Table of Contents

Clean

```
close all; clear; clc;
ttwistor;
```

Problem 1

```
trim_definition = [18; 0; 1800];

[Alon, Blon, Alat, Blat] = AircraftLinearModel(trim_definition,
aircraft_parameters);


% Calculate the eignvalues and vectors of the modes
[lon_vec, lon_val] = eig(Alon);
[lat_vec, lat_val] = eig(Alat);

% Longitudinal analysis
phugoid = lon_val(5,5);
phugoid_freq = sqrt(real(phugoid)^2 + imag(phugoid)^2);
phugoid_damp = -real(phugoid) / phugoid_freq;

short_period = lon_val(3,3);
short_period_freq = sqrt(real(short_period)^2 + imag(short_period)^2);
short_period_damp = -real(short_period) / short_period_freq;


% Lateral analysis
dutch = lat_val(3,3);
dutch_freq = sqrt(real(dutch)^2 + imag(dutch)^2);
dutch_damp = -real(dutch) / dutch_freq;


% Time constants of the roll and spiral
roll = lat_val(2,2);
spiral = lat_val(5,5);
roll_t = -1 / real(roll);
spiral_t = -1 / real(spiral);

% Use damp
lon_sys = ss(Alon, Blon, eye(5), zeros(5,2));
lat_sys = ss(Alat, Blat, eye(5), zeros(5,2));


Local minimum possible. Constraints satisfied.
```

```
fmincon stopped because the size of the current step is less than
the value of the step size tolerance and constraints are
satisfied to within the value of the constraint tolerance.
```

Problem 2

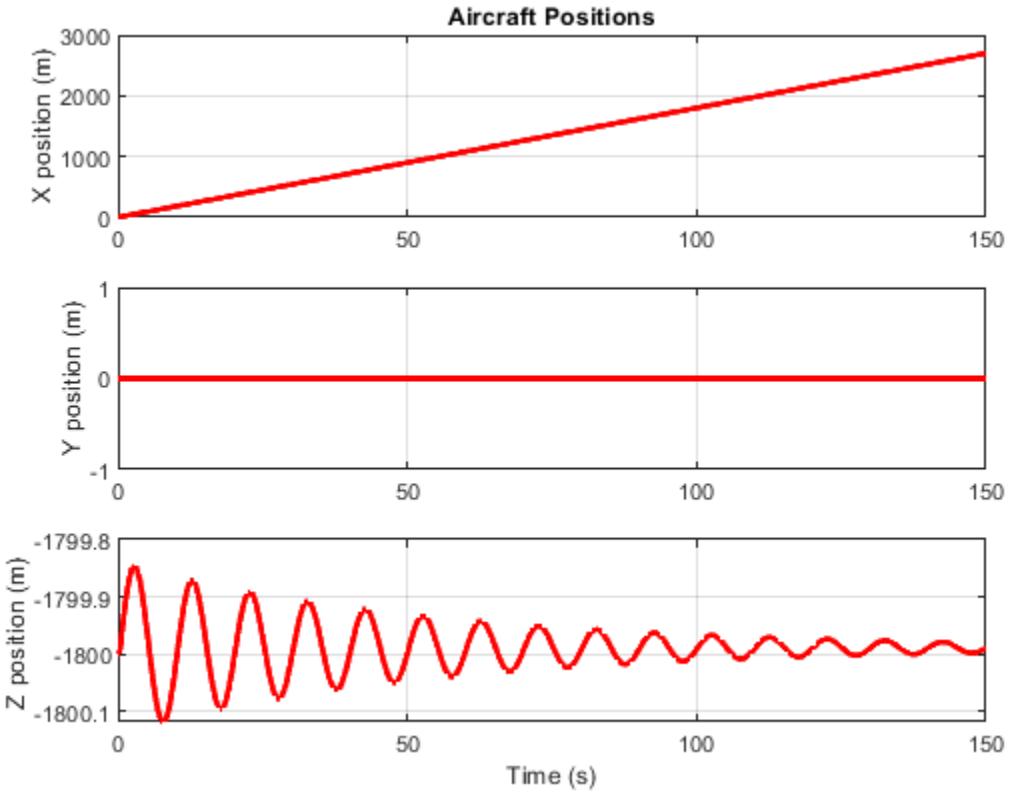
Apply an impulse on the elevator when in trim to excite the phugoid and short period modes

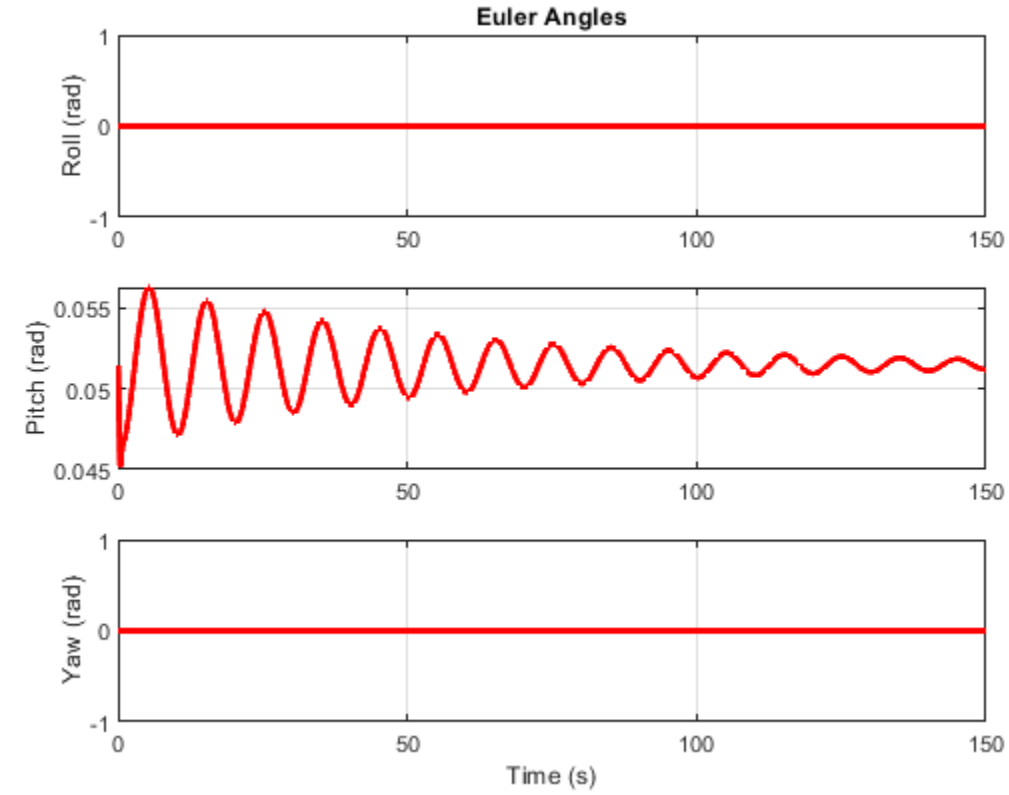
```
% Excite the lateral modes by applying a doublet to the aileron. Two short
% pulses, one positive and then one negative and then zero.

% Excite the lateral modes by applying a doublet to the rudder

% Initial state and surfaces
trim_definition = [18; 0; 1800];
[trim_state, trim_control] = TrimCalculator(trim_definition,
aircraft_parameters);
wind_inertial = [0; 0; 0];

% Elevator impulse
t_pulse = 0.2;
del_pulse = 10*pi/180;
pulse_vec = [del_pulse; 0; 0; 0];


% Integrate
odeFunc = @(t, aircraft_state)AircraftEOMPulse(t, aircraft_state,
trim_control, pulse_vec, t_pulse, wind_inertial, aircraft_parameters);
tspan = [0 150];

[TOUT, XOUT] = ode45(odeFunc, tspan, trim_state);

% Control Surfaces
UOUT = zeros(length(TOUT),4);
for i=1:length(TOUT)
    UOUT(i,:) = trim_control' + ControlSurfacePulse(TOUT(i), t_pulse,
pulse_vec)';
end

% Plotting
PlotSimulation(TOUT, XOUT, UOUT, 1:6, ['r', '-']);



%%%% Lateral Excitation AILERON
t_pulse = [0.2; 0.2];
del_pulse = 10*pi/180;
pulse_vec = [0; del_pulse; 0; 0];

% Integrate
odeFunc = @(t, aircraft_state)AircraftEOMPulse(t, aircraft_state,
```

