

Controller Design of the Draganflyer XP Quad Rotor UAV

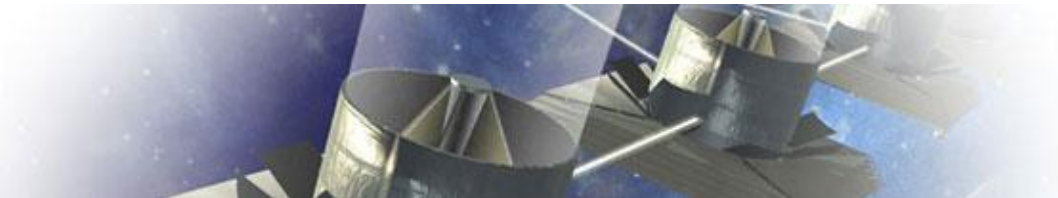
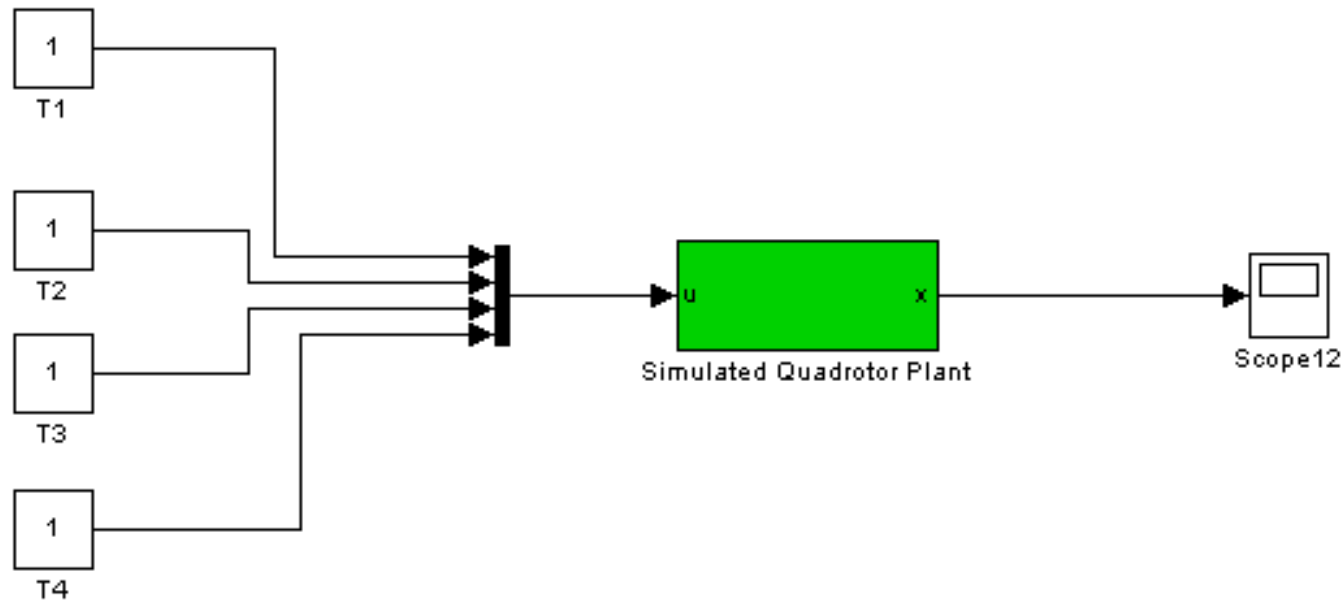
An AA/EE449 project in
collaboration with the UW DSSL

