Gaziantep University

FACULTY OF AERONAUTICS AND AEROSPACE

Aircraft Stability And Control

Termproject part 3

Stability And Control of Cessna 172 Skyhawk

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INTRODUCTION

In this part of project I am going to design controllers for multiple missions which are steady level flight, banking turn, climb to an altitude and landing.

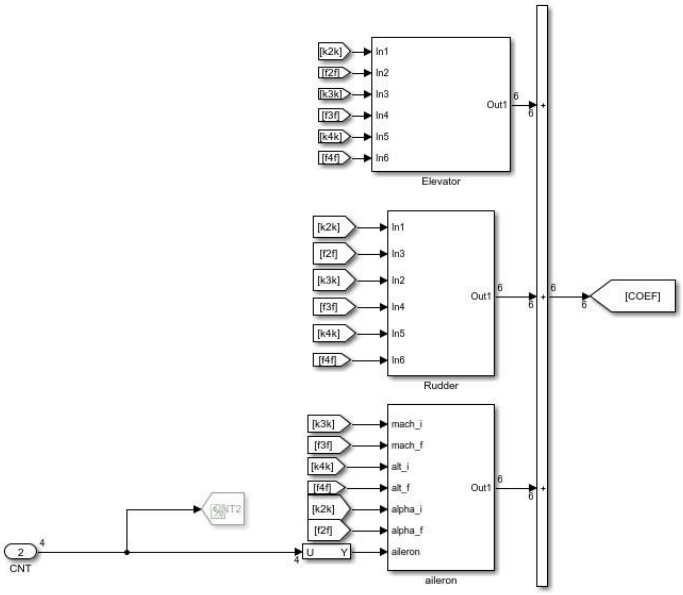
Brief Review of part 1 and part 2

First of all I should mention these 2 parts. In first part I designed equation of motion for my plane model by using formulas. Then I changed forces and moments to compare my equation of motion against to ground truth model. In second part, I wrote a Digital DATCOM file form my aircraft (cessna 172 skyhawk) also I wrote import files (Asymetrical and symetrical) for datcom output. After that I created simulink blocks for Gravitational Forces & Moments, Aerodynamic Forces & Moments, Propulsive Forces & Moments. Result of section2 was failure but I managed to solve that problem. In part 2 I've canceled my plane model so problem was my simulation blocks (flight gear) were still connected my plane model and I was getting error because of that. In addition to this solution I rewrote my datcom file because I saw some mistakes.

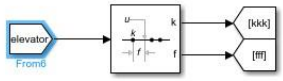
Simulink Controller Design

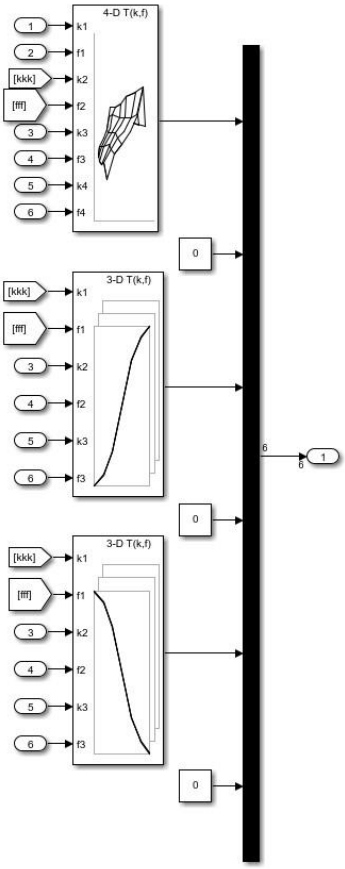
Aerodynamics forces and moments :

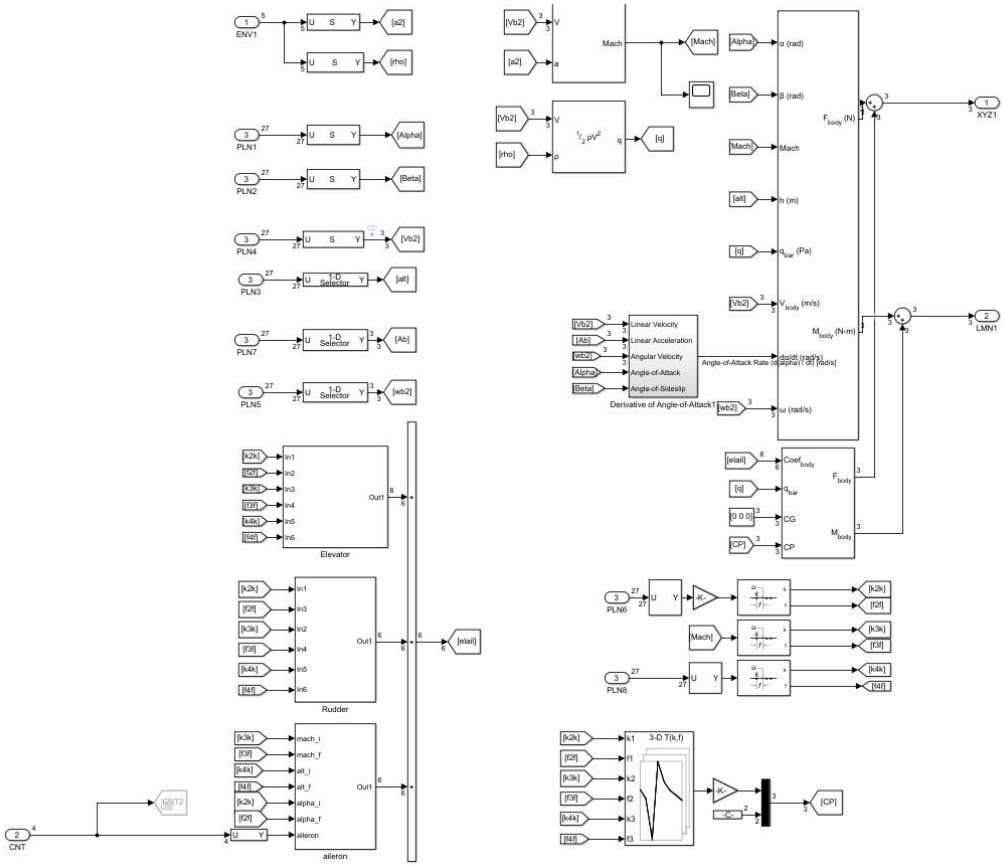
In this part I designed controllers for missions. In part 2 I couldn't create elevator blocks so I also created that and arrange all blocks inside Aerodynamic Forces and Moments.