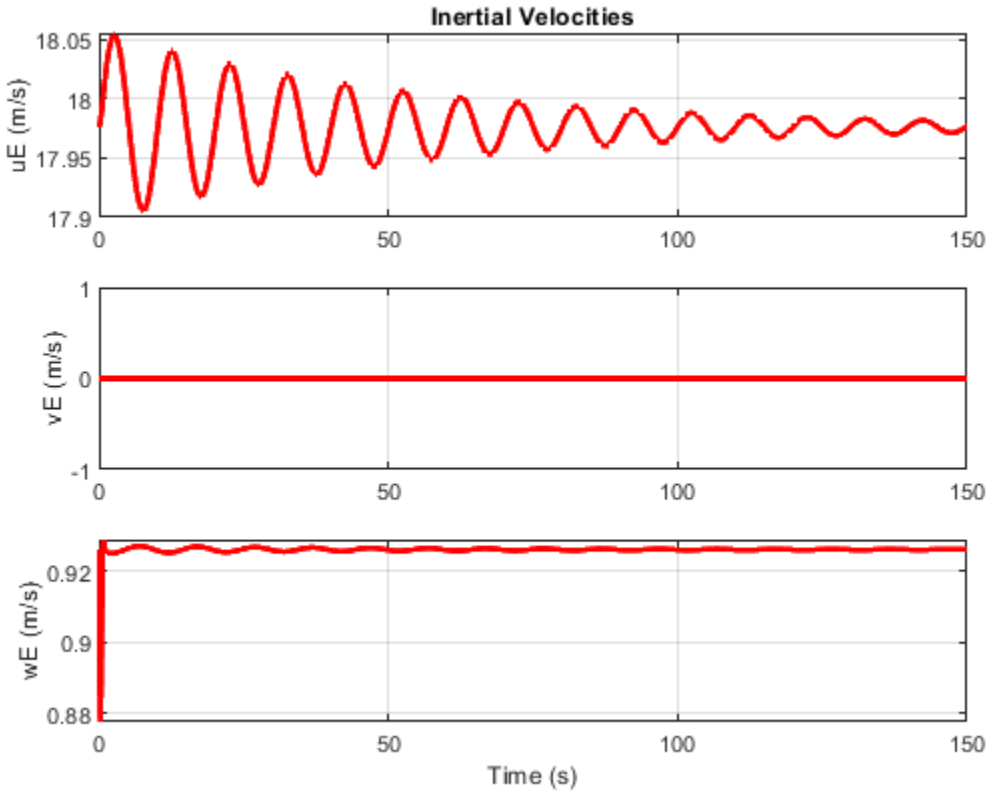
```
trim_control, pulse_vec, t_pulse, wind_inertial, aircraft_parameters);
tspan = [0 150];

[TOUT, XOUT] = ode45(odeFunc, tspan, trim_state);

% Control Surfaces
UOUT = zeros(length(TOUT),4);
for i=1:length(TOUT)
    UOUT(i,:) = trim_control' + ControlSurfacePulse(TOUT(i), t_pulse,
pulse_vec)';
end

% Plotting
PlotSimulation(TOUT, XOUT, UOUT, 7:12, ['b', '-']);


%%%% Lateral Excitation RUDDER
t_pulse = [0.2; 0.2];
del_pulse = 10*pi/180;
pulse_vec = [0; 0; del_pulse; 0];

% Integrate
odeFunc = @(t, aircraft_state)AircraftEOMPulse(t, aircraft_state,
trim_control, pulse_vec, t_pulse, wind_inertial, aircraft_parameters);
tspan = [0 150];

[TOUT, XOUT] = ode45(odeFunc, tspan, trim_state);

% Control Surfaces
UOUT = zeros(length(TOUT),4);
for i=1:length(TOUT)
    UOUT(i,:) = trim_control' + ControlSurfacePulse(TOUT(i), t_pulse,
pulse_vec)';
end

% Plotting
PlotSimulation(TOUT, XOUT, UOUT, 13:18, ['m', '-']);
```

