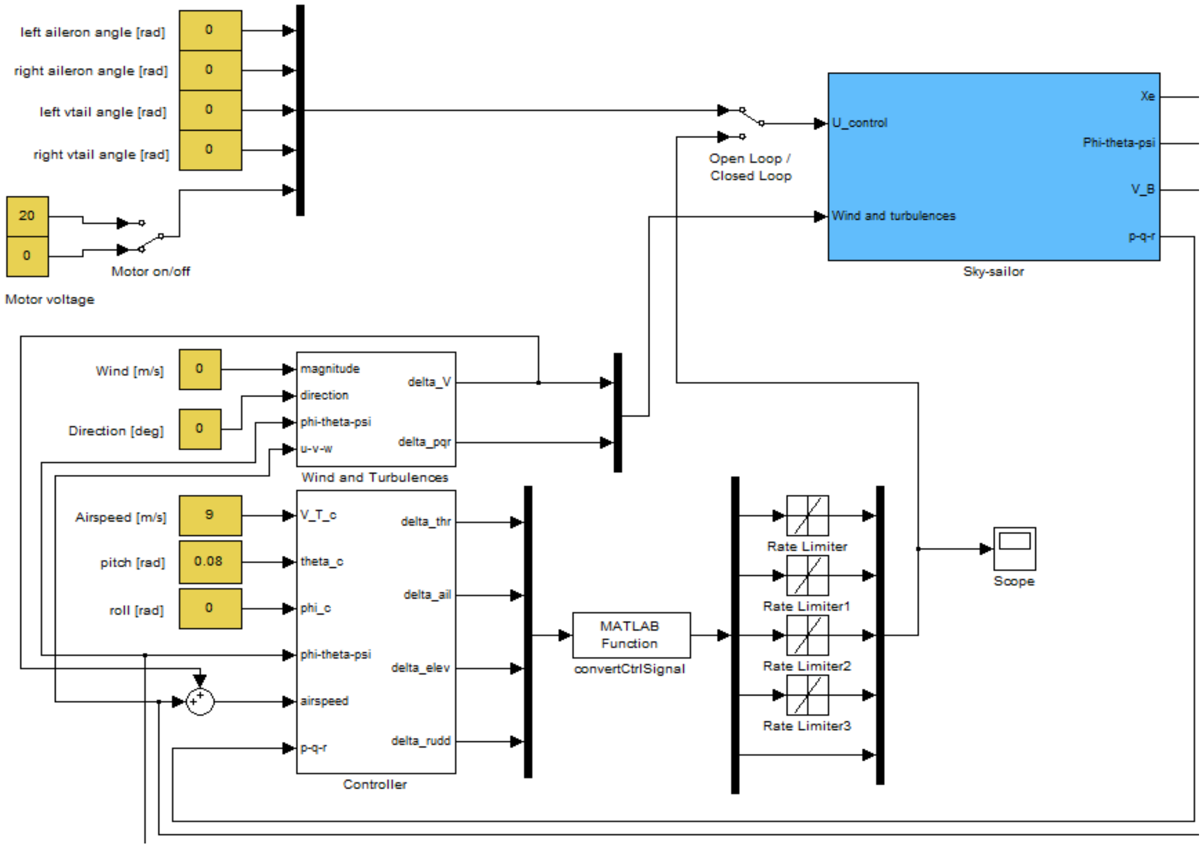
Exercise 2

Fixed-wing Control and Simulation

Download and unzip the file ***Sky-Sailor.zip*** from http://www.rsl.ethz.ch/education-students/lectures/robotdynamics.html into your **personal folder** (**NOT onto the Desktop**!) and open **Sky_Sailor_Simulation.mdl** with Matlab/Simulink**.**

1 Simulation of Sky-Sailor in Open-Loop

The model allows you to switch from manual input to automatic control.



a) Open the subsystems and observe how the simulation model was created. The subsystem **Initial conditions** allows you to set the initial position, velocity (groundspeed), angles and angular rates of the airplane.

b) Observe the open-loop dynamic stability: set the initial pitch angle to 12°, the x-body velocity (u) to 8 m/s and run the simulation with motor off (all other initial conditions set to zero).

c) Analyze the forces and how they evolve in **figure1**. Can you explain them?

d) What's the period of the characteristic oscillation (phugoid)? How about the amplitude half-value period? Hint: insert scopes from the library browser in order to monitor the interesting state variables or run **show_uav_final** in the Matlab console after the simulation finished.