Andy Bradford
Andrew Nelson
Justin Palm

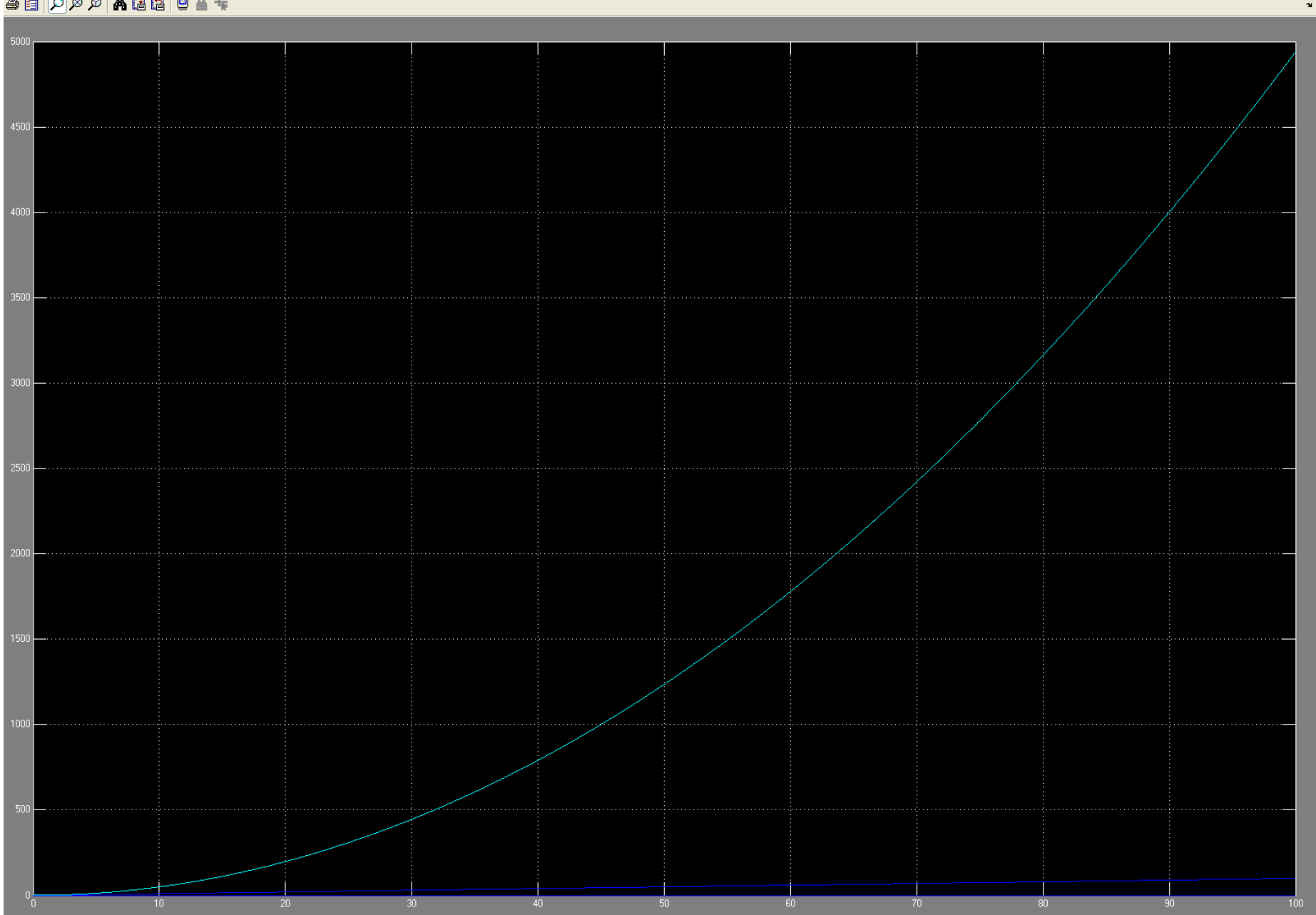


Distributed Space
Systems Lab