This elevator block is connected to controller (Pilot&Autopilot section) You can see other connections in next section



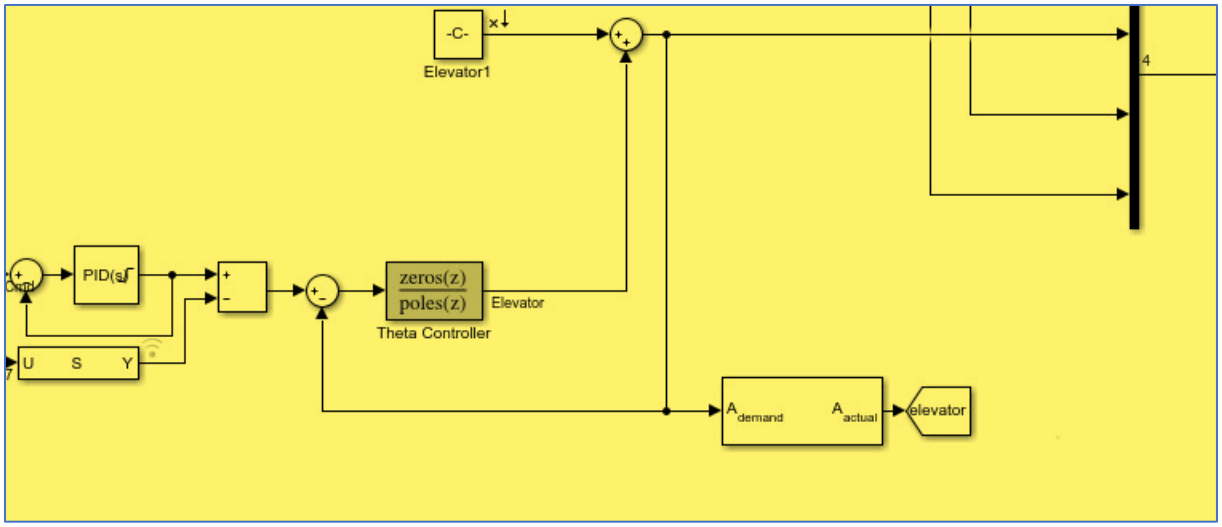


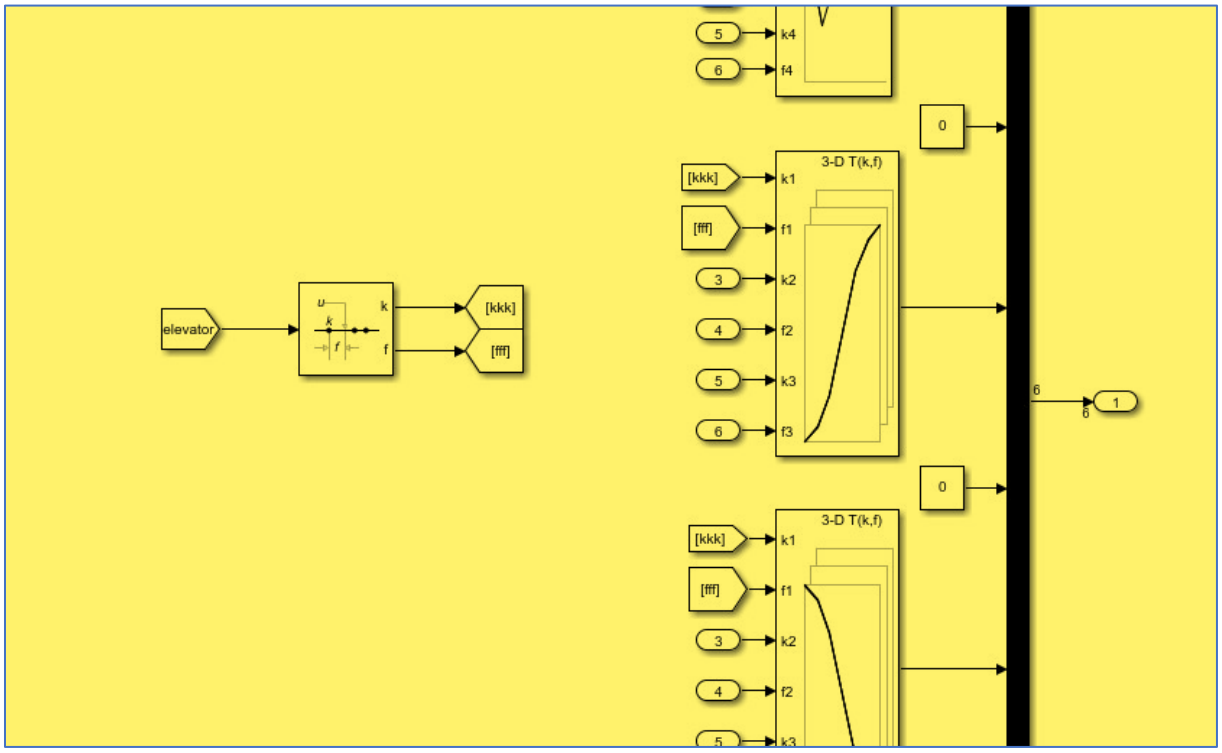


Pilot & Autopilot :

I have 3 main mission and 1 side mission that I choose (landing) so I designed different kind of controllers . First, I connected controllers to surfaces and force blocks which are elevator aileron and propulsive forces&moments.

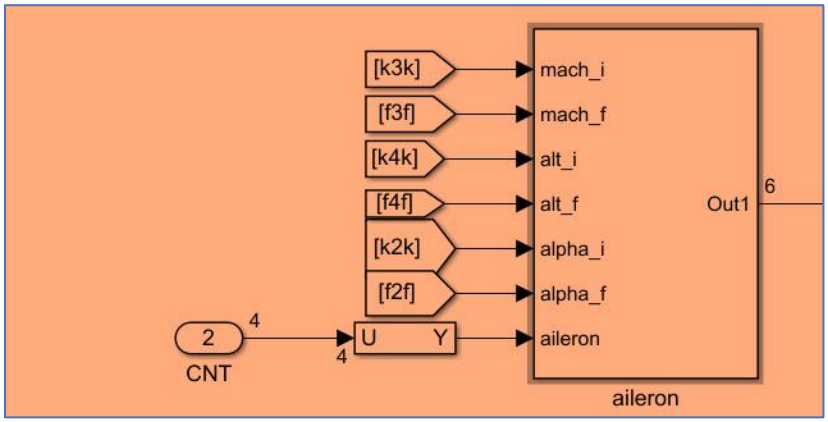
Elevator connection :

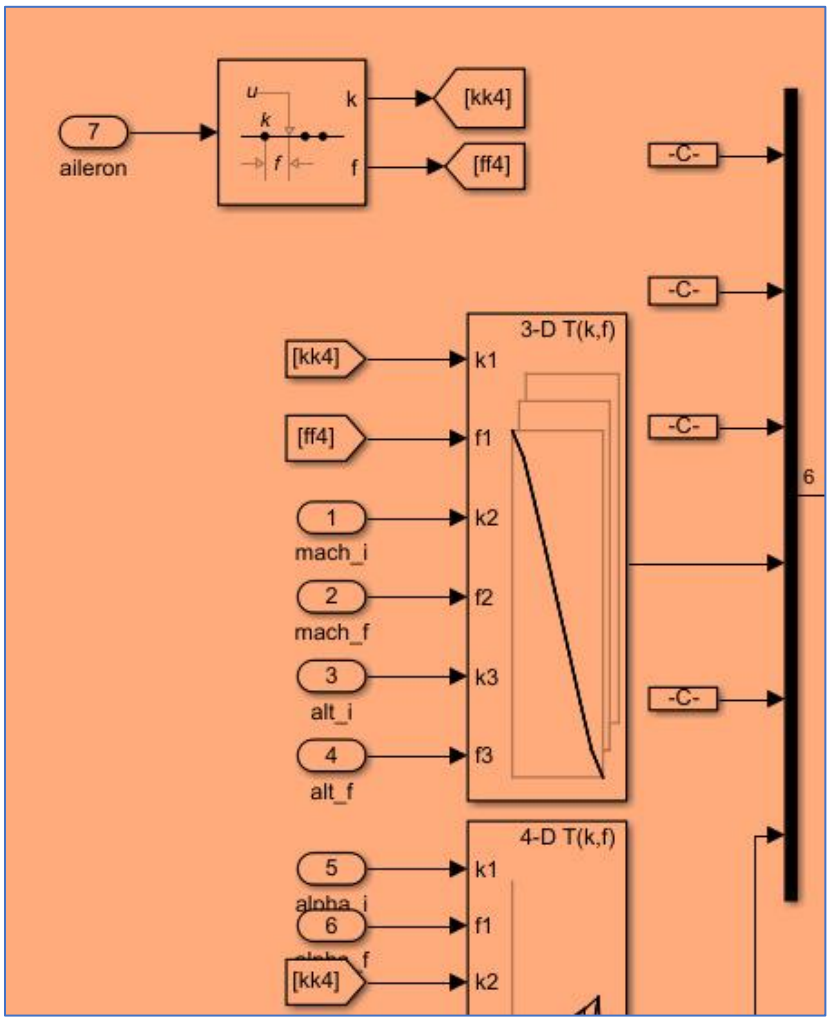




Aileron connection :

