Auto Pilot

Task 5

Team 4

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Introduction:

❖ In order to Design a controller first of all we should get the transfer functions of all full longitudinal dynamics model.

❖ Our methodology is to using inner loops architecture.

❖ Then using SISO tool to design the controller.

❖ Finally we use SIMULINK to check the performance of our design.
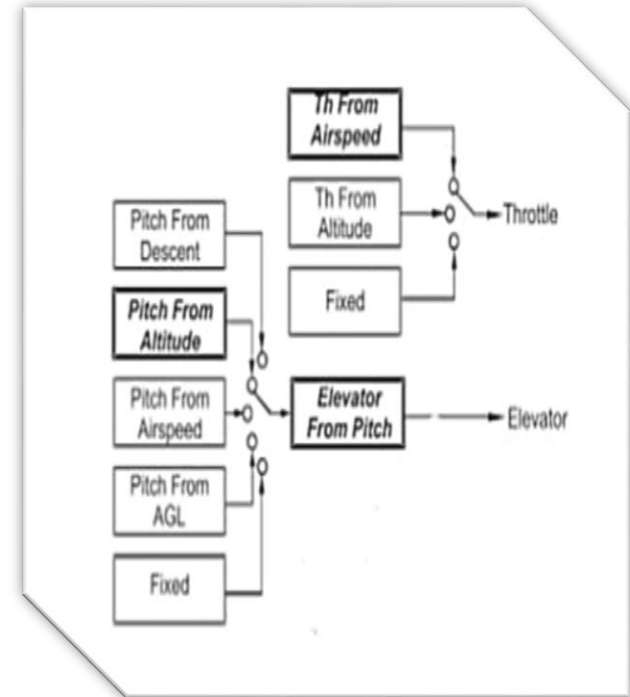
Design Pitch Controller With Pitch Rate Feedback
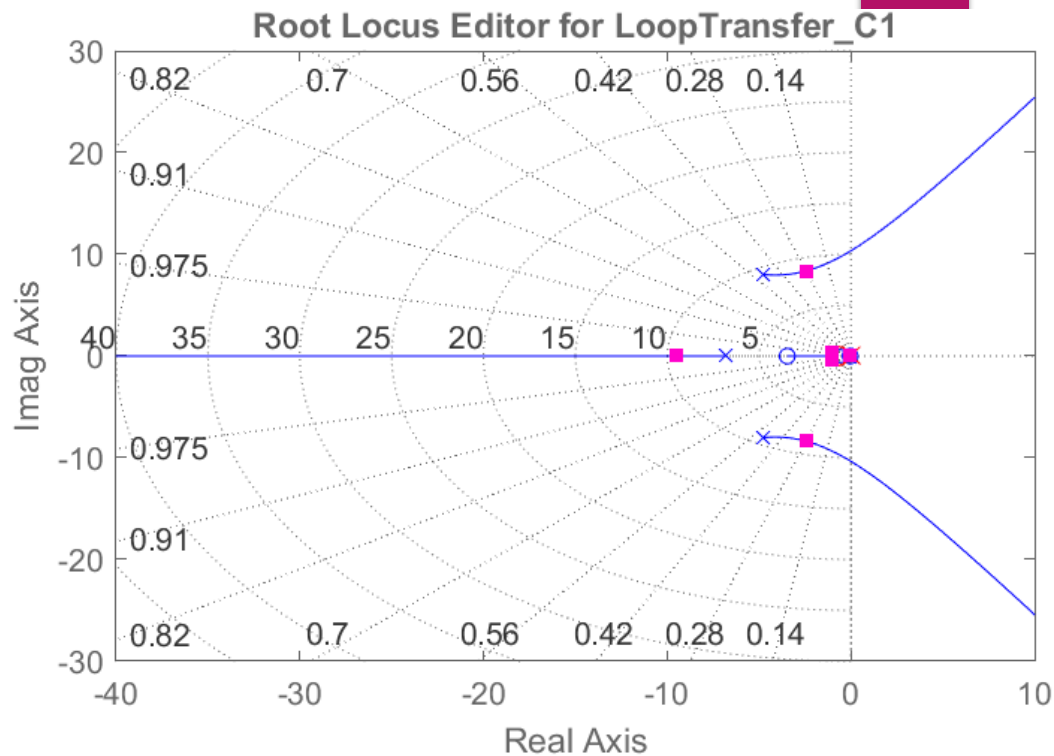
The open loop transfer function is:

```
OL_theta_thetacom =

                     527 s^2 + 1848 s + 74.13
        --------------------------------------------------------------
        s^5 + 16.43 s^4 + 108.3 s^3 + 441.9 s^2 + 18.57 s + 1.377
```
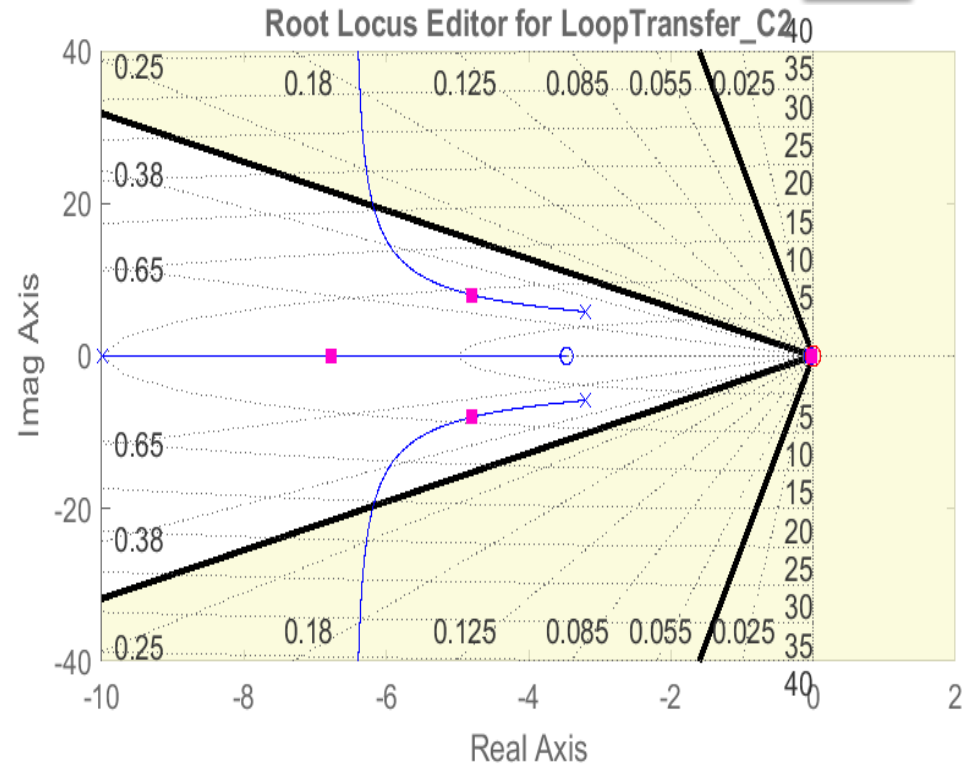
SISO Tool Design