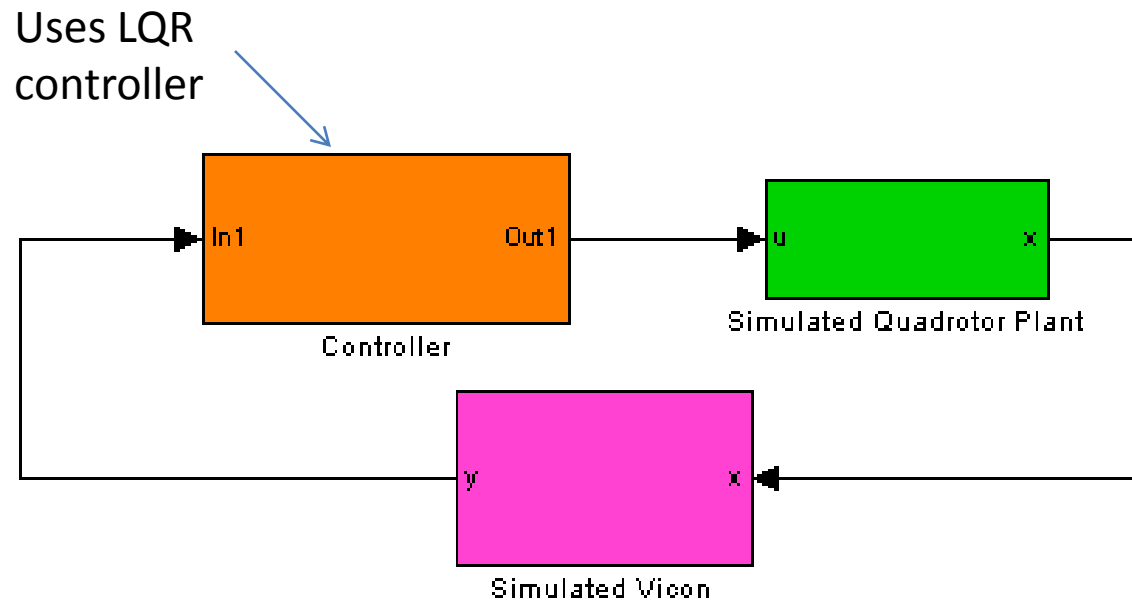
Open Loop Simulation

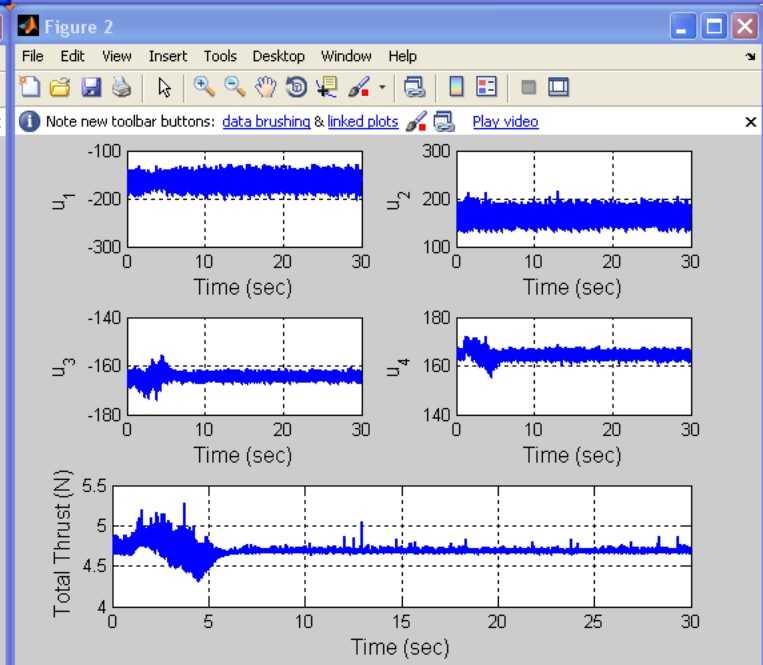