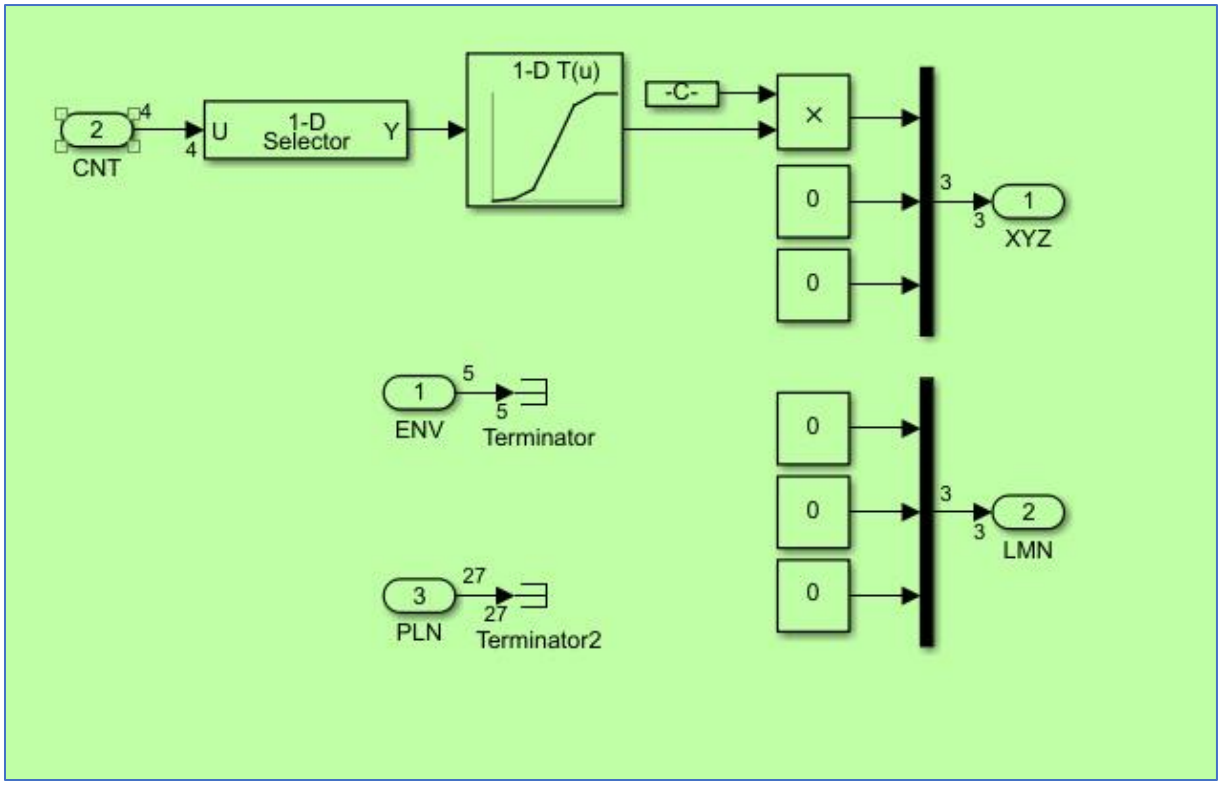
CNT input comes from output of Pilot&Autopilot and I choosed correct signal from there by using selector block



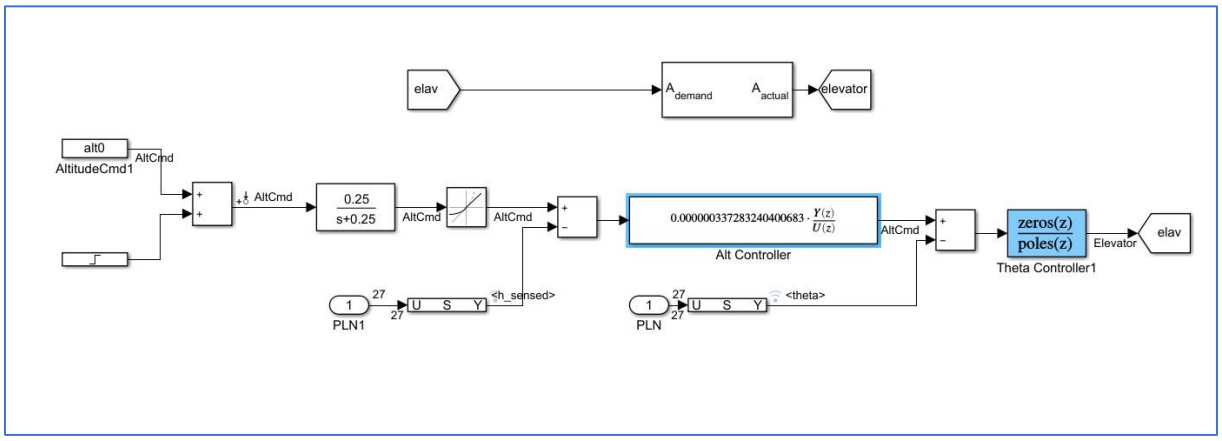


Thrust connection:

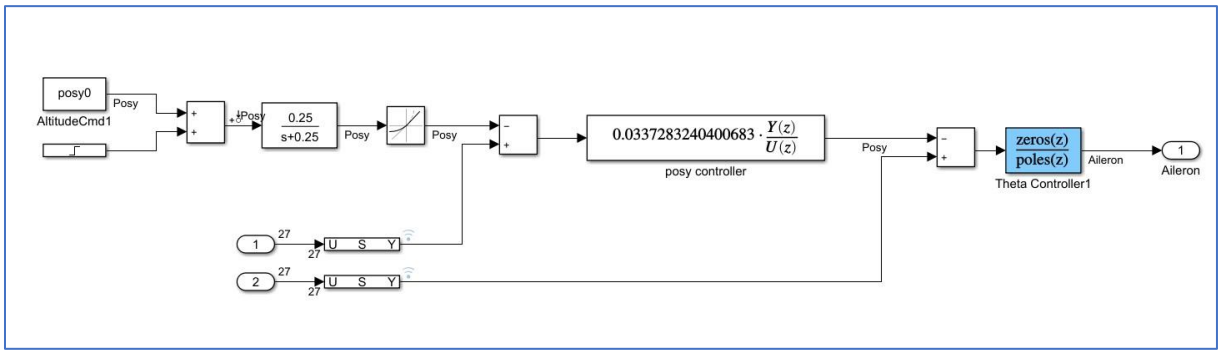
Throttle is the fourth signal of Autopilot section.