Root locus

SISO Tool Design

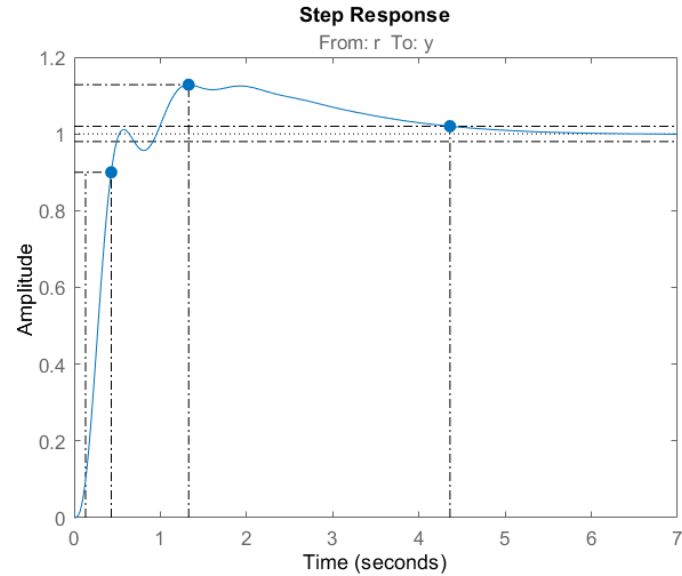Root locus

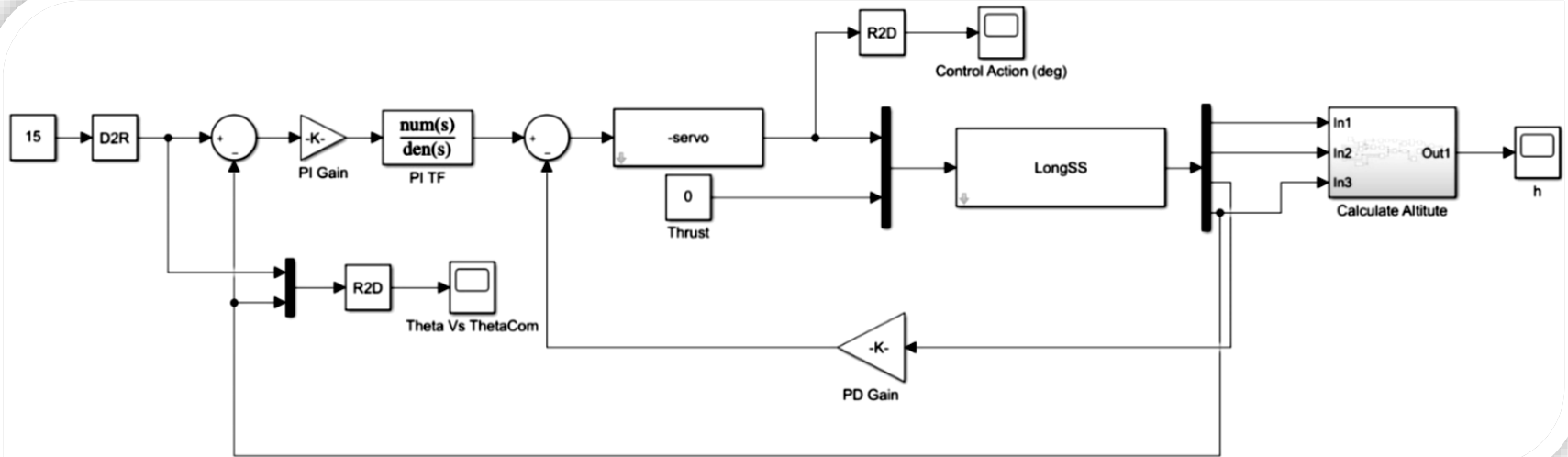Root Locus Editor for LoopTransfer_C2

Step response
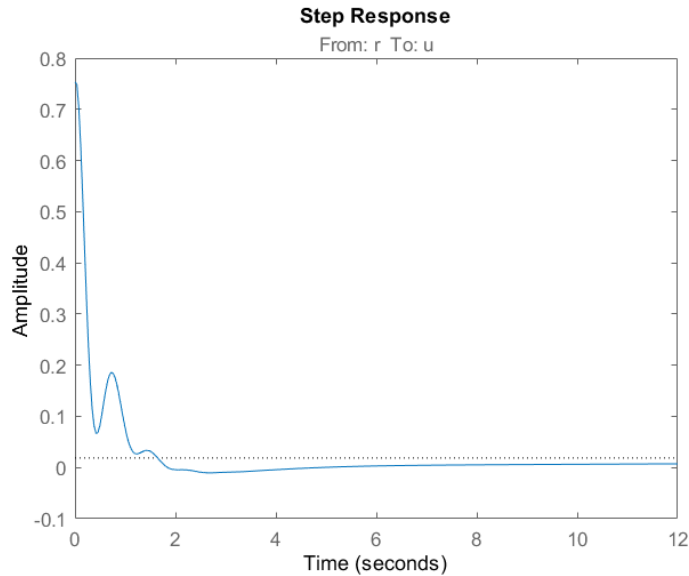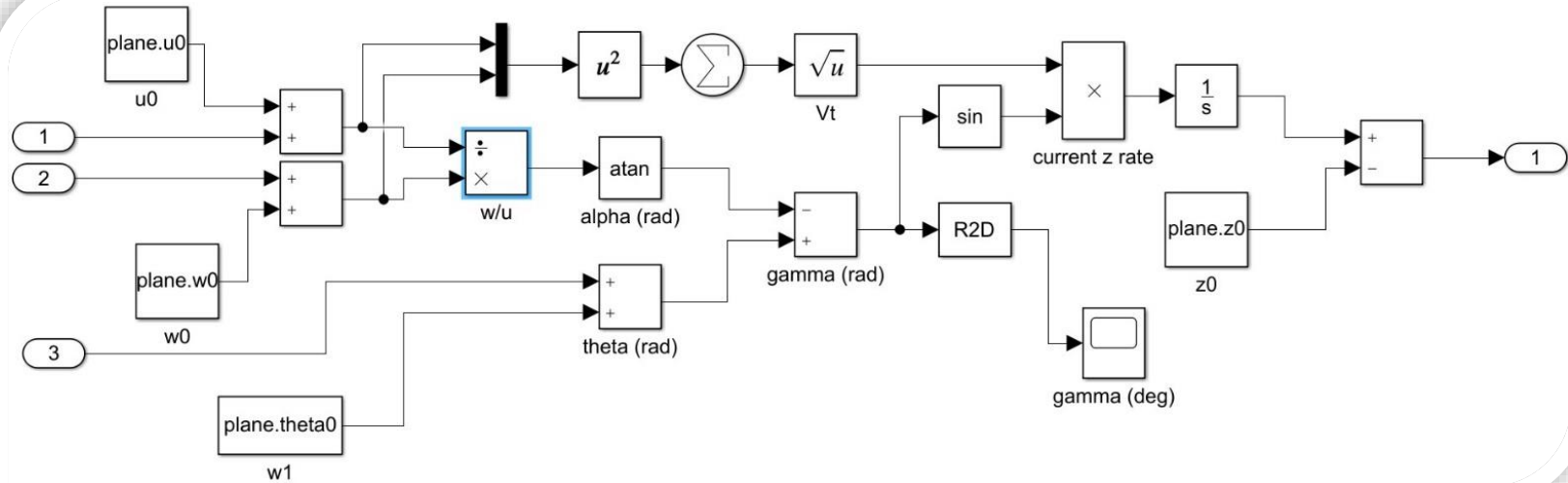
▶ Control action

▶ System Response

Simulink test

Simulink test

Necessity of velocity control

Necessity of velocity control

▶ when we input positive pitch angle, the action depends on the thrust if the thrust is big enough to climb upward the airplane will climb upward if the thrust is not enough the airplane would dive downward but logically, when the pilot input a positive pitch the airplane should climb upward