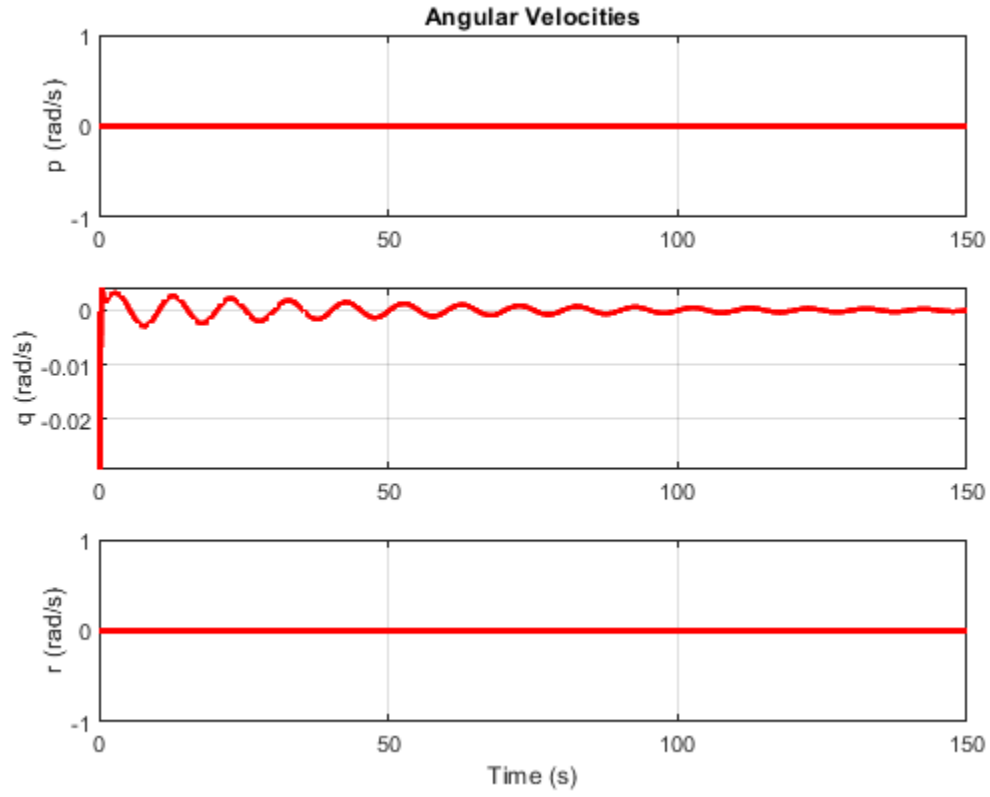
Local minimum possible. Constraints satisfied.

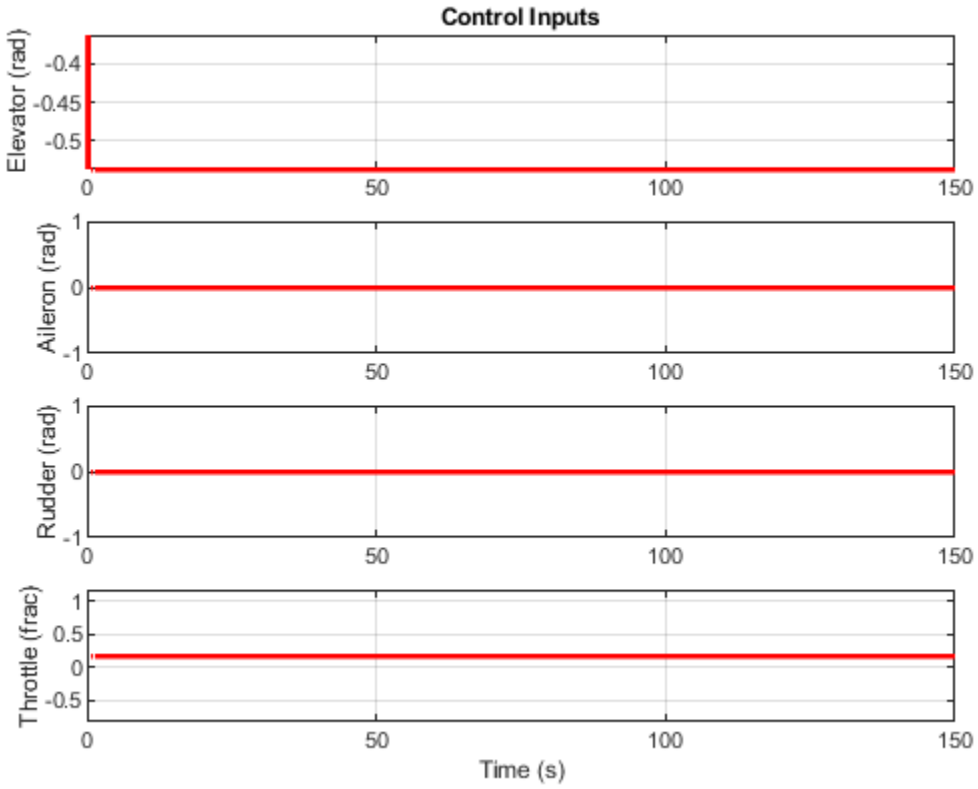
fmincon stopped because the size of the current step is less than the value of the step size tolerance and constraints are satisfied to within the value of the constraint tolerance.

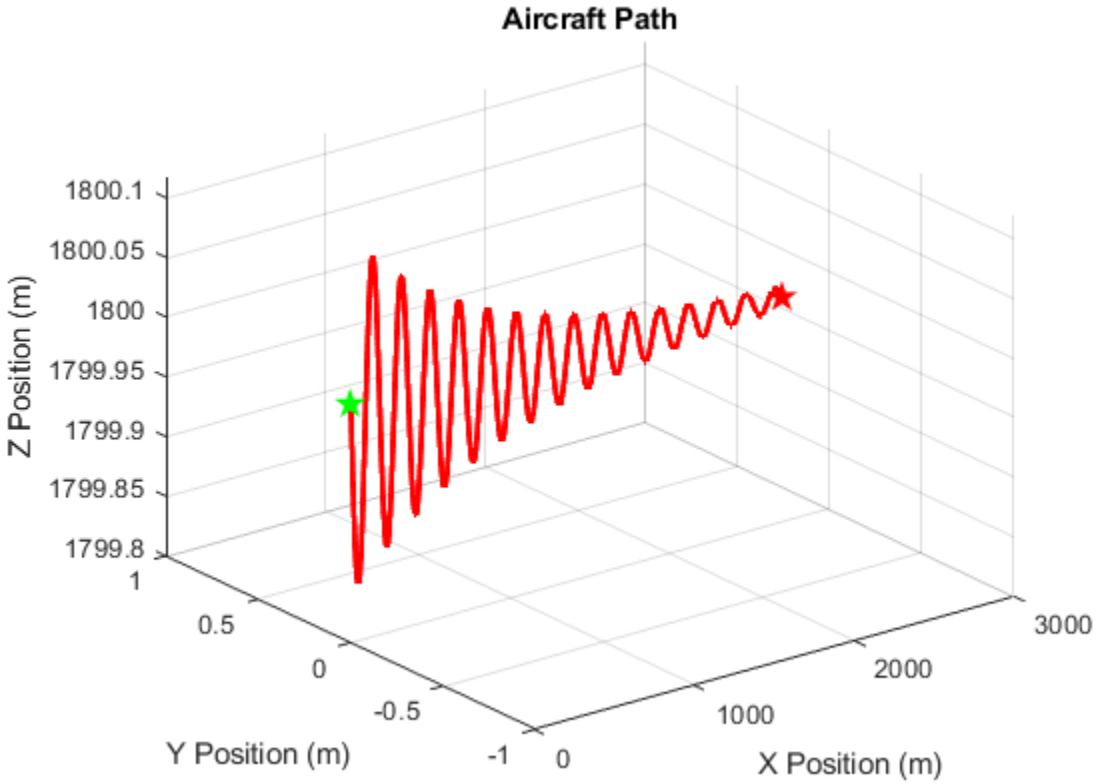

Aircraft Positions
X position (m)
3000
2000
1000
0
Y position (m)
1
0
-1
Z position (m)
-1799.8
-1799.9
-1800
-1800.1
0
50
100
150
Time (s)

