AER1216: Fundamentals of UAS

Assignment # 4
Due: Nov. 18$^{\text{th}}$

Consider a fixed-wing UAS configuration. Please develop the design and verification process as follows:

1. Write down the dynamic equations, based on Fig. 4. Assume that the UAS is symmetric along the xz plane ($I_{xy} = I_{yz} = 0$), and ensure the answers are expressed in terms of forces, moments, velocities, angular velocities, mass and moments of inertia. [**5 marks**]

2. Write down the kinematic equations, based on Fig. 3. Ensure the answers are expressed in terms of Euler angles, velocities, and angular velocities. [**5 marks**]

3. Use linearized forces to estimate X, Y, Z, L, M, N, with the inputs $\delta_e, \delta_p, \delta_a, \delta_r$ (hint: consider aerodynamic derivatives and their equivalent for the control variables). [**5 marks**]

4. Express the linearized system (longitudinal and lateral) based on Fig. 6. Start from equations presented in the lecture notes. You may assume that all aerodynamic higher-order derivatives are zero except for $M_{\dot{w}}$ and $Z_{\dot{w}}$. [**10 marks**]

5. Draw a control design diagram (using PID control) for an altitude hold autopilot, based on the longitudinal system. [**5 marks**]

6. Draw a control design diagram (using PID control) for a level coordinated turn autopilot, based on the lateral system. [**5 marks**]

7. Draw a simulation diagram where the previously designed control structure is implemented on a nonlinear dynamics model, developed in steps 1-3. [**5 marks**]

8. Consider the nonlinear model defined in steps 1-3, and the linearized model developed in step 4. For each model, provide one reason why the model can be useful in simulation, design or testing of controllers. [**5 marks**]

9. Add your own comments detailing any additional design/simulation considerations that you would like to investigate. [**5 marks**]

The process shall be presented as a development "recipe" where formulas, equations are specified, and serves as an almost programmable design sheet that the designer can follow to conduct the investigation.