Unmanned aerial vehicles
(excerpts and comments)

(Some) design paramaters

- $V_A = 13\ m/s$ - UAV longitudinal velocity
- $W = 6\ m/s$ - Constant wind velocity
- $\phi_W = 230\pi/180\ rad$ - Constant wind direction
- $A = 3\ m/s$ - Time varying wind velocity amplitude (variance)
- $\phi_A = \pi\ rad$ - Time varying wind's angle variance

- You can choose different ones, as soon as the wind velocity is not bigger that the UAV velocity

Control+estimator (you can play with several parameters)

- **Control Law**

$$\chi_c = \chi' - \frac{1}{\alpha}\chi^{\infty}\frac{2}{\pi}\frac{k}{1+(ke)^2}\hat{V}_g'(sin\chi' - a \cdot cos\chi') - \frac{\kappa}{\alpha}sat(\frac{\tilde{\chi}'}{\epsilon}) \tag{14}$$

- **Estimator**

$$\begin{aligned}\dot{\hat{V}}_g' = \frac{\partial V_g'}{\partial \chi'}\left[-\chi^{\infty}\frac{2}{\pi}\frac{k}{1+(ke)^2}(sin\chi' - a \cdot cos\chi')\hat{V}_g' - \kappa sat(\frac{\tilde{\chi}'}{\epsilon})\right] + \\ \Gamma\rho\tilde{\chi}'\chi^{\infty}\frac{2}{\pi}\frac{k}{1+(ke)^2}\hat{V}_g'(sin\chi' - a \cdot cos\chi')\end{aligned} \tag{15}$$

Where, as on slide 22, the partial derivative of the ground velocity is approximated as:

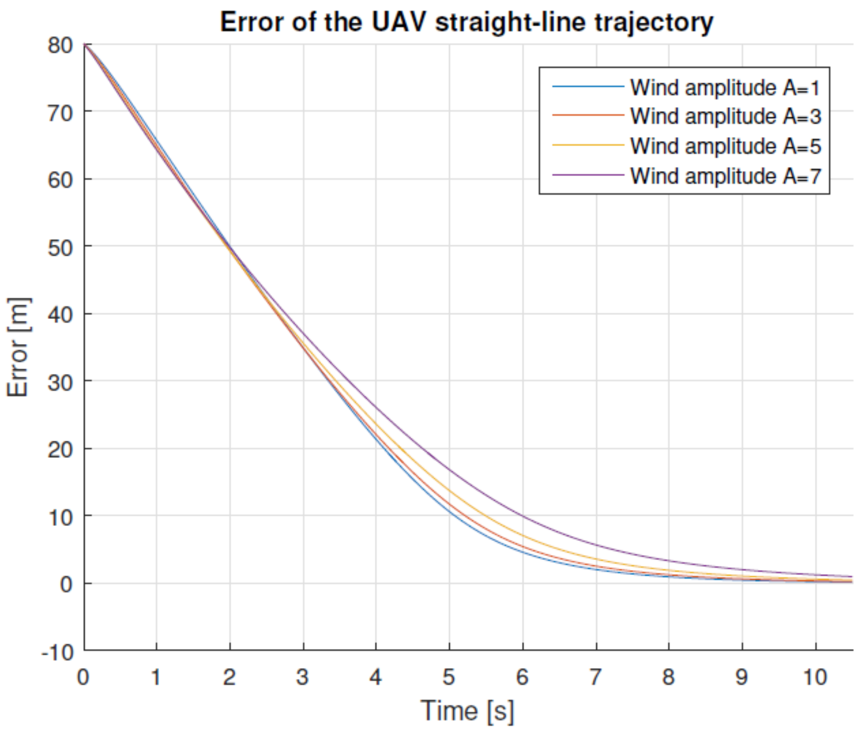
$$\begin{aligned}\frac{\partial V_g'}{\partial \chi'} \approx \frac{\partial V_g}{\partial \chi'} = W sin(\psi_W - \chi') + \left[V_a^2 - W^2 sin^2(\psi_W - \chi')\right]^{-\frac{1}{2}} W^2 + \\ sin(\psi_W - \chi')cos(\psi_W - \chi')\end{aligned} \tag{16}$$

First steps to derive the estimator in the circular case

$$\mathcal{V} = \frac{1}{2}\tilde{d}^2 + \frac{1}{2}\rho\tilde{\chi}'^2$$
$$\dot{\mathcal{V}} = \tilde{d}\dot{\tilde{d}} + \rho\tilde{\chi}'\dot{\tilde{\chi}}'$$