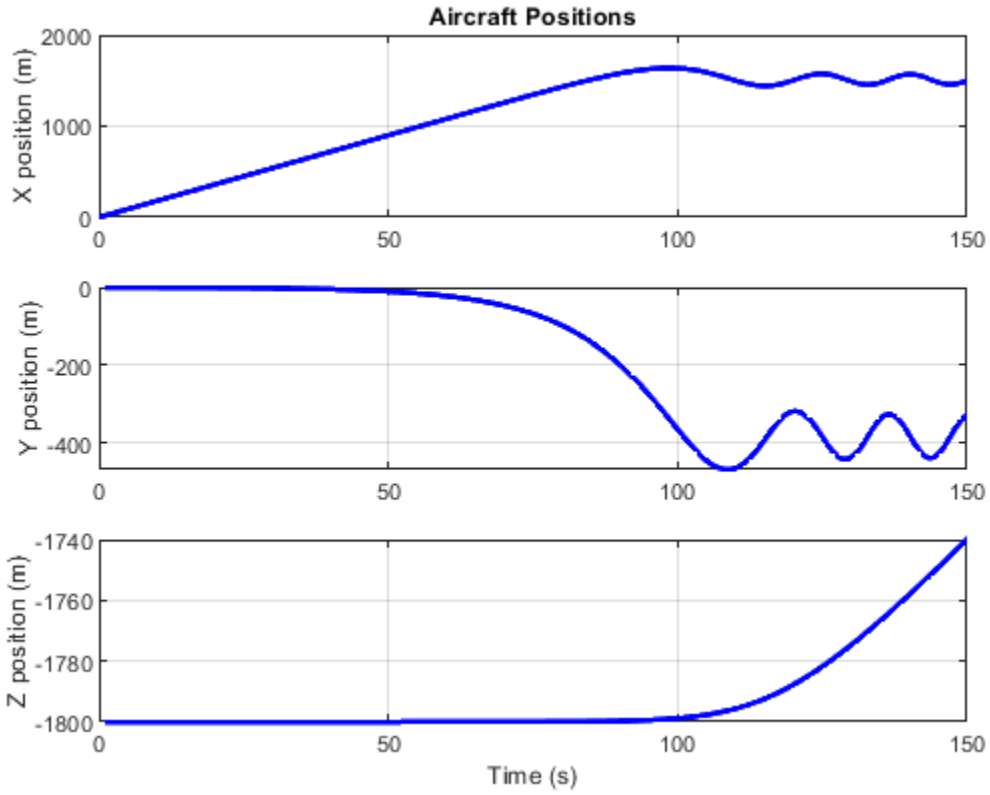

Euler Angles
Roll (rad)
1
0
-1
Pitch (rad)
0.055
0.05
0.045
Yaw (rad)
0
50
100
150
Time (s)

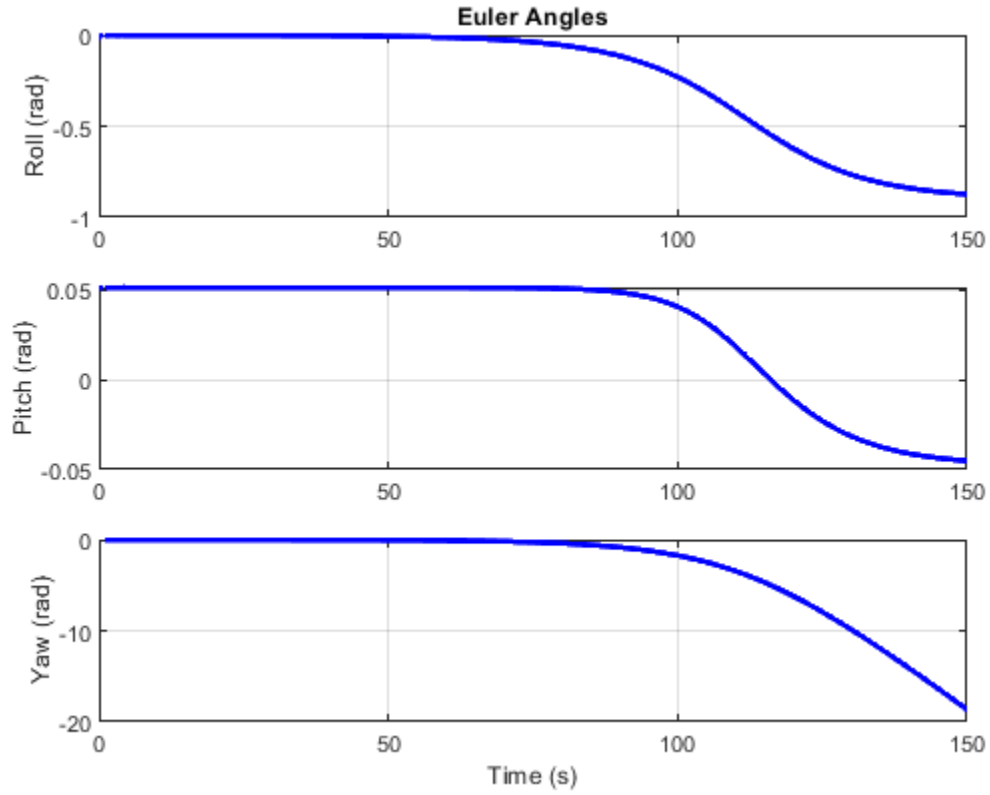

Inertial Velocities
uE (m/s)
18.05
18
17.95
17.9
vE (m/s)
1
0
-1
wE (m/s)
0.92
0.9
0.88
0
50
100
150
Time (s)