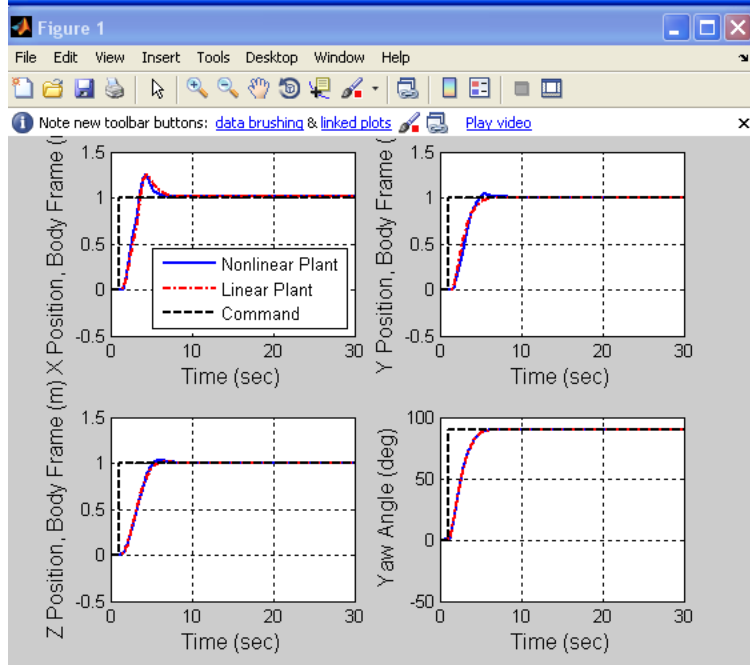
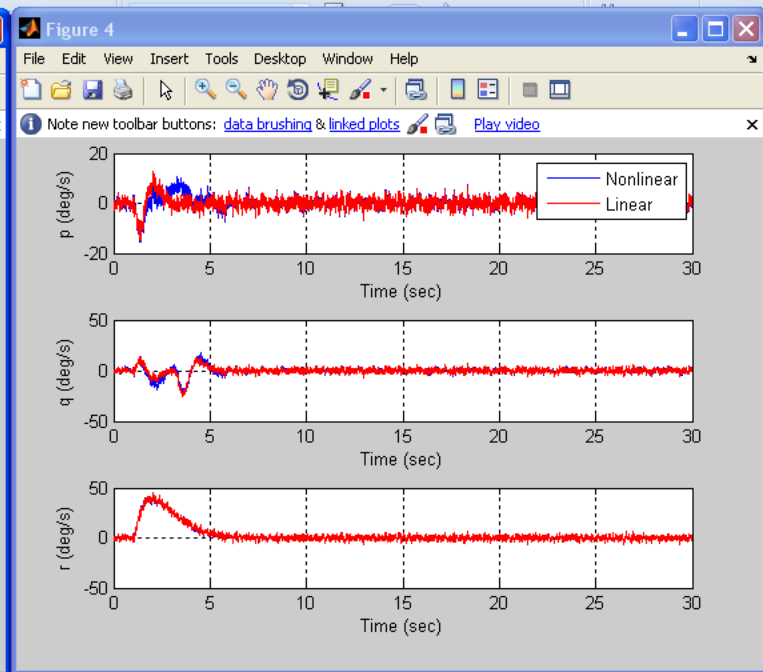
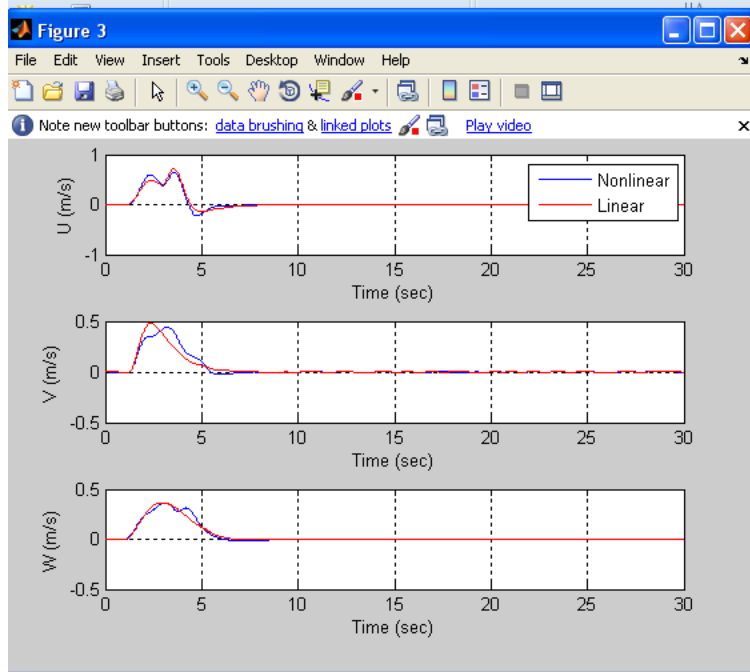