Necessity of velocity control

$$\because \gamma = \theta - \alpha$$

$$tan\,(\alpha) = \frac{w}{u}$$

$$\because \dot{h} = V_{to} * Sin(\gamma)$$
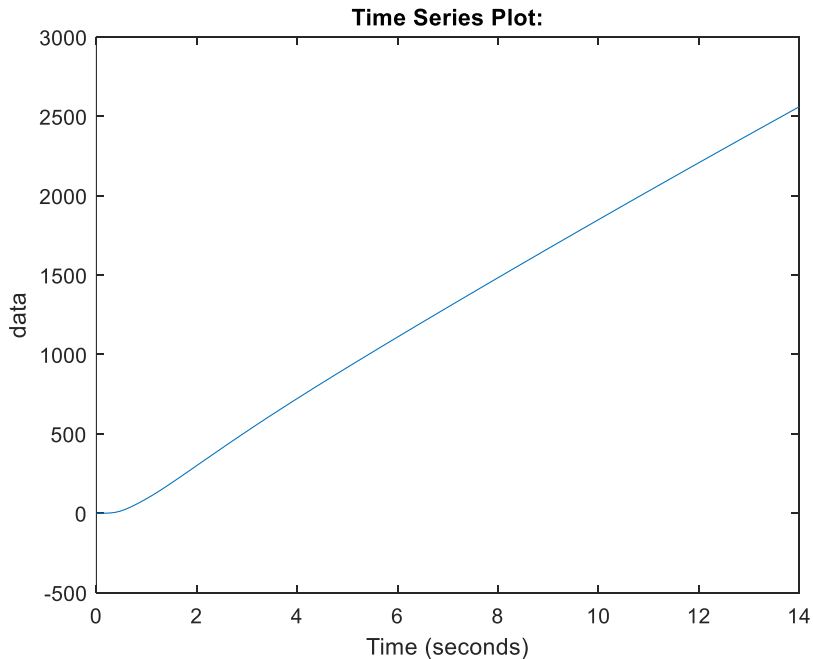
Necessity of velocity control

▶ Our plane climbs upward because it has enough thrust to accomplish this. But this not meaning that we control altitude because the airplane will climb to specific height that its thrust enough to reach, then the airplane would dive downward. And this specific height may be before or after that height we need to reach, so we need to control the velocity to reach to required altitude by change thrust (δ_{th})

NT-33A engine

▶ Our aircraft 'NT-33A' was a training aircraft that was developed from the Lockheed martin.

▶ The Powerplant installed is 1 × Allison J33-A-35 centrifugal flow turbojet engine, with 5,400 lbf (24 kN) thrust for take-off with water injection

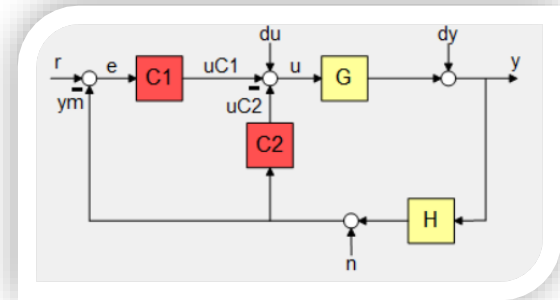▶ 4,600 lbf (20,461.82 N) maximum continuous thrust.

Velocity Controller

Then the open loop transfer function is

```
Ol_u_ucom =

          0.00235 s^3 + 0.015 s^2 + 0.1027 s - 5.831e-05

  -------------------------------------------------------------------
  s^6 + 16.53 s^5 + 110 s^4 + 452.7 s^3 + 62.76 s^2 + 3.234 s + 0.1377

Continuous-time transfer function.
```