- Continue from these steps

Bounds with time-varying winds



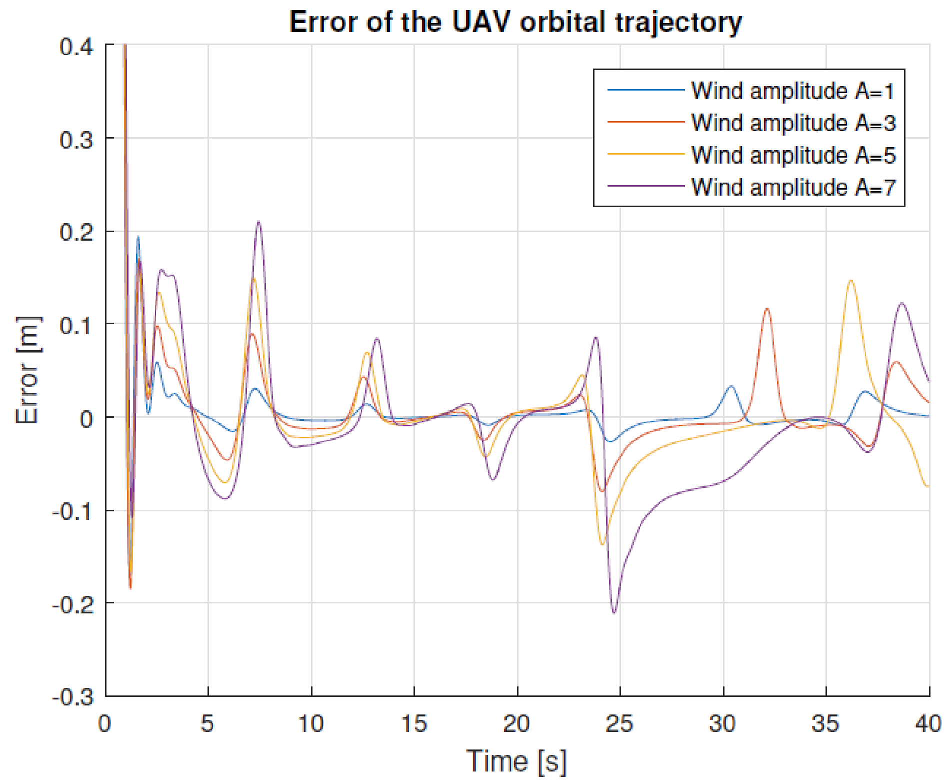


Figure 16: Example of a mixed path trajectory

- You can also play with frequency
- It would be nice to show a plot of how the wind actually changes (in the local UAV coordinates should be easier)

Mixed path (there is no unique solution)