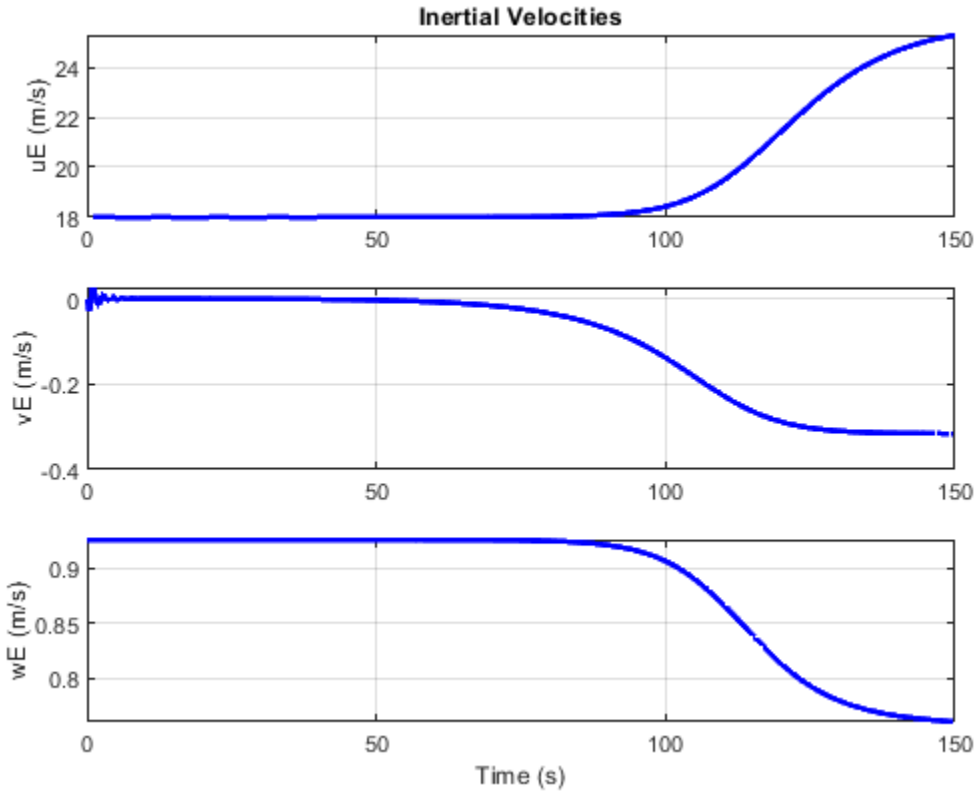

Angular Velocities
p (rad/s)
1
0
-1
q (rad/s)
0
-0.01
-0.02
r (rad/s)
0
50
100
150
Time (s)

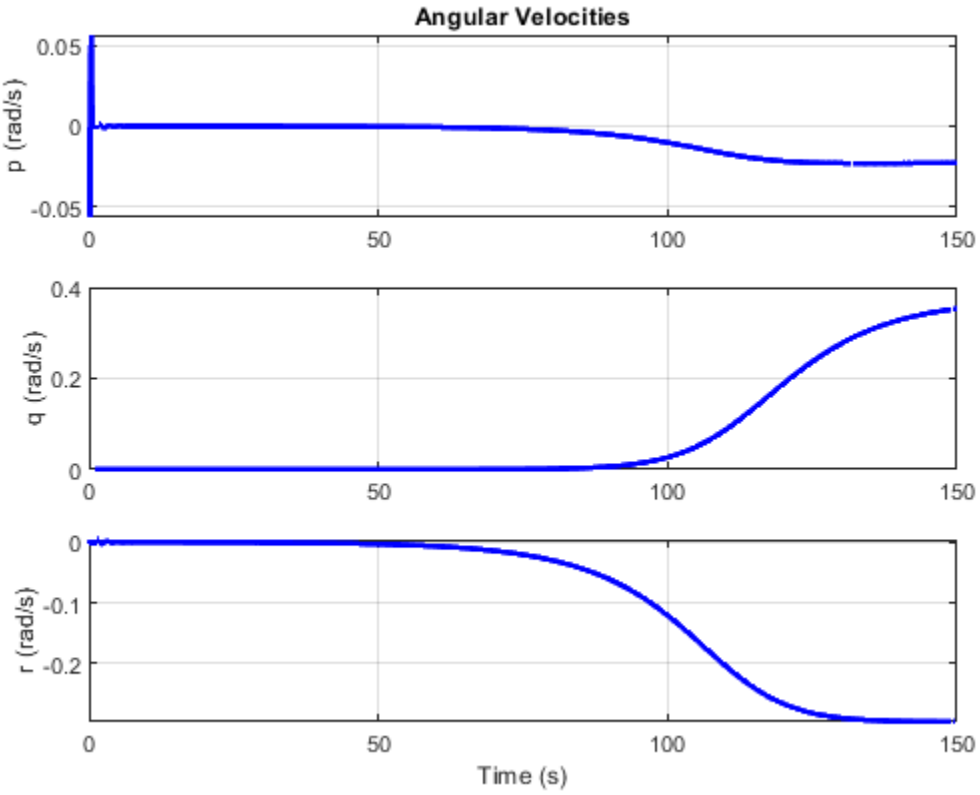

Control Inputs
Elevator (rad)
-0.4
-0.45
-0.5
Aileron (rad)
Rudder (rad)
Throttle (frac)
1
0.5
0
-0.5
-1
0
50
100
150
Time (s)

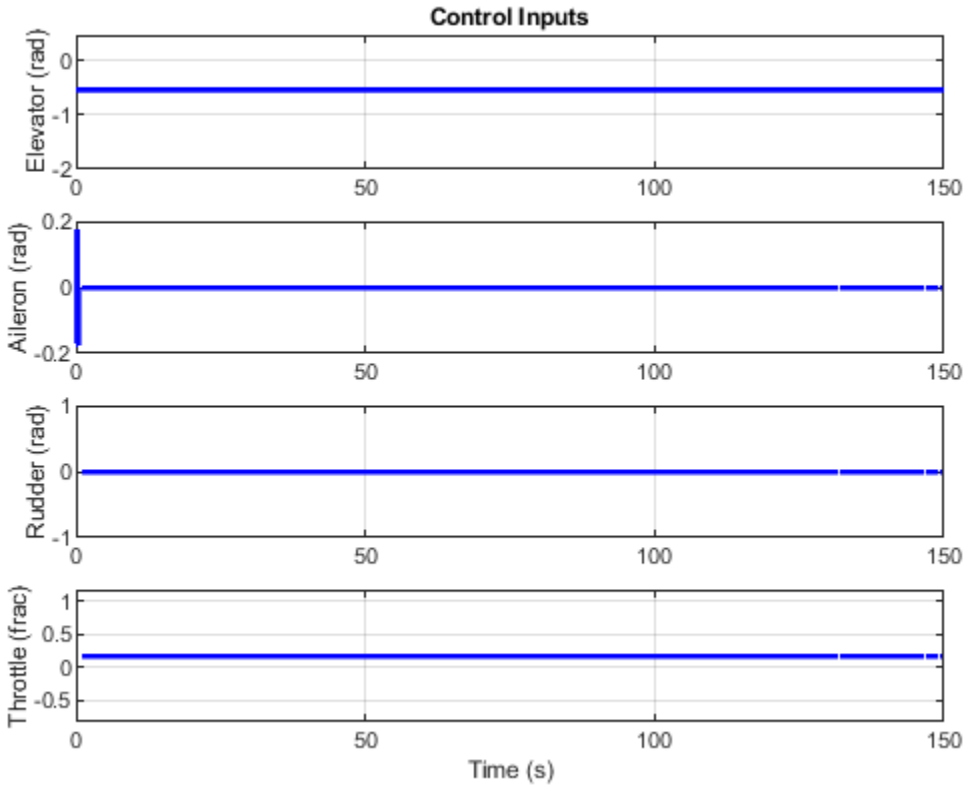

Aircraft Path
Z Position (m)
1800.1
1800.05
1800
1799.95
1799.9
1799.85
1799.8
Y Position (m)
1
0.5
0
-0.5
-1
X Position (m)
0
1000
2000
3000