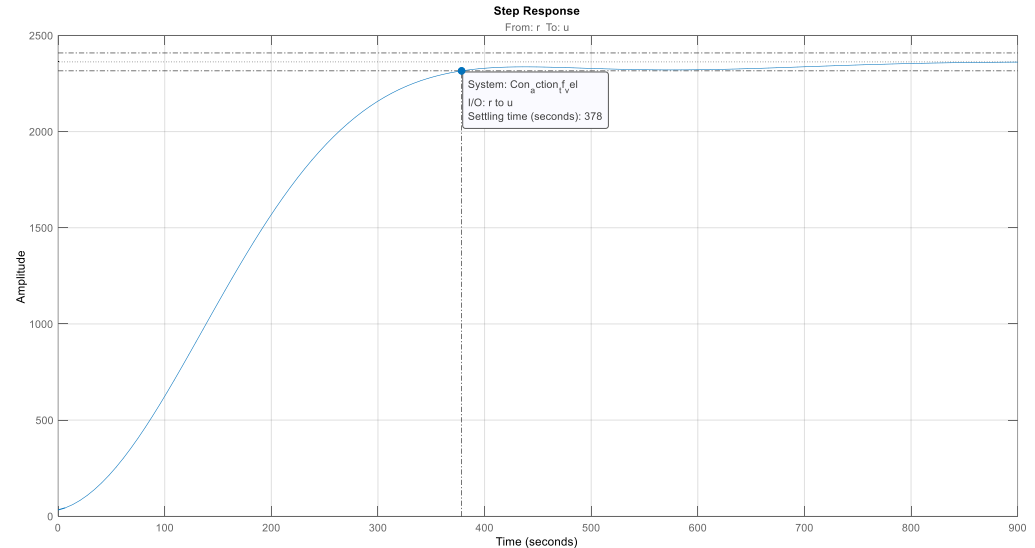# Velocity Controller

velocity_C1_tf =

$$\frac{32.915\ (s+0.03648)}{s}$$

velocity_C2_tf =

$$\frac{15.095\ (s+0.1)}{(s+0.109)}$$

Step response & Control action

Step response
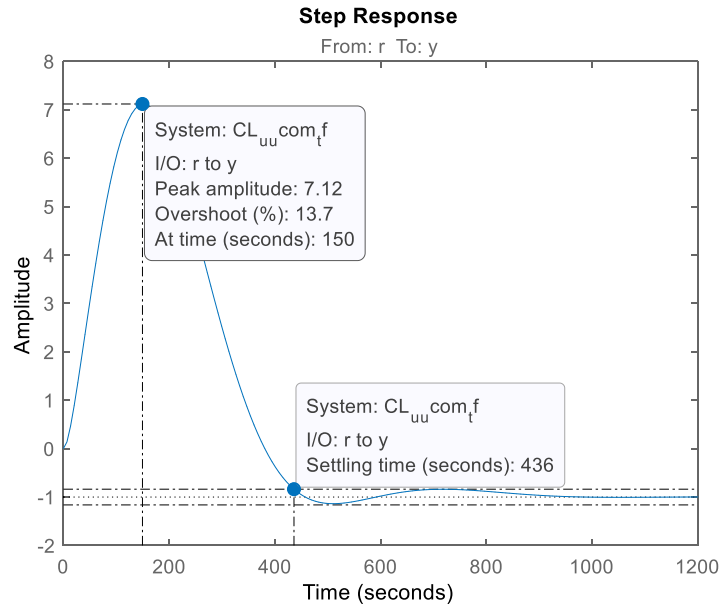
Control action

Altitude controller

OL_h_thetacom =

From input to output "y":

$$-1145\ s^4 - 4001\ s^3 + 1.073e06\ s^2 + 7.461e05\ s + 2.728e04$$
