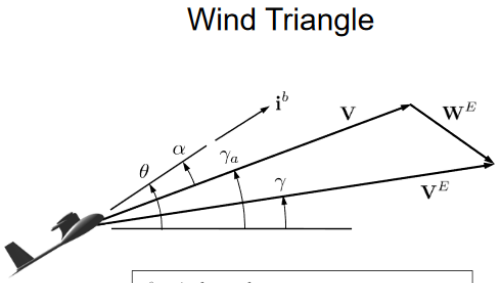
$$R_B^s(\alpha) = \begin{pmatrix} \cos\alpha & 0 & \sin\alpha \\ 0 & 1 & 0 \\ -\sin\alpha & 0 & \cos\alpha \end{pmatrix}$$

Wind Frame: $\mathbf{p}_w = R_s^w(\alpha)\mathbf{p}_s$

$$R_B^w(\alpha,\beta) = R_s^w(\beta)R_B^s(\alpha) = \begin{pmatrix} \cos\beta\cos\alpha & \sin\beta & \cos\beta\sin\alpha \\ -\sin\beta\cos\alpha & \cos\beta & -\sin\beta\sin\alpha \\ -\sin\alpha & 0 & \cos\alpha \end{pmatrix}$$

$R_w^B(\alpha,\beta) = (R_B^w)^T(\alpha,\beta)$

Wind Triangle



θ: pitch angle
α: angle of attack
γ: flight path angle
γ_a: air-mass-relative flight path angle

$\gamma_a = \theta - \alpha$

Kinematics and Dynamics

Name	Description
x_E	Intertial x (North) position
y_E	Interial y (East) position
z_E	Inertial z (Down) position
ϕ	Roll Angle
θ	Pitch Angle
ψ	Yaw Angle
u^E	Inertial Velocity along $\hat{i}_B$
v^E	Inertial Velocity along $\hat{j}_B$
w^E	Inertial Velocity along $\hat{k}_B$
p	Angular Velocity along $\hat{i}_B$ (Roll rate)
q	Angular Velocity along $\hat{j}_B$ (Pitch rate)
r	Angular Velocity along $\hat{k}_B$ (Yaw rate)