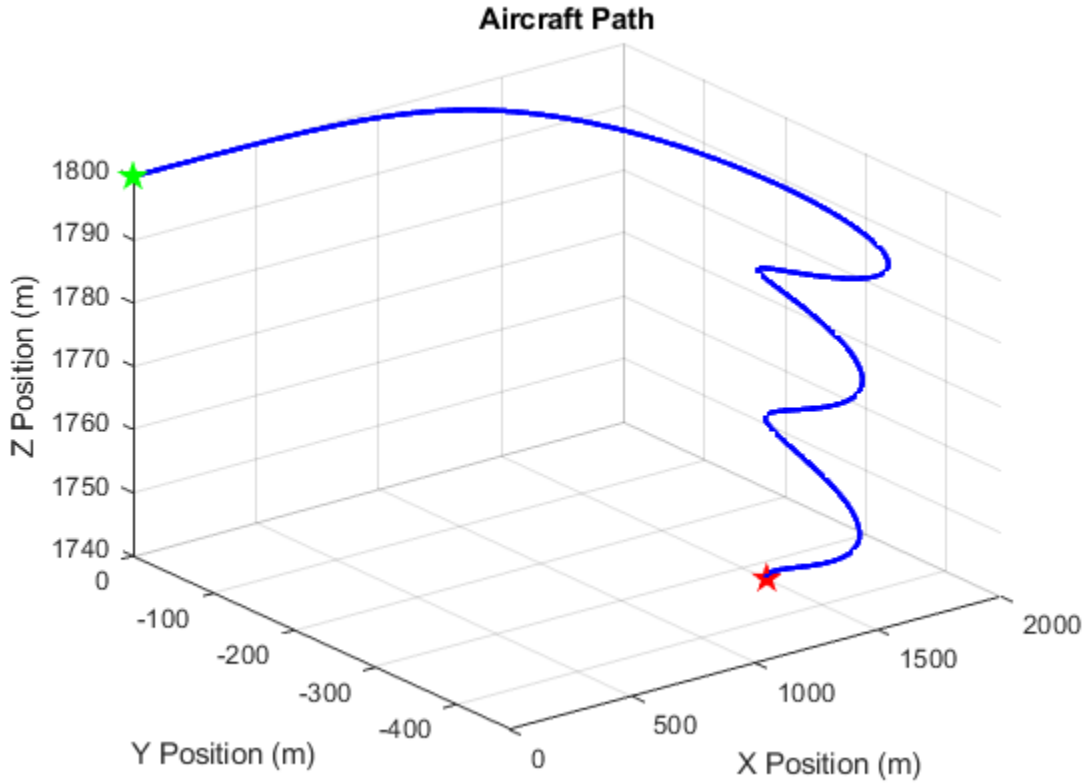

Aircraft Positions
X position (m)
2000
1000
0
Y position (m)
0
-200
-400
Z position (m)
-1740
-1760
-1780
-1800
0
50
100
150
Time (s)