Distributed Space
Systems Lab

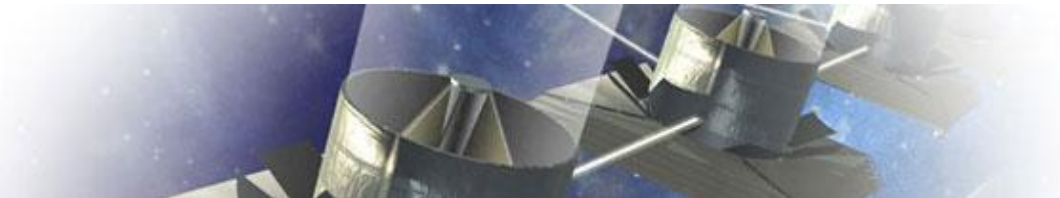


Closed Loop Simulation





But we don't understand LQR just yet,
so we're attempting PID control



Distributed Space
Systems Lab

State Space

A =

0	0	0	0	0	0	0	9.8100	0	0	0	0	0
0	0	0	0	0	0	-9.8100	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	1.0000	0	0	0	0	0	0	0	0	0
0	0	0	0	1.0000	0	0	0	0	0	0	0	0
0	0	0	0	0	1.0000	0	0	0	0	0	0	0
1.0000	0	0	0	0	0	0	0	0	0	0	0	0
0	1.0000	0	0	0	0	0	0	0	0	0	0	0
0	0	1.0000	0	0	0	0	0	0	0	0	0	0

B =

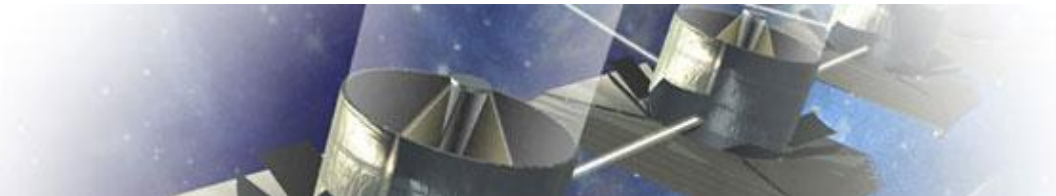
0	0	0	0
0	0	0	0
-0.0297	0.0297	-0.0297	0.0297
0	0.5066	0	-0.5066
0.4954	0	-0.4954	0
0.2470	0.2470	0.2470	0.2470
0	0	0	0
0	0	0	0
0	0	0	0
0	0	0	0
0	0	0	0
0	0	0	0
0	0	0	0

C =

0	0	0	0	0	0	1	0	0	0	0	0
0	0	0	0	0	0	0	1	0	0	0	0
0	0	0	0	0	0	0	0	1	0	0	0
0	0	0	0	0	0	0	0	0	1	0	0
0	0	0	0	0	0	0	0	0	0	1	0
0	0	0	0	0	0	0	0	0	0	0	1