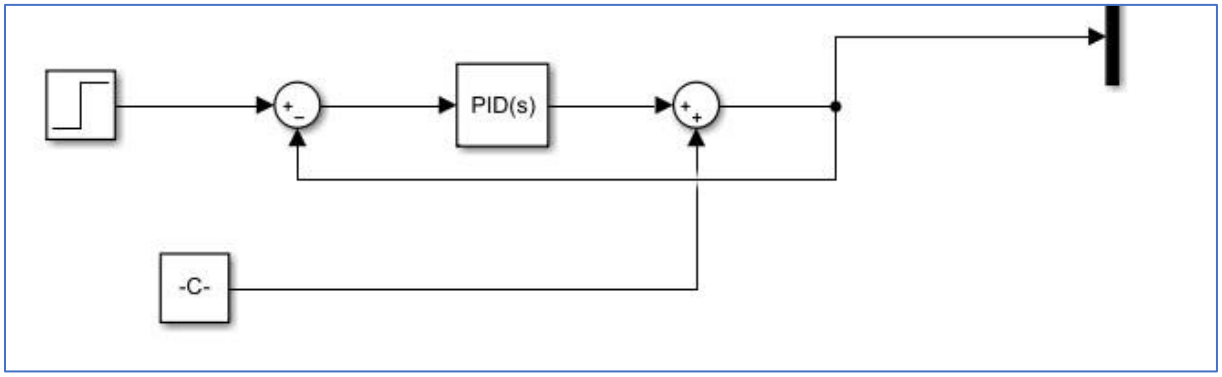
Elevator controller



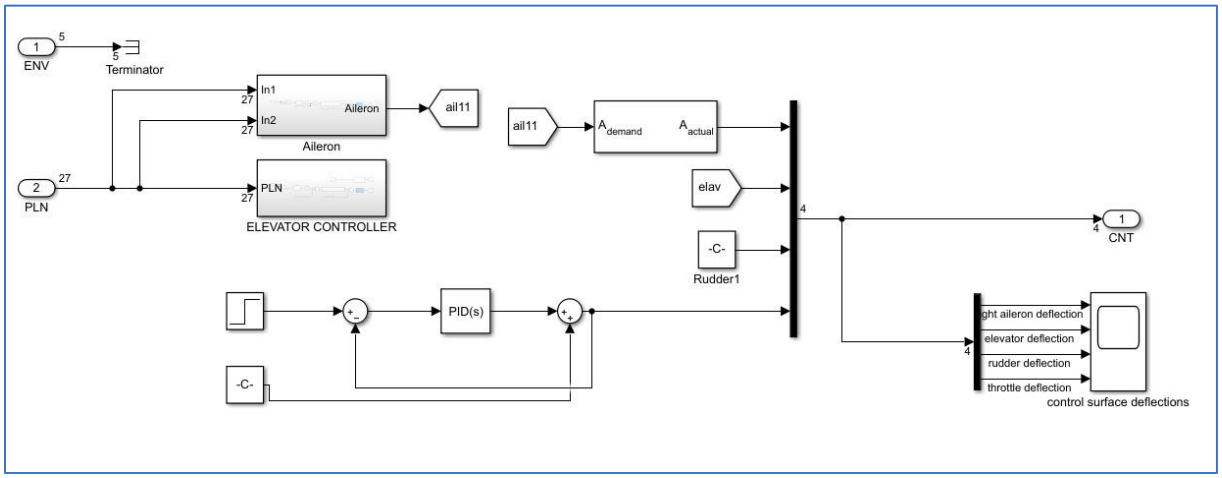
Aileron controller



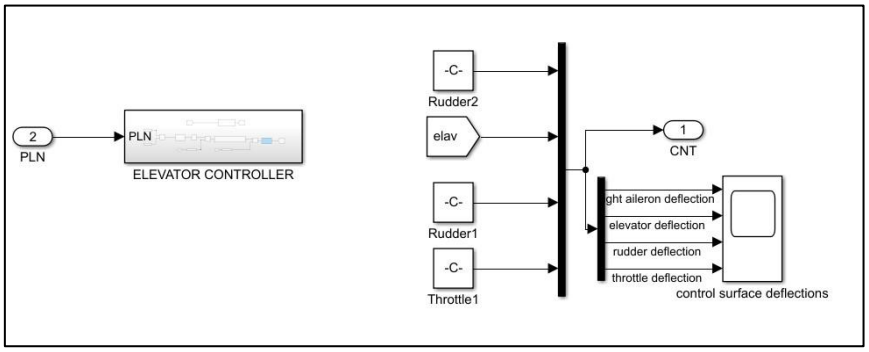
Thrust controller

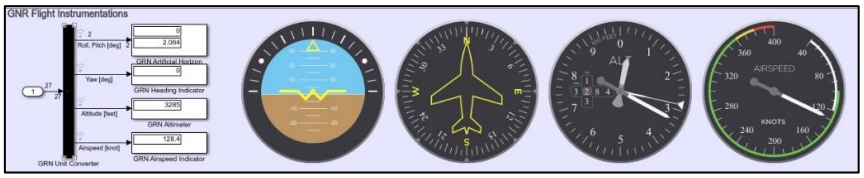


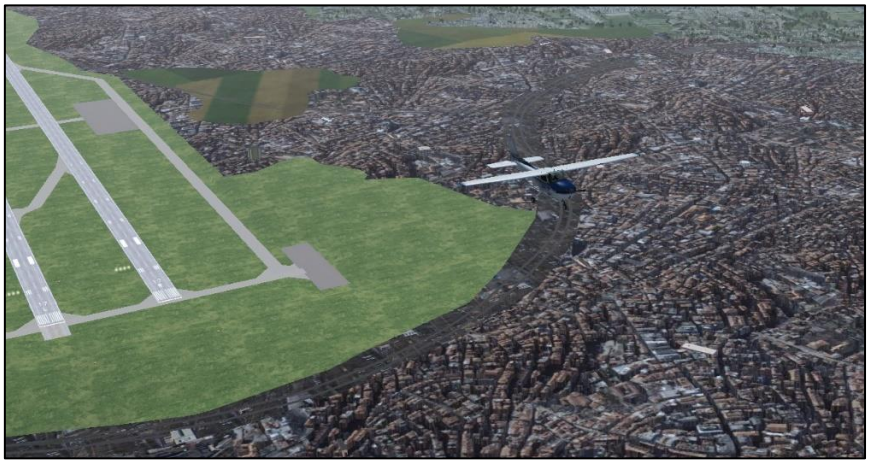
All Controllers Together:



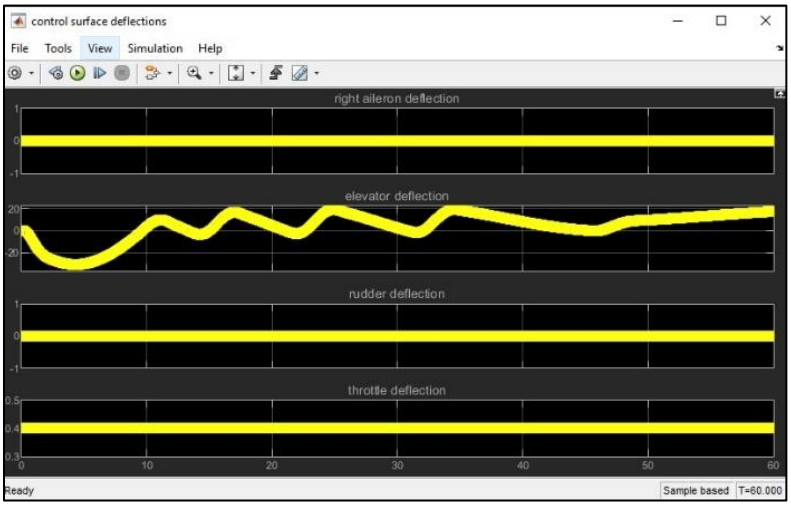
MISSION 1 (Steady Level Flight)