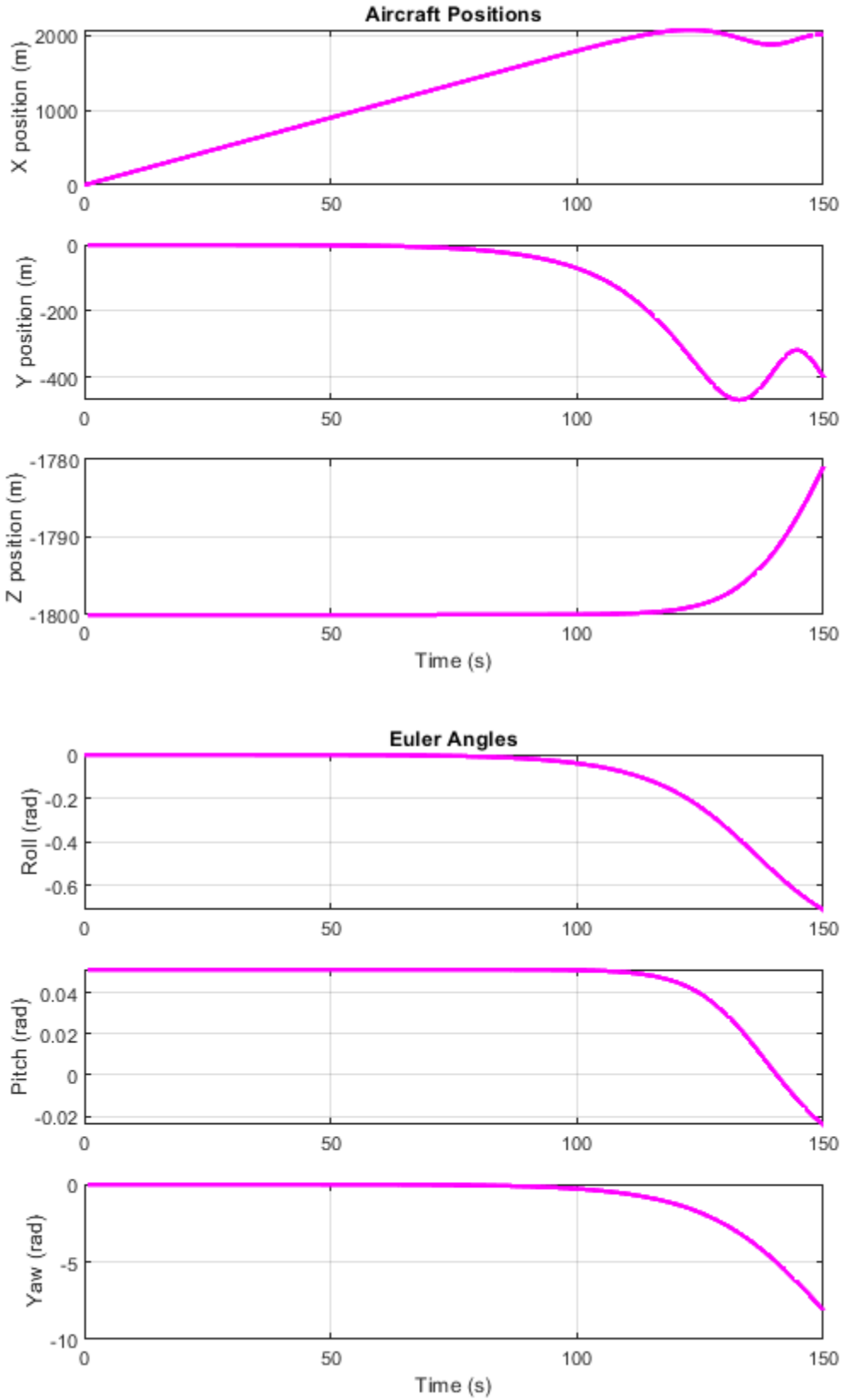

Euler Angles
Roll (rad)
0
-0.5
-1
Pitch (rad)
0.05
0
-0.05
Yaw (rad)
0
-10
-20
0
50
100
150
Time (s)

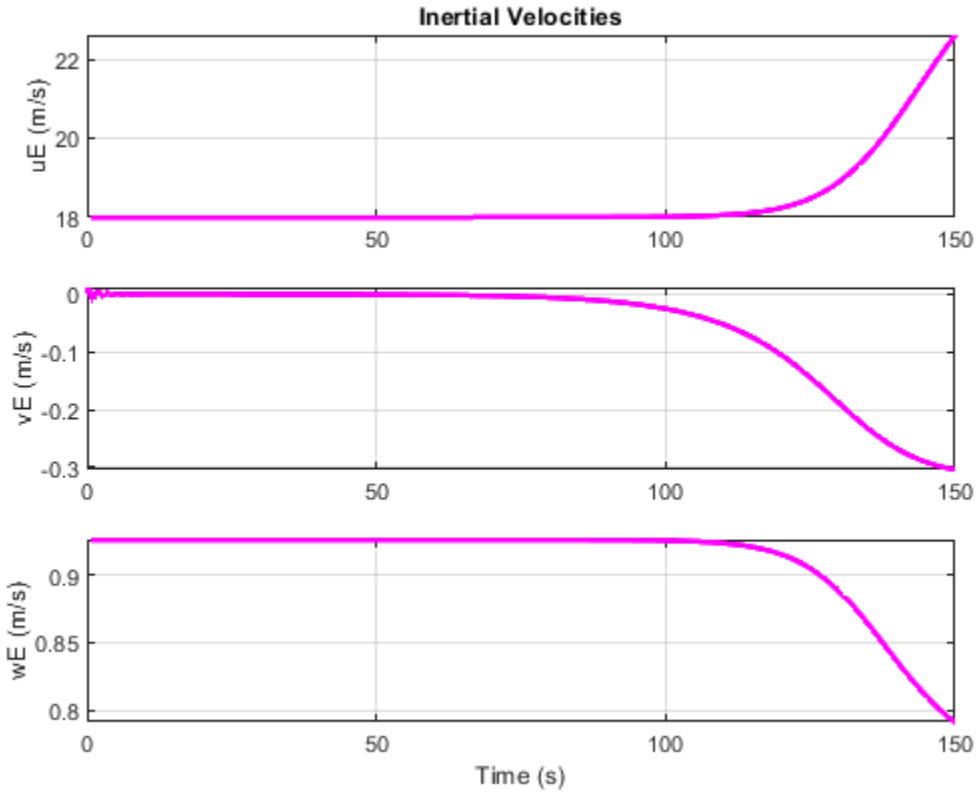

Inertial Velocities
uE (m/s)
24
22
20
18
0
50
100
150
vE (m/s)
0
-0.2
-0.4
wE (m/s)
0.9
0.85
0.8
Time (s)

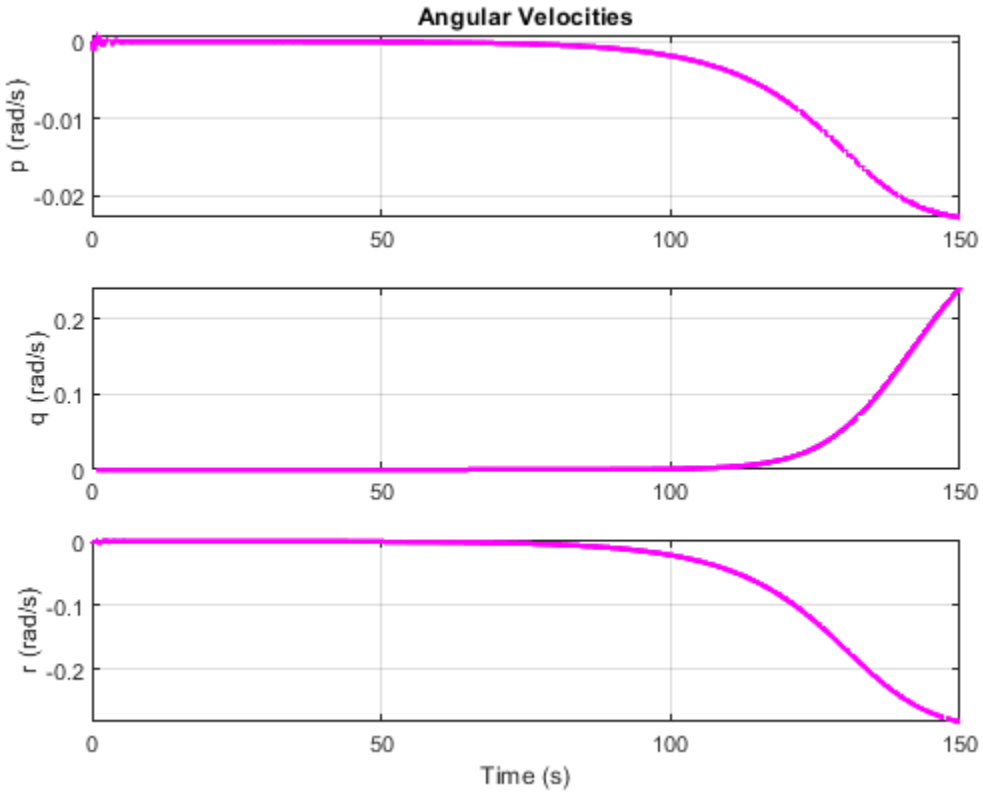

Angular Velocities
p (rad/s)
0.05
0
-0.05
0
50
100
150
q (rad/s)
0.4
0.2
r (rad/s)
-0.1
-0.2
Time (s)