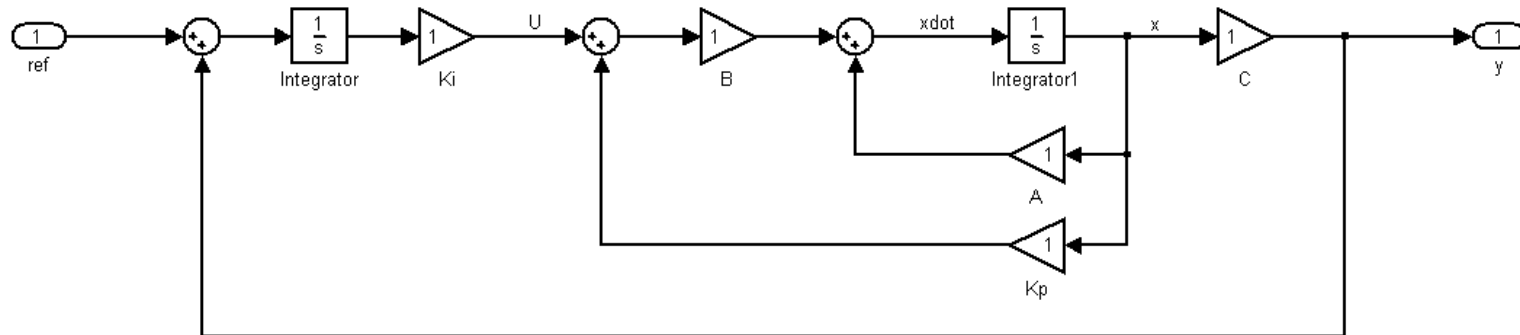
D =

0	0	0	0
0	0	0	0
0	0	0	0
0	0	0	0
0	0	0	0
0	0	0	0
0	0	0	0



Distributed Space
Systems Lab

The Luenberger Observer



However...

```
>> rank(ctrb(A,B))

ans =

    12

>> rank(ctrb(Alarge,Blarge))

ans =

    16
```