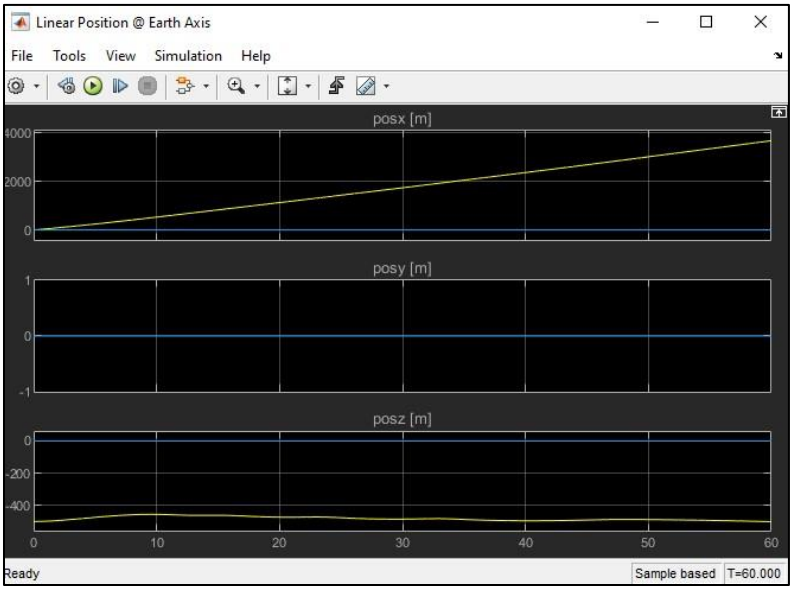


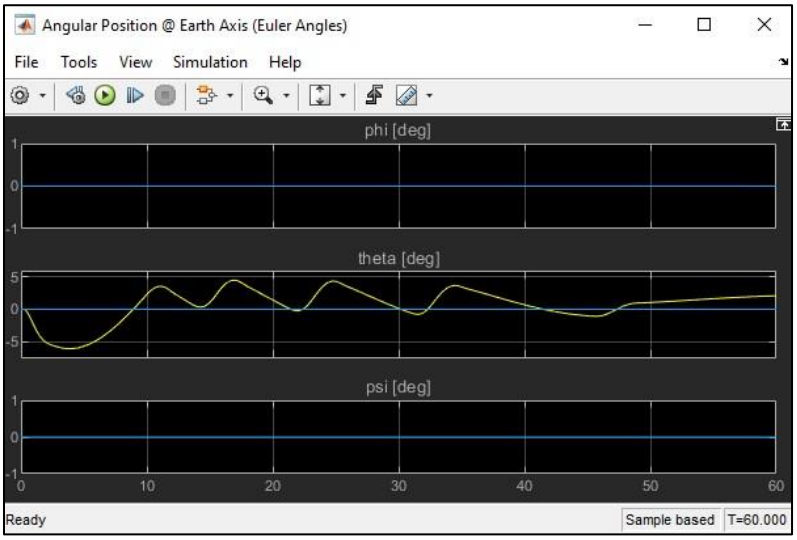




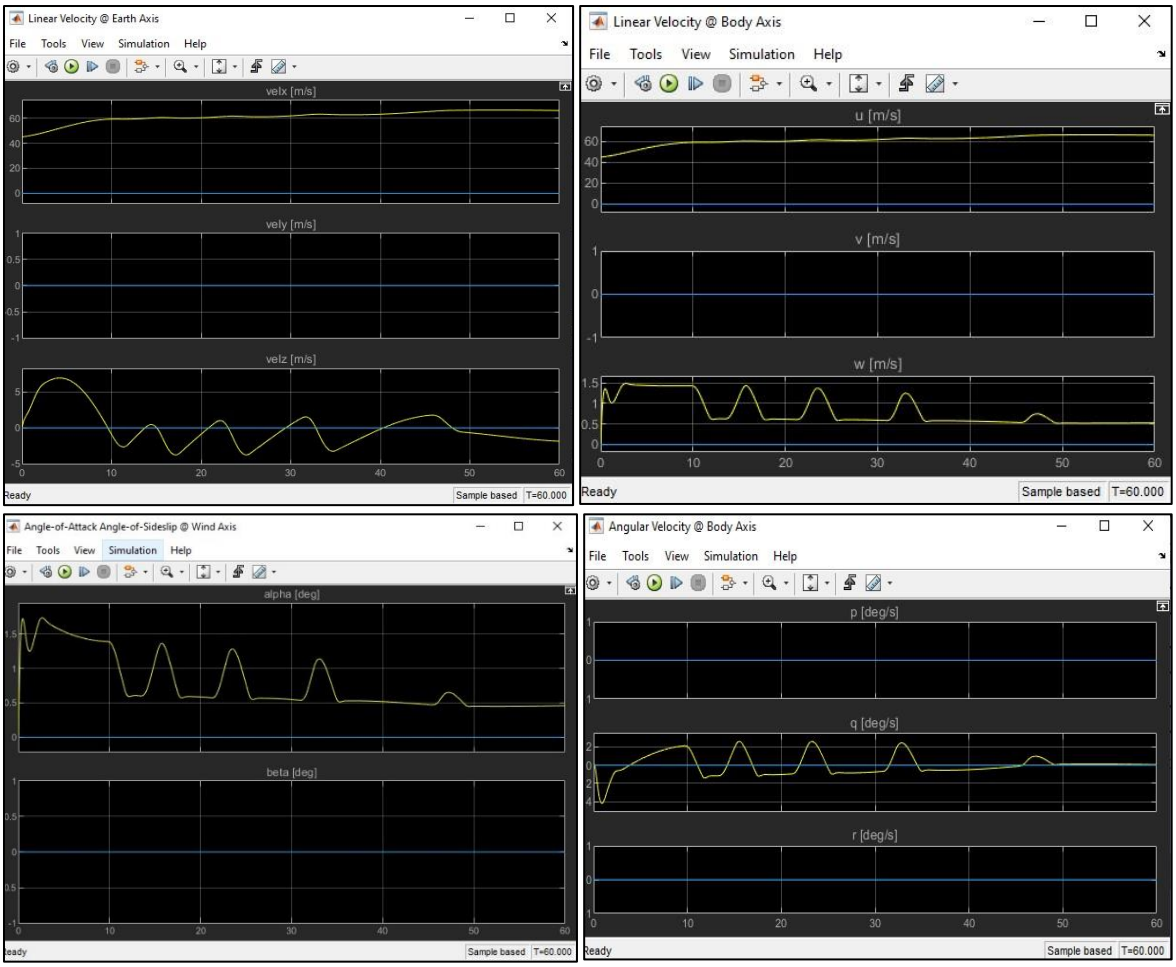
In this mission, I arranged an elevator surface controller to flight steady and horizontal. I designed this controller from matlab lightweight aircraft design also I've adjusted values, inputs and transfer functions for my aircraft which are suitable.