$$\rule{10cm}{0.4pt}$$
$$s^7 + 16.43\ s^6 + 153.4\ s^5 + 996.9\ s^4 + 1678\ s^3 + 970\ s^2 + 36.61\ s$$
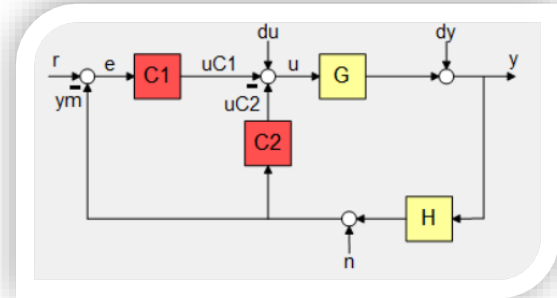
Altitude Controller

```
altitude_C1_tf =

    0.00067403 (s+1.784)
    --------------------
            s
```

```
altitude_C2_tf =

    0.0014691 (s+1.799)
```

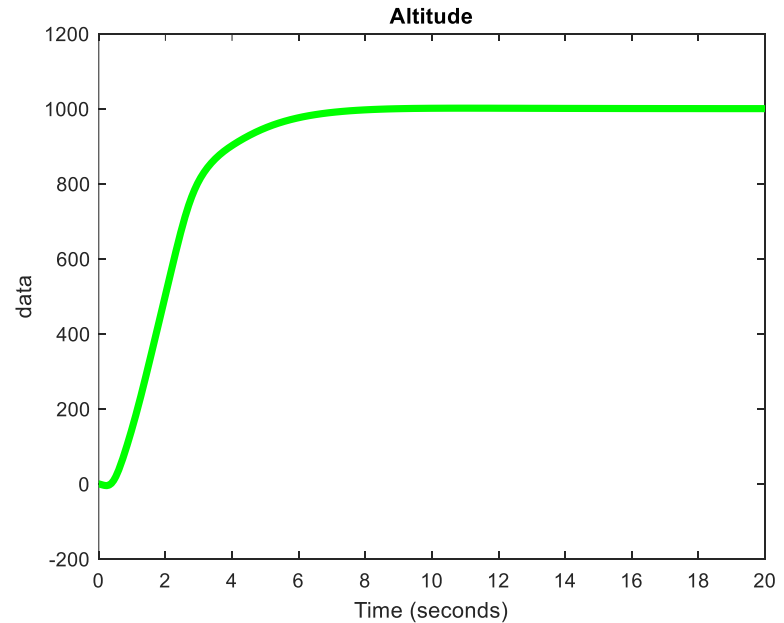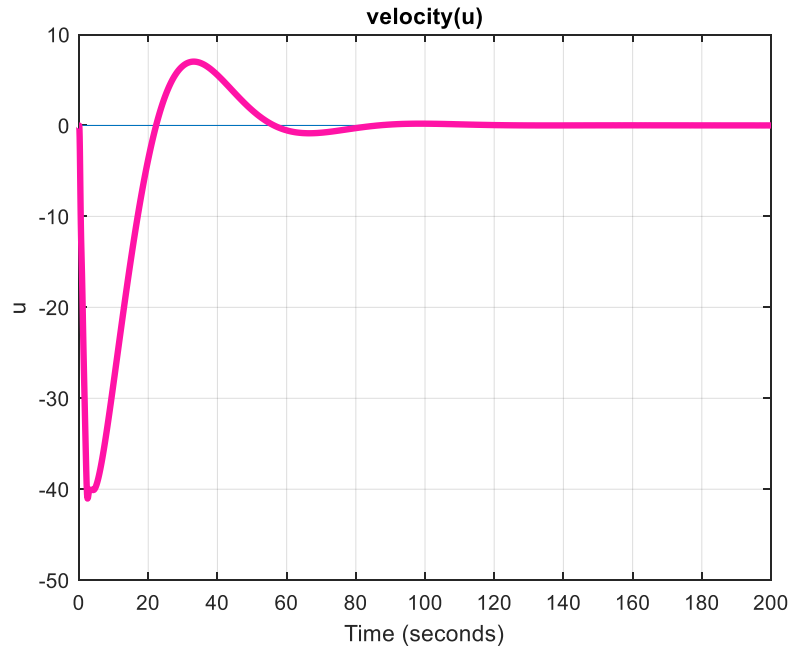# *Step response & Control action*