...and Heemstra's Augmented matrices...

```
>> R=rank(ctrb(Aaug,Baug))

R =

    16

>> rank(Aaug)

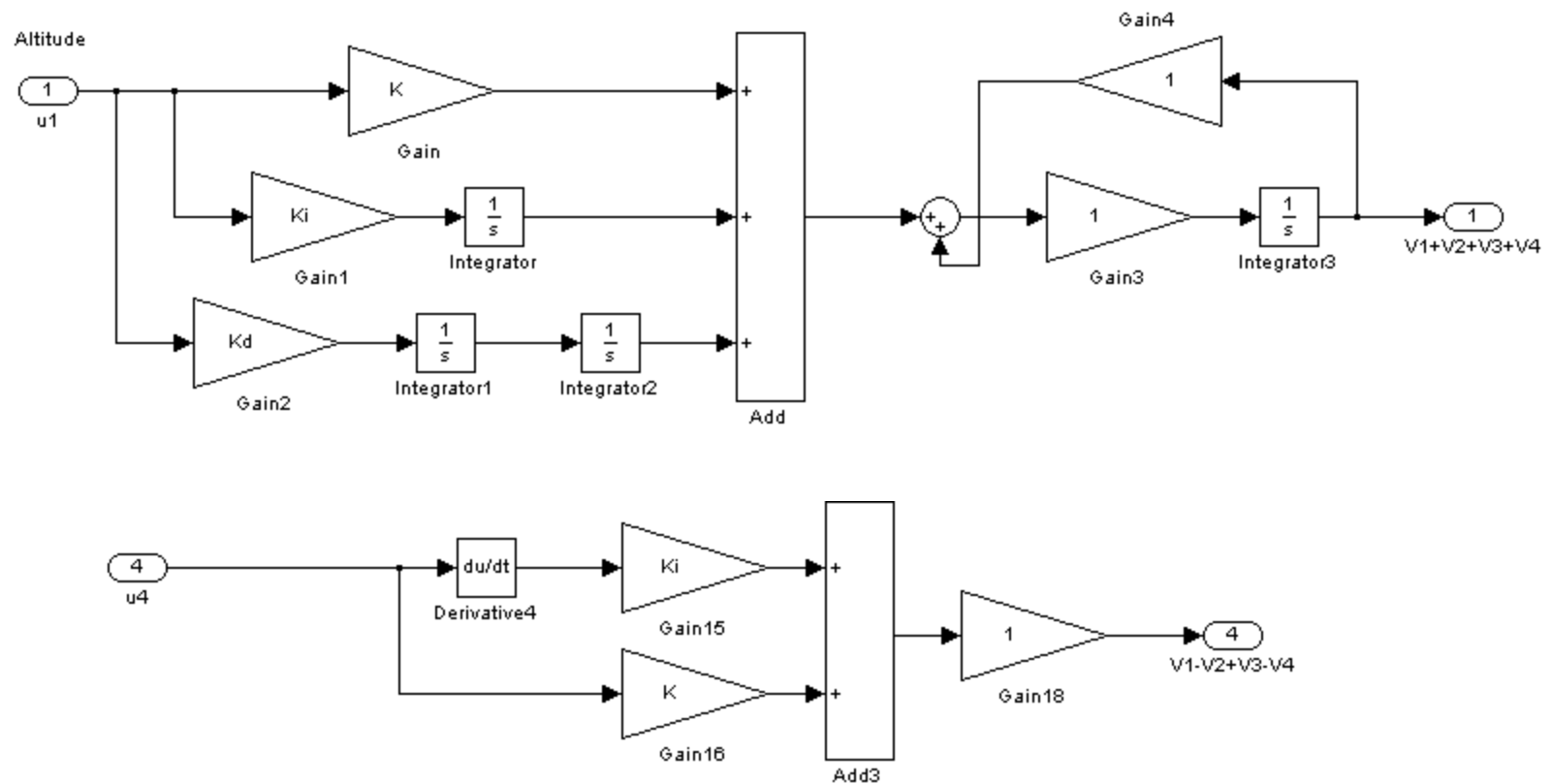
ans =

    20
```