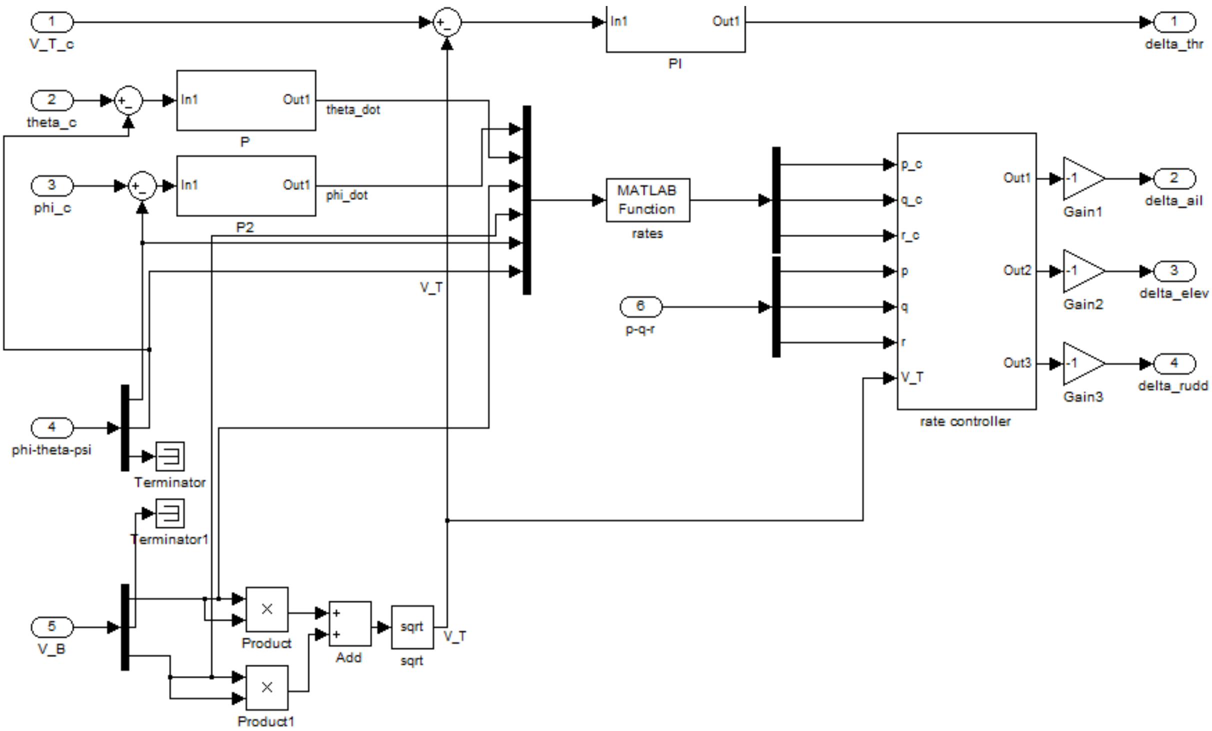
e) Now find the v-tail control surface deflections (symmetric!) that settle to a steady state 12 m/s total speed. Set all initial conditions besides the previous x-body velocity (8 m/s) to zero.

f) Investigate the influence of the CoG location: open **param.m** and change to the value 3 cm forward. What's happening? How about, if you move it 3 cm backwards? Can you explain the effects? Reset to the correct CoG.

g) Switch on some wind: this will also generate turbulences. What is your verdict concerning dynamic stability?

2 Simulation of the Sky-Sailor in Closed-Loop

Now switch to automatic control. Reset the wind and initial conditions.



a) Explore the control structure.

b) Set small roll and pitch angles, leave the speed at 9 m/s and run the simulation. Does the result correspond to your expectations?

c) Try the feedback controlled airplane with the CoG position at the back. Move it back to the correct position. Can you see a difference?

d) Now try a bit more violent angles, find the limitations of the controller, the airplane respectively.

e) Increase the rate control proportional gains gradually. How can you explain the reaction? Do you think the reference tracking is good? How about aerodynamic efficiency? Reset to the original values.

f) Now increase the gains of the attitude controller. Can you explain the resulting behavior? Reset the gains.

g) Tune the gains such that a better controller will result (in your opinion). If you are convinced to have found the perfect controller, call the assistant.

h) Switch on some wind again. Is your controller robust enough?