Step response
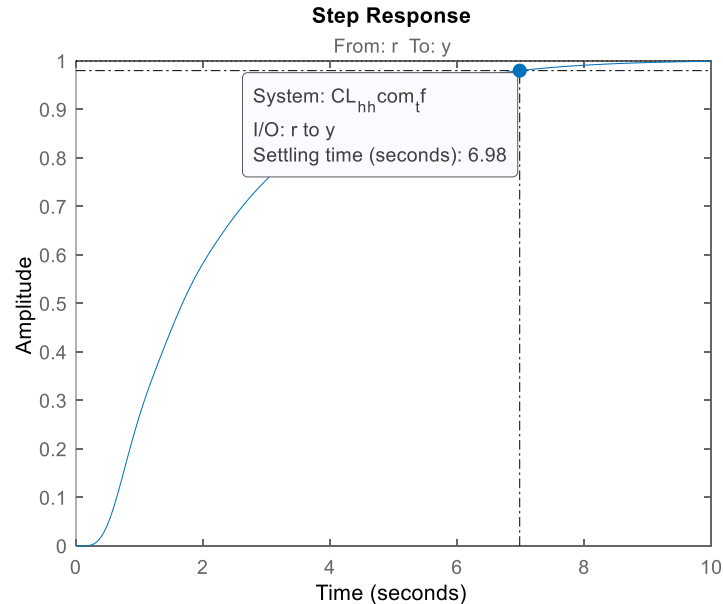
Control action
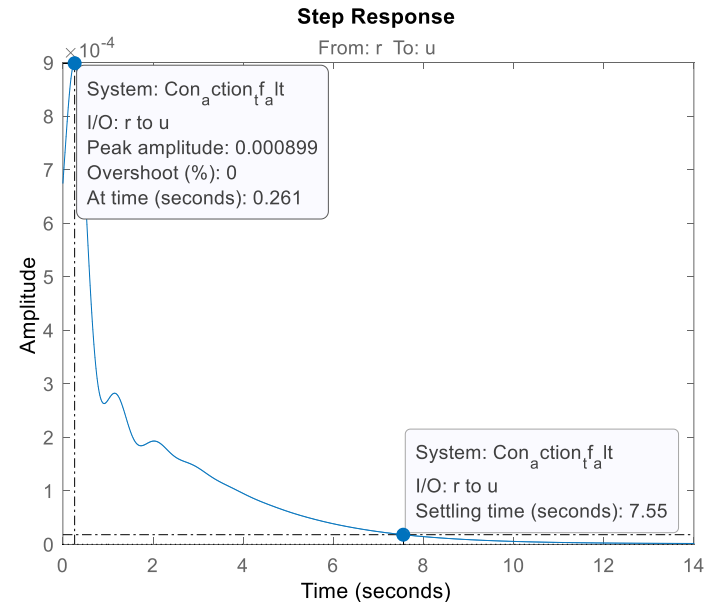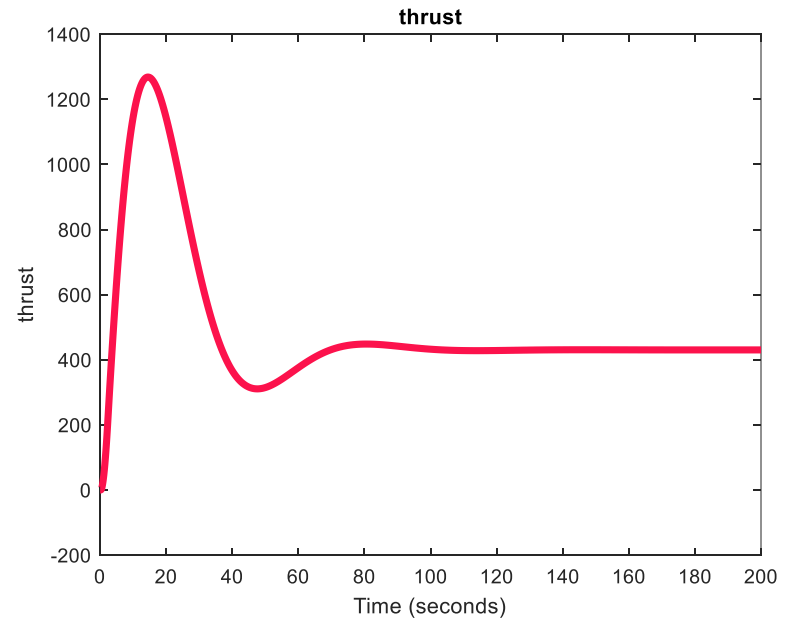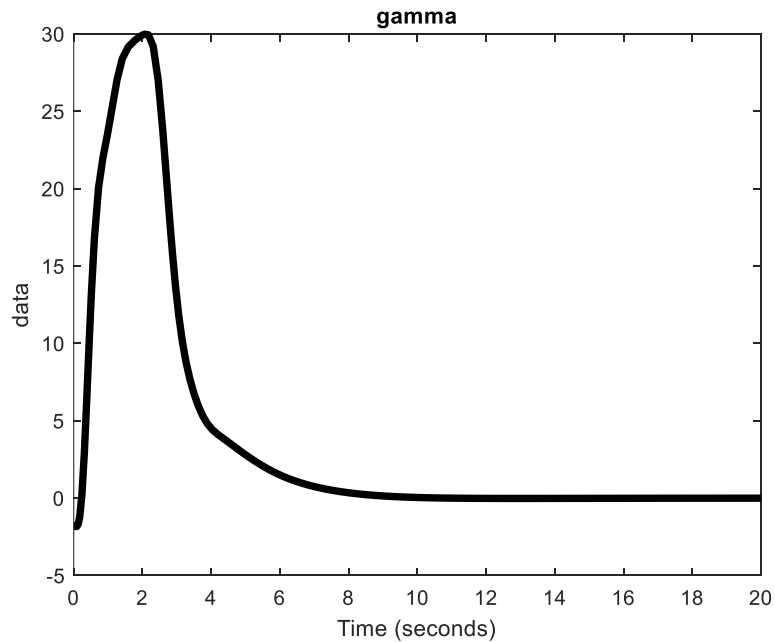
simulation