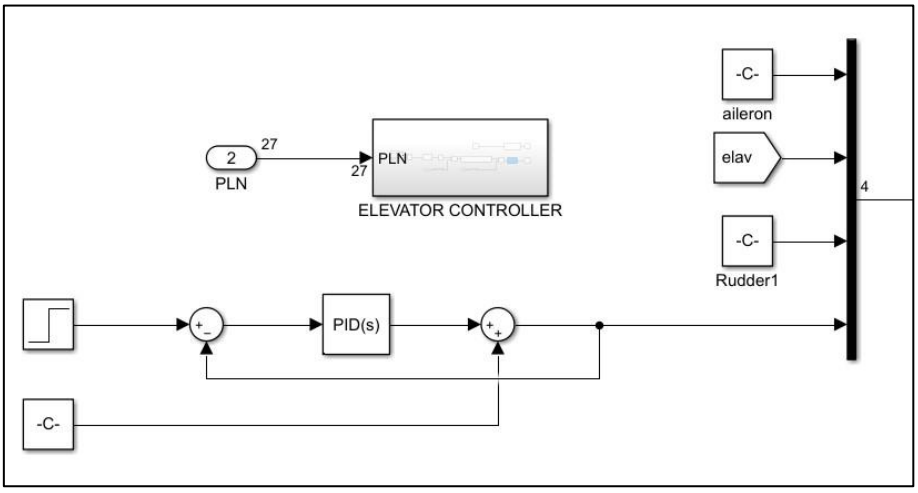




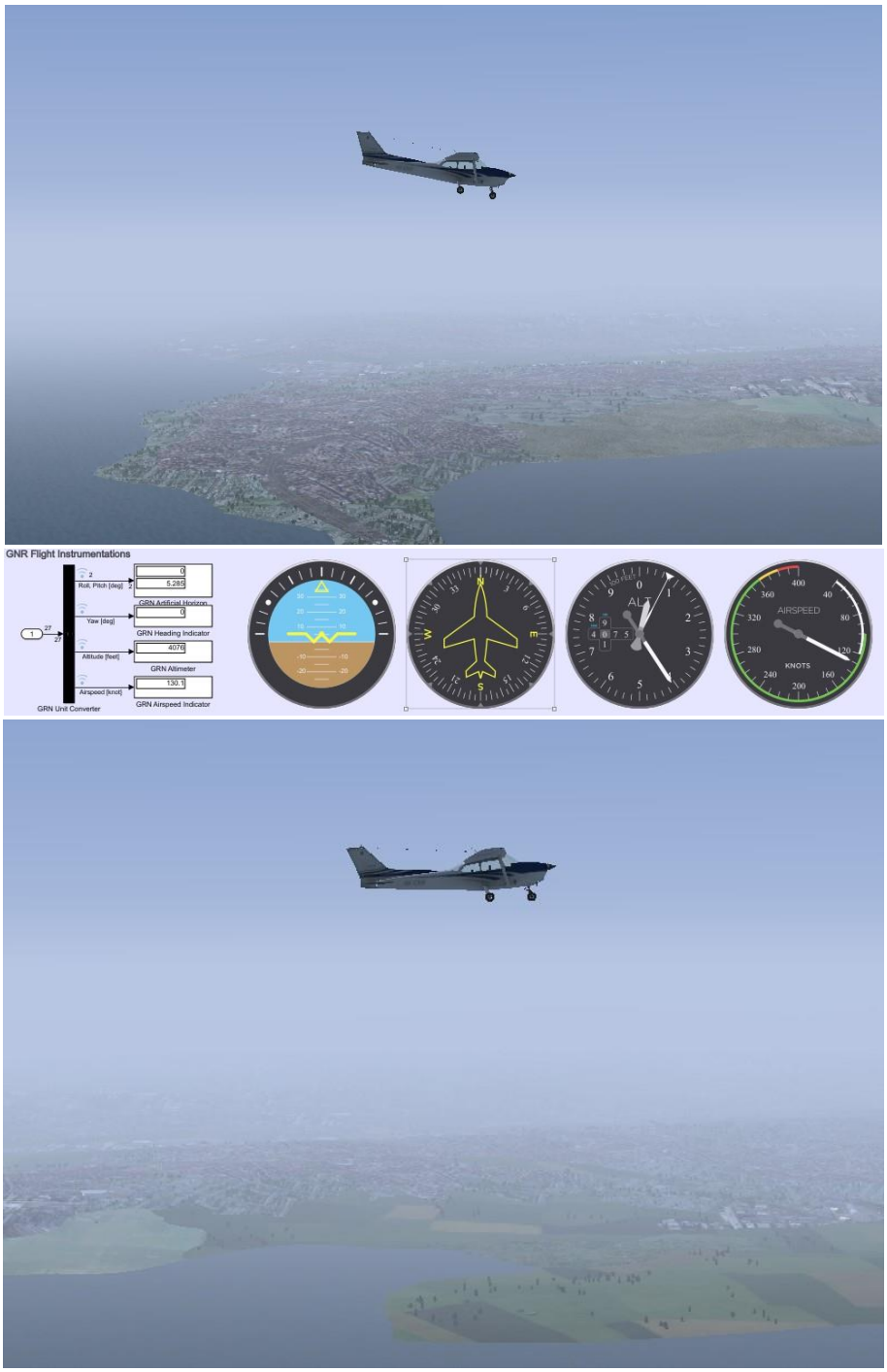
My controller changes the elevator deflection to fly initial altitude. As I see in the graphs posz stabilize after 7sec. Between 0 to 7 sec elevator controller sets its parameter for steady level flight to complete the mission Final results are very good for me.

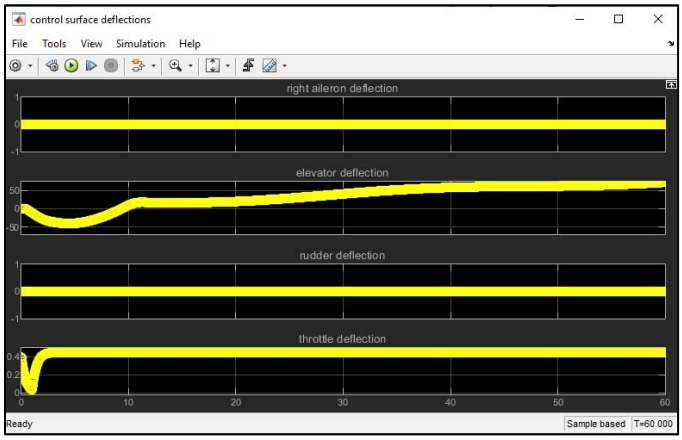


MISSION 2(Climbing)

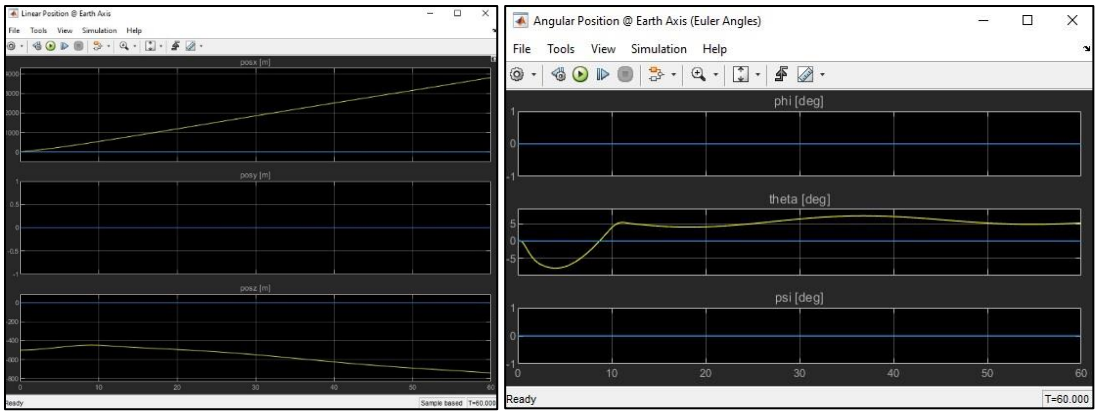


I've designed throttle controller for this mission. Throttle controller controls the velocity and elevator controller controls the altitude change. When I run this two controller together they manage their jobs to climb desired altitude. Elevator controller try to reach desired altitude and throttle controller provide required thrust to climb.