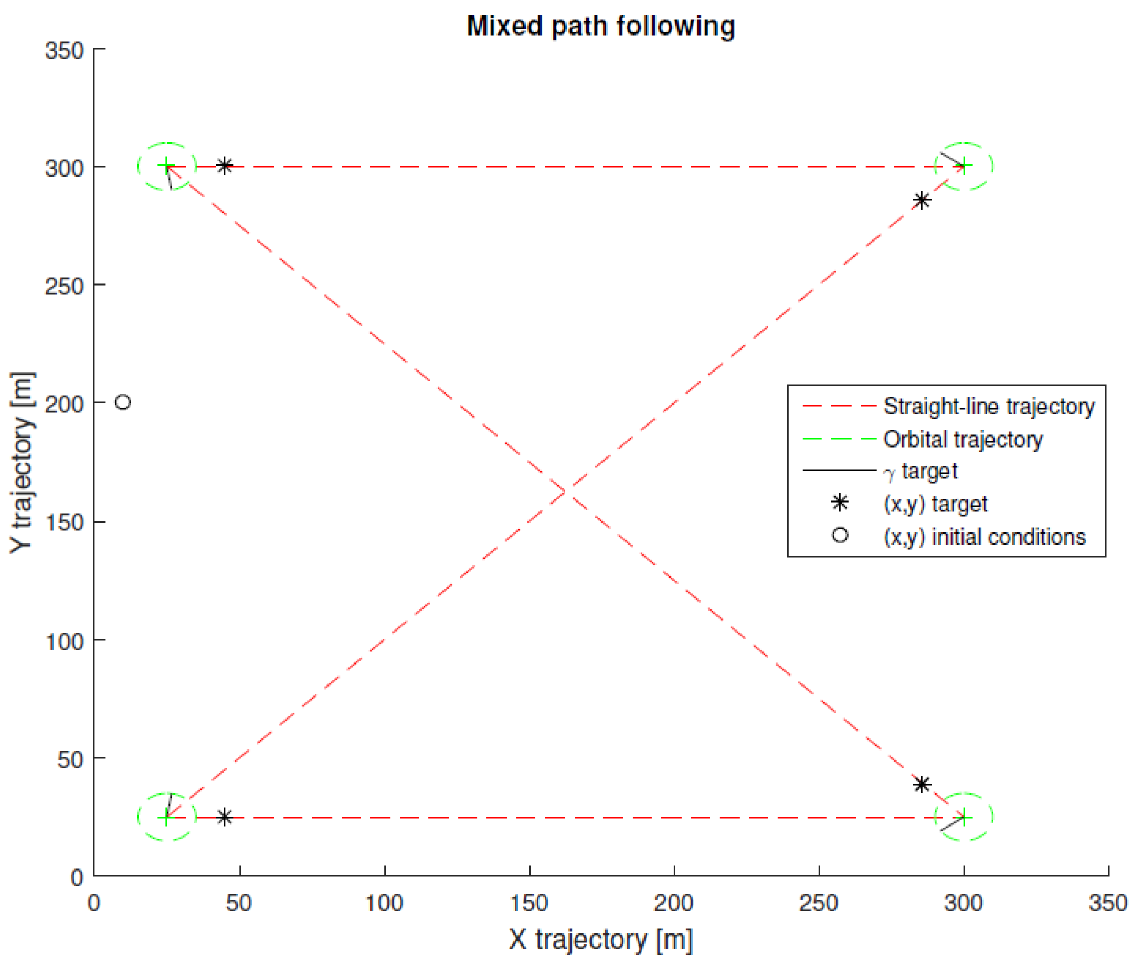


Figure 23: Coordinate frame definition with corresponding course angles of the UAV

Mixed path (there is no unique solution)

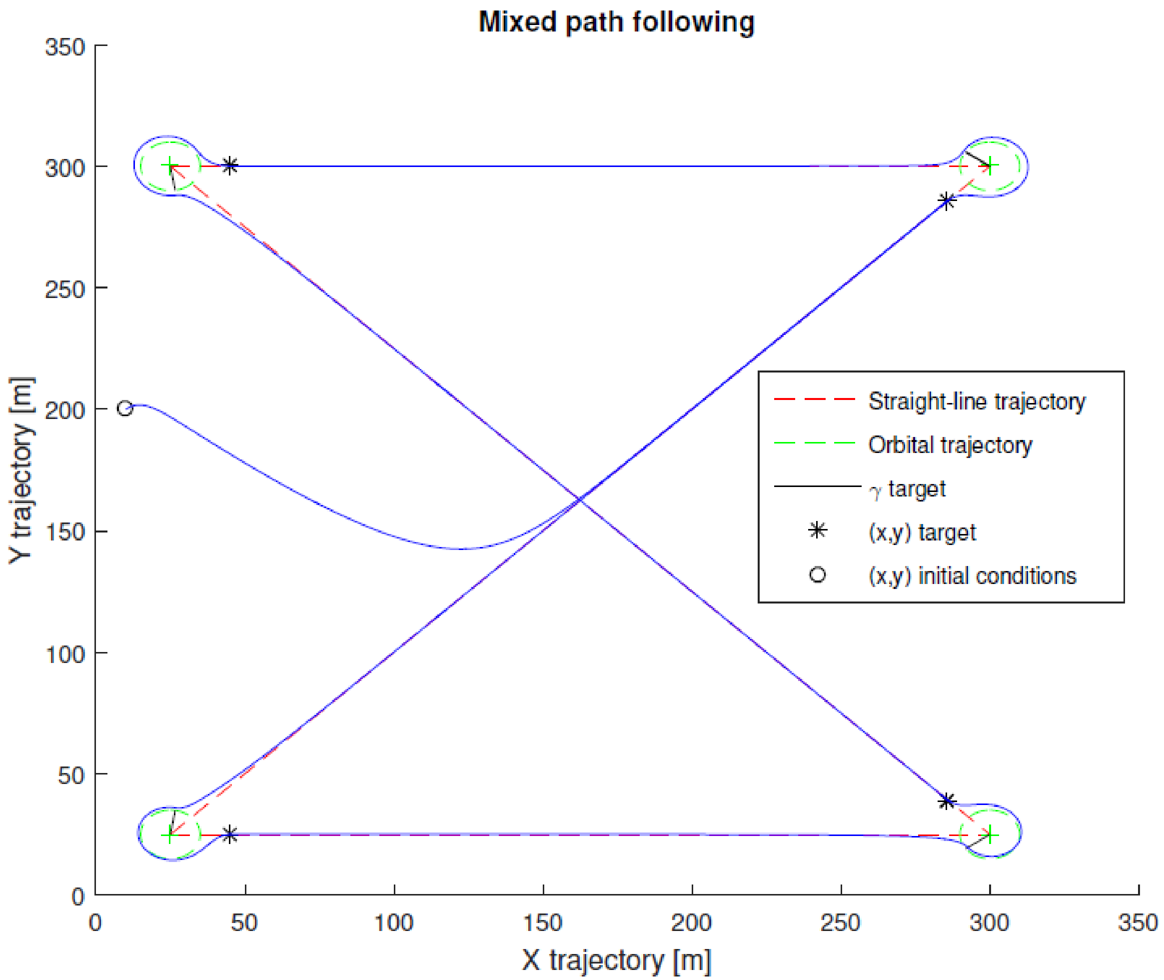


Figure 25: Coordinate frame definition with corresponding course angles of the UAV

Extension to 3D

$$\dot{x} = V_a cos(\psi) + W cos(\psi_W) + A cos(\psi_A) \tag{57}$$

$$\dot{y} = V_a sin(\psi) + W sin(\psi_W) + A sin(\psi_A) \tag{58}$$

$$\dot{z} = V_a cos(\zeta) + W cos(\zeta_W) + A cos(\zeta_A) \tag{59}$$

- Try to check how straight-line and circular paths can be extended to 3D (including course control and estimator)