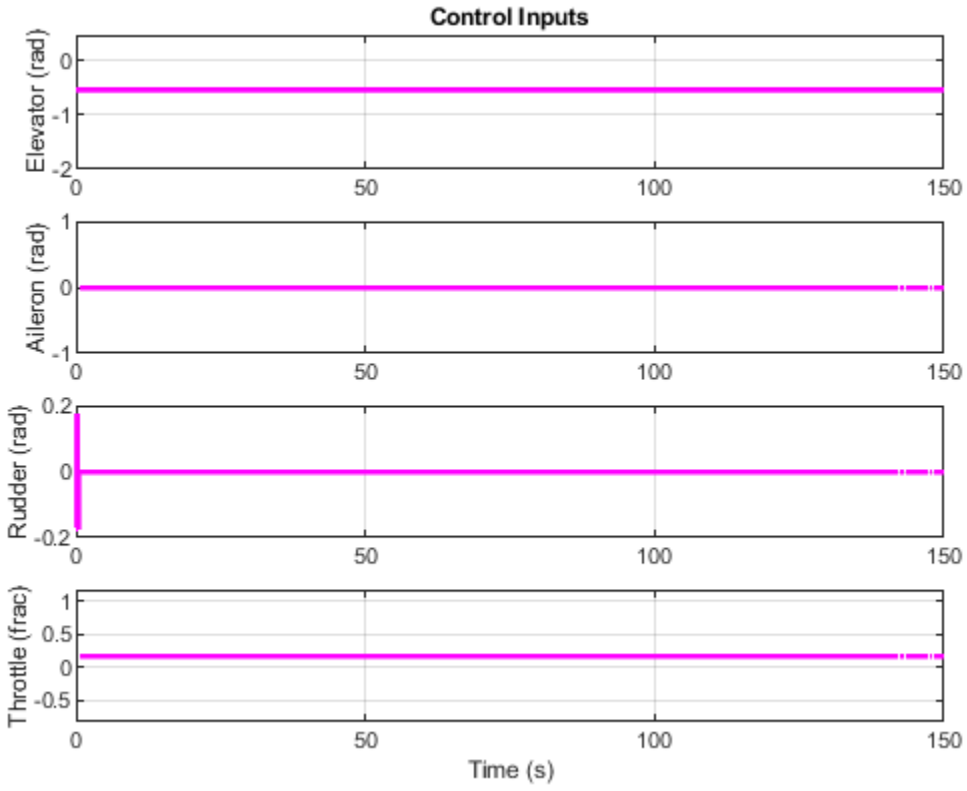

Control Inputs
Elevator (rad)
Aileron (rad)
Rudder (rad)
Throttle (frac)
Time (s)

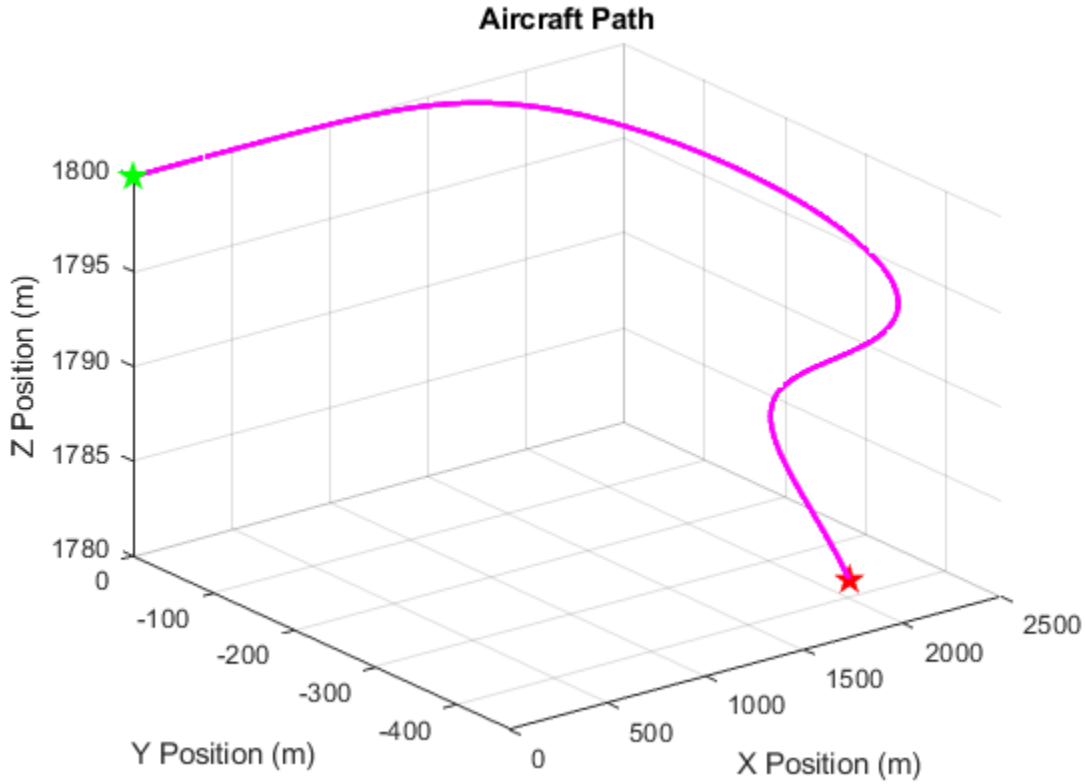

Aircraft Path
Z Position (m)
Y Position (m)
X Position (m)


Aircraft Positions
X position (m)
2000
1000
0
Y position (m)
0
-200
-400
Z position (m)
-1780
-1790
-1800
0
50
100
150
Time (s)
Euler Angles
Roll (rad)
0
-0.2
-0.4
-0.6
Pitch (rad)
0.04
0.02
0
-0.02
Yaw (rad)
0
-5
-10
0
50
100
150
Time (s)


Inertial Velocities
uE (m/s)
22
20
18
0
50
100
150
vE (m/s)
0
-0.1
-0.2
-0.3
wE (m/s)
0.9
0.85
0.8
Time (s)


Angular Velocities
p (rad/s)
0
-0.01
-0.02
q (rad/s)
0.2
0.1
r (rad/s)
-0.1
-0.2
Time (s)


Control Inputs
Elevator (rad)
0
-1
-2
Aileron (rad)
1
0
-1
Rudder (rad)
0.2
0
-0.2
Throttle (frac)
1
0.5
0
-0.5
0
50
100
150
Time (s)


Aircraft Path
Z Position (m)
1800
1795
1790
1785
1780
Y Position (m)
0
-100
-200
-300
-400
X Position (m)
0
500
1000
1500
2000
2500

Published with MATLAB® R2024a