Results
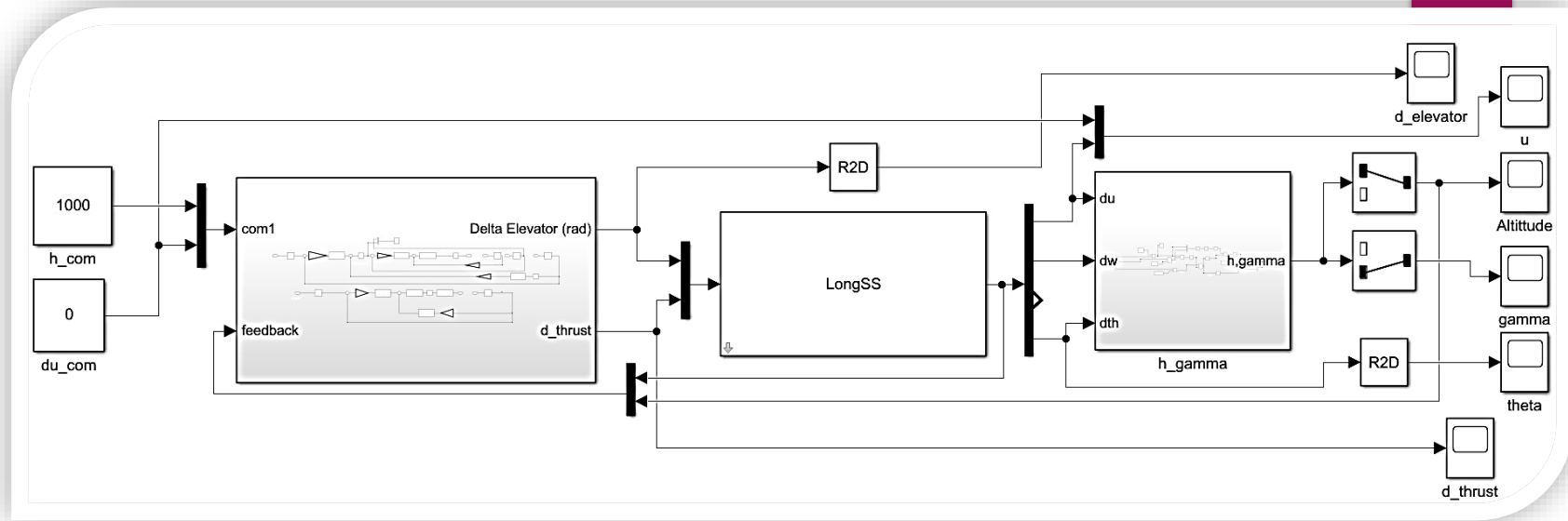
Simulation Blocks
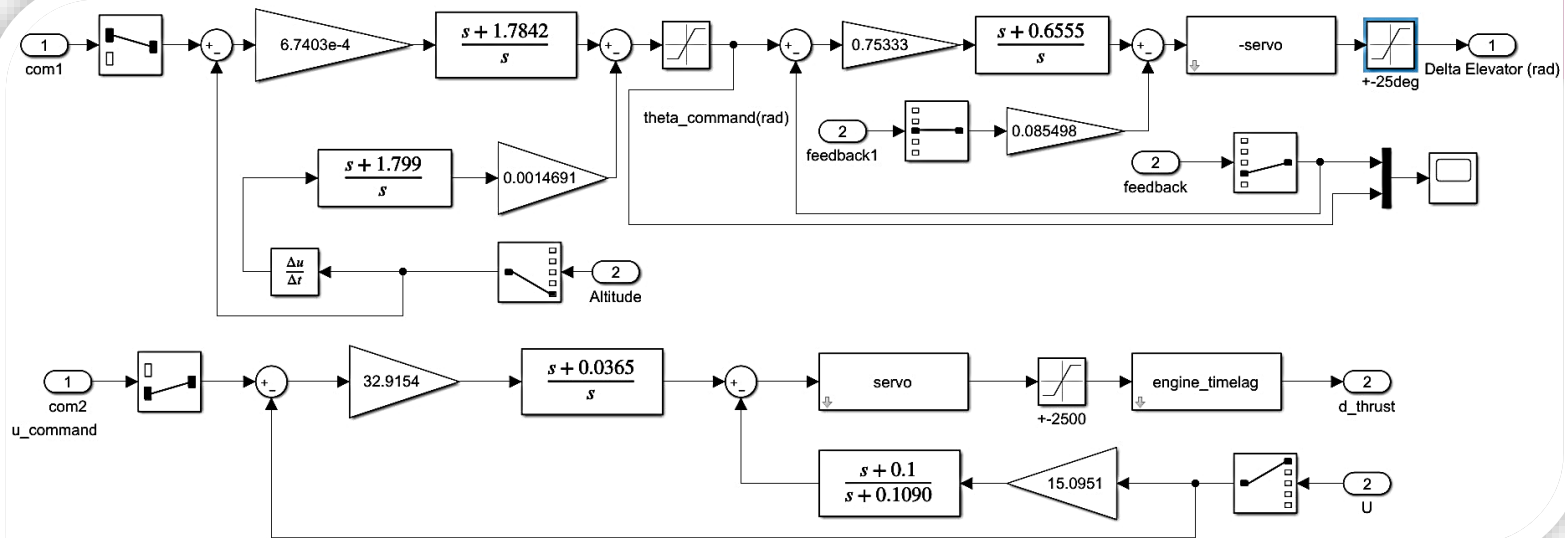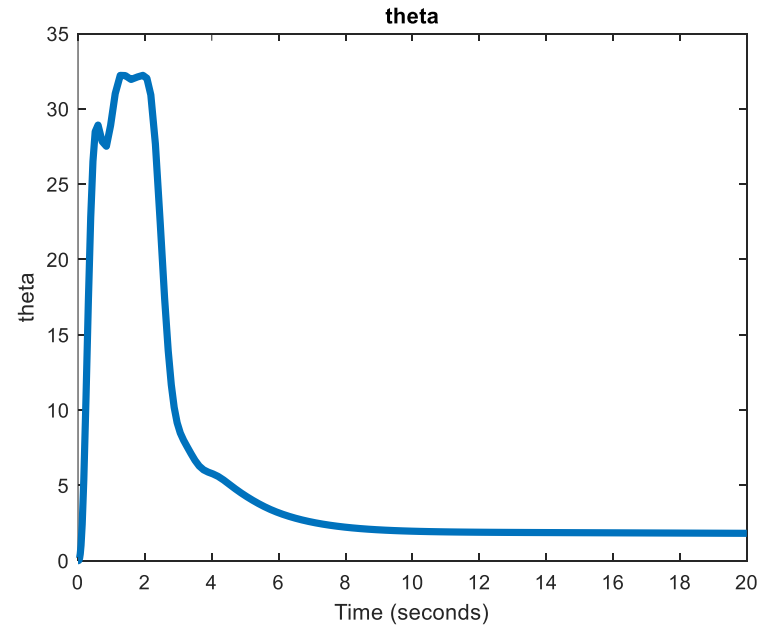
Simulation Blocks

