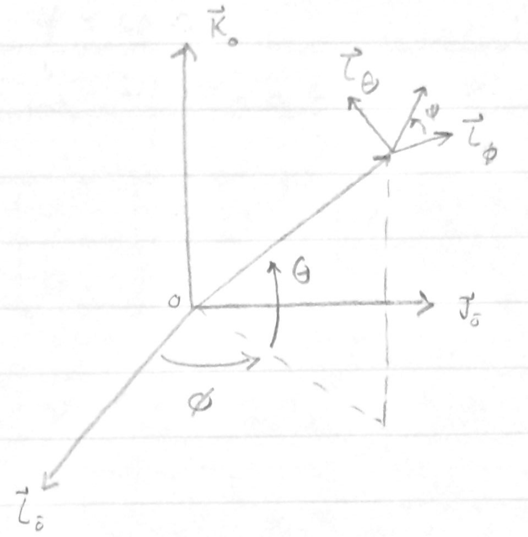
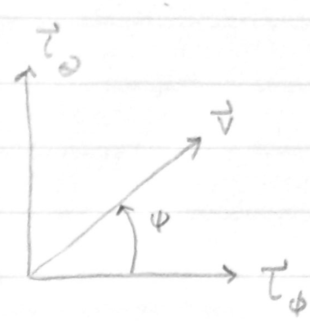
DATE





state vector: $\underline{x} = [\phi, \theta, V, \psi, \omega]^T$ where $\dot{\psi} = \omega$

$$\dot{\phi} = \frac{V\cos\psi}{r\cos\theta}, \quad \dot{\theta} = \frac{V\sin\psi}{r}, \quad \dot{V} = \frac{F_x}{m}, \quad \dot{\psi} = \omega, \quad \dot{\omega} = \frac{M_z}{J}$$

$$\dot{\underline{x}} = \begin{bmatrix} \frac{V\cos\psi}{r\cos\theta} & \frac{V\sin\psi}{r} & \frac{F_x}{m} & \omega & \frac{M_z}{J} \end{bmatrix} \longleftarrow$$ (note, closed loop heading dynamics look simpler)

expression for the path: $\phi_p(s) = \frac{W}{2}\sin(2\pi s)$ $\theta_p(s) = -\frac{H}{2}\sin(4\pi s)$

(note the constant radius)

(note, you need the − to go in the right dir. around the path)

expression for path position, try this:

$$s^*(t) = \arg\min_s \left(\phi(t) - \phi_p(s)\right)^2 + \left(\theta(t) - \theta_p(s)\right)^2$$

rotational dynamics w/ model ref ctrl:

$$\dot{\psi} = \omega$$

$$\dot{\omega} = \alpha_1 + \alpha_2 u_r \qquad u_r = \frac{1}{\alpha_2}\left(-b_1 e_1 - b_2 e_2 - \alpha_1 + \frac{1}{\tau_r^2}\left(\psi_{sp} - 2\tau_r \dot{\psi}_{des} - \psi_{des}\right)\right)$$

$$= -b_1 e_1 - b_2 e_2 + \frac{1}{\tau_r^2}\left(\psi_{sp} - 2\tau_r \dot{\psi}_{des} - \psi_{des}\right)$$

$$= -b_1(\psi - \psi_{des}) - b_2(\omega - \dot{\psi}_{des}) + \frac{1}{\tau_r^2}\left(\psi_{sp} - 2\tau_r \dot{\psi}_{des} - \psi_{des}\right)$$

$$= -b_1\psi + b_1\psi_{des} - b_2\omega + b_2\dot{\psi}_{des} + \frac{1}{\tau_r^2}\psi_{sp} - \frac{2}{\tau_r}\dot{\psi}_{des} - \frac{1}{\tau_r^2}\psi_{des}$$

$$= -b_1\psi - b_2\omega + \left(b_1 - \frac{1}{\tau_r^2}\right)\psi_{des} + \left(b_2 - \frac{2}{\tau_r}\right)\dot{\psi}_{des} + \frac{1}{\tau_r^2}\psi_{sp}$$

PAGE

PREPARED BY choose $b_1 = \frac{1}{\tau_r^2}$ $b_2 = \frac{2}{\tau_r}$

$$\dot{\psi} = \omega$$

$$\dot{\omega} = -b_1 \psi - b_2 \omega + \frac{1}{\tau_r^2} \psi_{sp}$$

$$\begin{bmatrix} \dot{\psi} \\ \dot{\omega} \end{bmatrix} = \begin{bmatrix} 0 & 1 \\ -b_1 & -b_2 \end{bmatrix} \begin{bmatrix} \psi \\ \omega \end{bmatrix} + \frac{1}{\tau_r^2} \begin{bmatrix} 0 \\ 1 \end{bmatrix} \psi_{sp}$$

so the state vector is still $\underline{x} = [\phi, \theta, v, \psi, \omega]$, but now,

$$\dot{\underline{x}} = \left[\frac{v\cos\psi}{r\cos\theta} \quad \frac{v\sin\psi}{r} \quad \frac{F_x}{m} \quad \underbrace{\omega \quad -b_1\psi - b_2\omega + \frac{1}{\tau_r^2}\psi_{sp}}_{\text{linear!}} \right]$$

So, what to use for F_x? F_x is, in general, a function of $\underline{x}$.

Idea 1: $F_x(\underline{x}) = c_1 \cos^2\psi$ ← doesn't capture the wind window

Idea 2: $F_x(\underline{x}) = c_1 \cos^2\psi \exp\left(-\left(\frac{\psi}{c_2}\right)^2\right)$ ← can tune c_2 to capture wind window