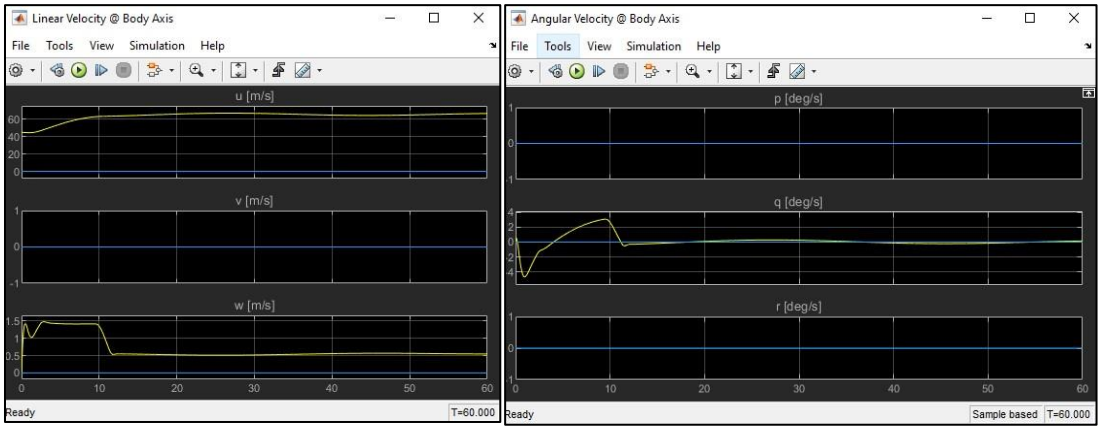


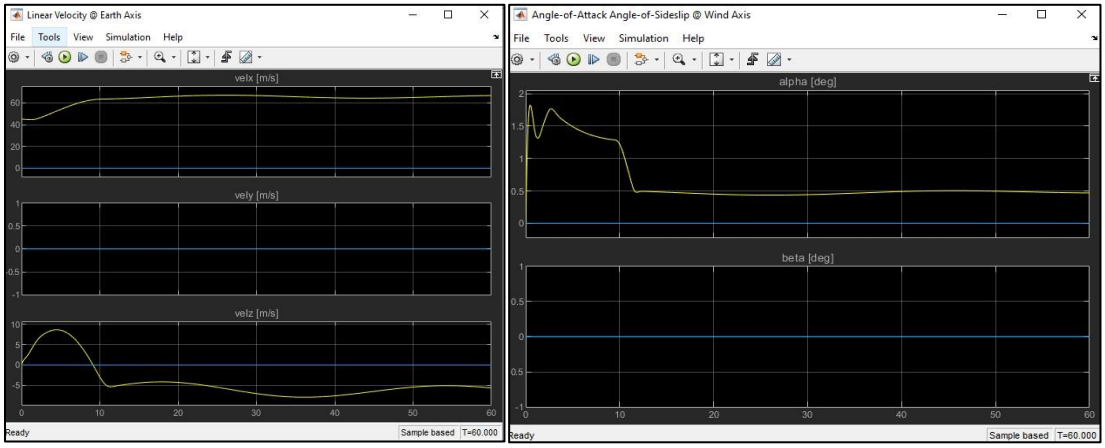


I can clearly see the deflections to reach desired altitude. I should mention that throttle defleciton is in the desired throttle range which is not provide higher than 0.2 mach



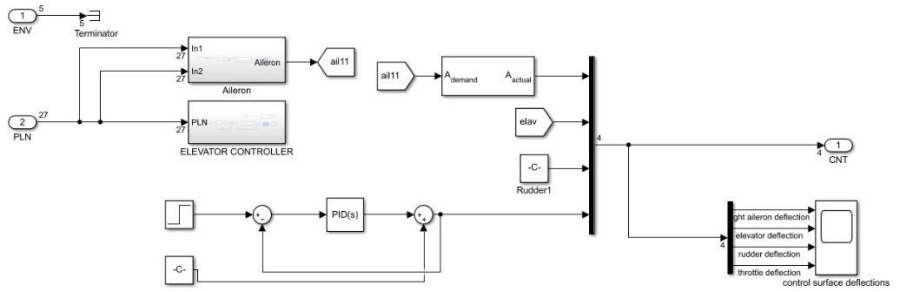
Posz stabilize after 80 sec but my simulation ends at 60 sec because simulation take too long

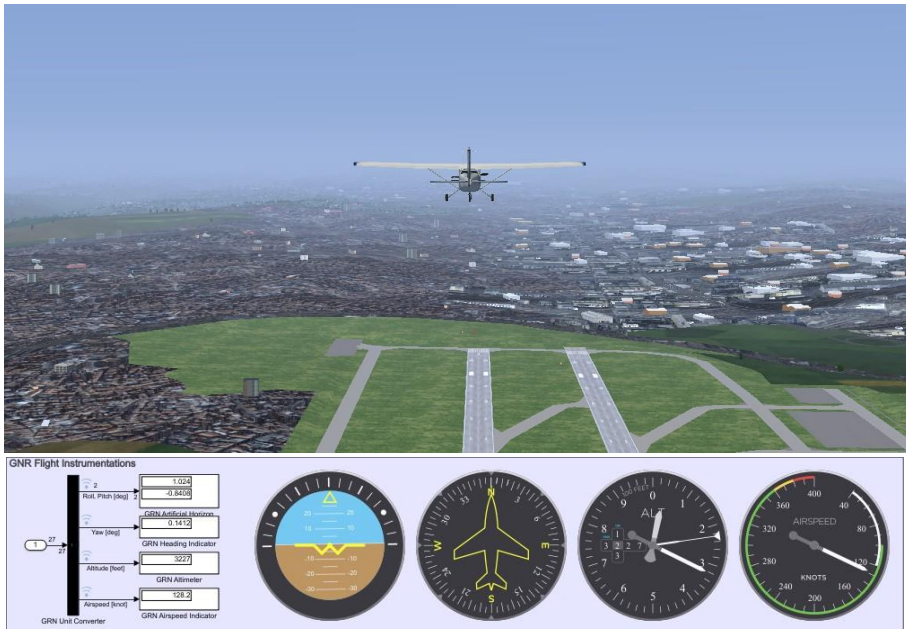




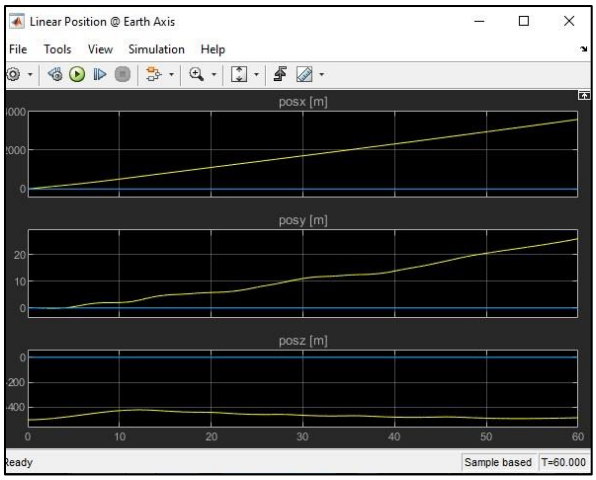
AoA value is change after 7 sec as I mention before controller sets its parameter.