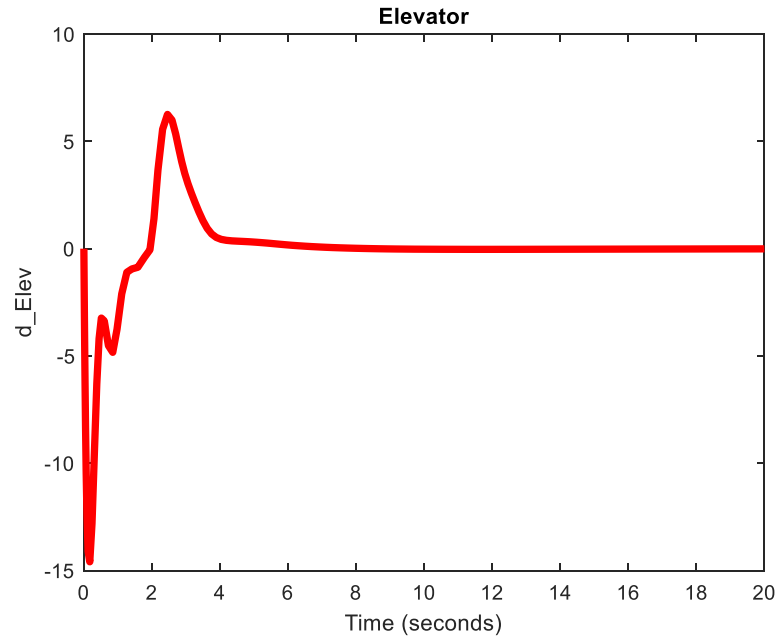# Simulink Results of 1000ft Command

Simulink Results of 1000ft Command

Simulink Results of 1000ft Command

Thank You