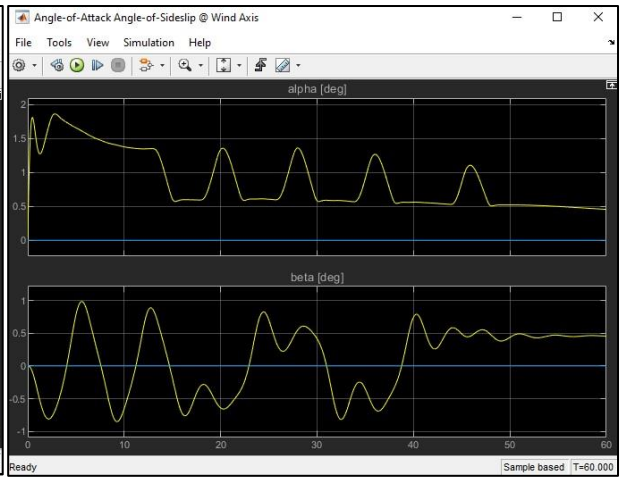
MISSION 3(Banking Turn)

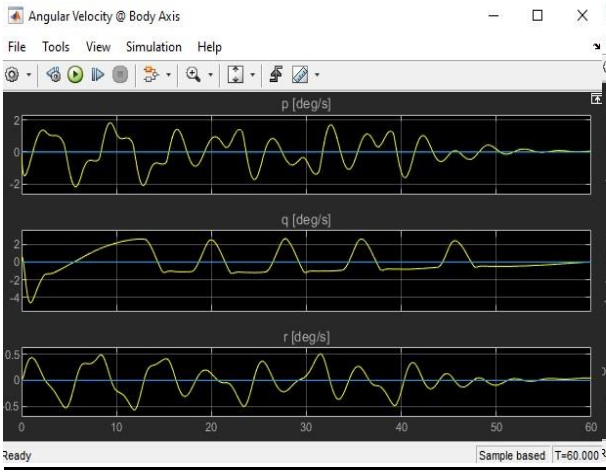


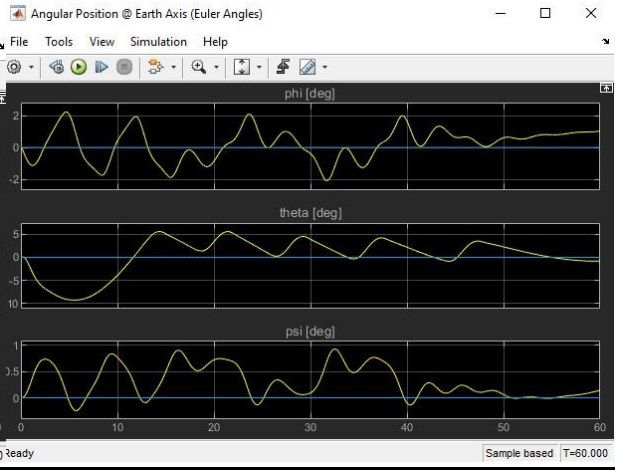


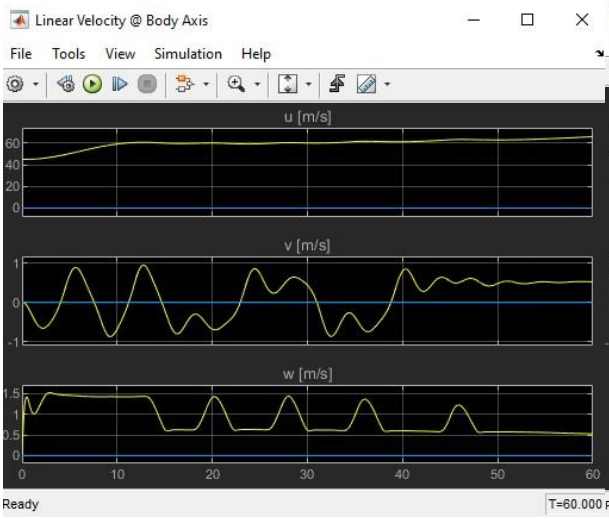
I designed an aileron surface controller for this mission.Aileron controller has same procedure as elevator controller but it's inputs and outputs provide roll angle to system in desired posy range.I think I couldn't succeed in this mission but I learned how to control ailerons.

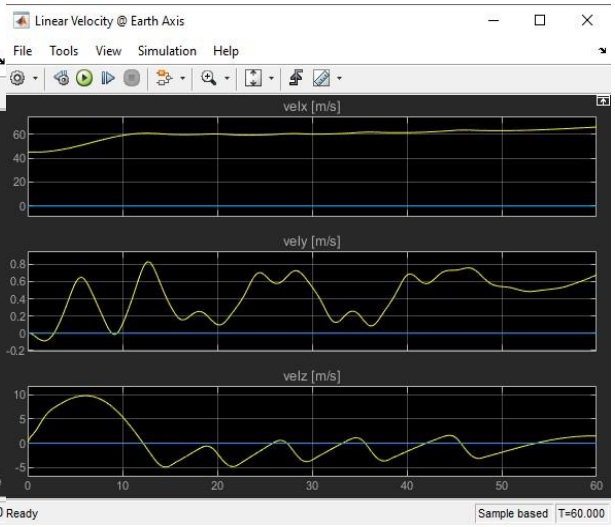

Linear Position @ Earth Axis
File Tools View Simulation Help
posx [m]
posy [m]
posz [m]
Ready
Sample based
T=60.000


Angle-of-Attack Angle-of-Sideslip @ Wind Axis
File Tools View Simulation Help
alpha [deg]
beta [deg]
Ready
Sample based
T=60.000

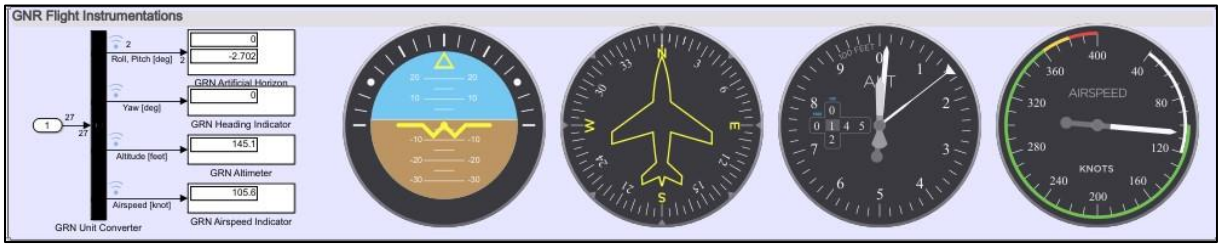

Angular Velocity @ Body Axis
File Tools View Simulation Help
p [deg/s]
q [deg/s]
r [deg/s]
Ready
Sample based
T=60.000


Angular Position @ Earth Axis (Euler Angles)
File Tools View Simulation Help
phi [deg]
theta [deg]
psi [deg]
Ready
Sample based
T=60.000


Linear Velocity @ Body Axis
File Tools View Simulation Help
u [m/s]
v [m/s]
w [m/s]
Ready
T=60.000


Linear Velocity @ Earth Axis
File Tools View Simulation Help
velx [m/s]
vely [m/s]
velz [m/s]
Ready
Sample based
T=60.000

MISSION 4 (Landing)



I made this mission for fun. I just wanted to know that I could land but simulink blocks doesn't perceive environment so my aircraft went under the runway.