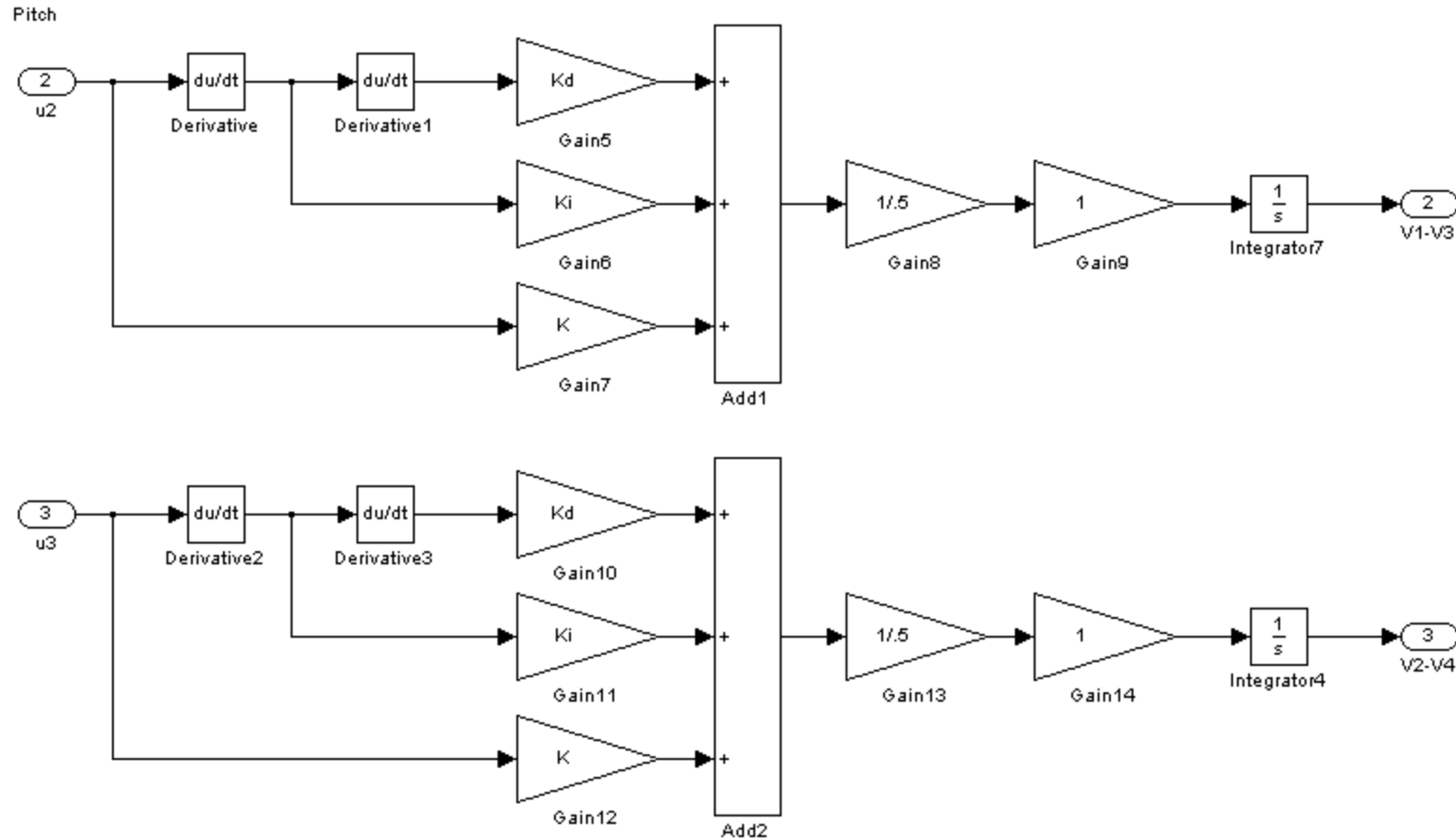


Distributed Space
Systems Lab

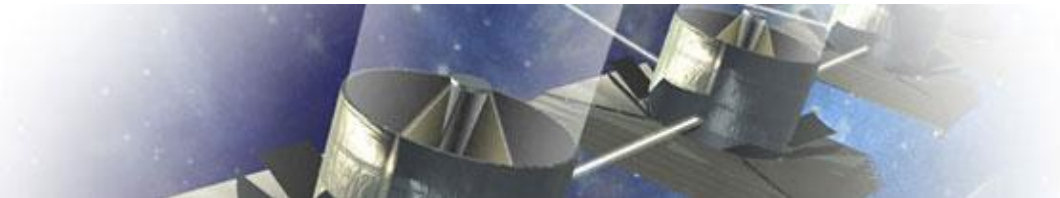
A Linear PID Control Approach



Linear System Continued



Where we go from here...



Distributed Space
Systems Lab

Bibliography

B. Heemstra. (2010) *Linear Quadratic Methods Applied to Quadrotor Control*. Unpublished Masters thesis. University of Washington.

C. Balas. (2007) *Modeling and Linear Control of a Quadrotor*. Unpublished Masters thesis. Cranfield University.

<https://dspace.lib.cranfield.ac.uk/bitstream/1826/2417/1/Modelling%20and%20Linear%20Control%20of%20a%20Quadrotor.pdf>

S. Bouabdallah, A. Noth, and R. Siegwart, "PID vs LQ control techniques applied to an indoor micro quadrotor", 2004 IEEE/RSJ International Conference on Intelligent Robots and Systems, 2004.(IROS 2004). Proceedings, vol. 3, pp. 1-6.

P. Castillo, A. Dzul, and R. Lozano, "Real-Time Stabilization and Tracking of a Four-Rotor Mini Rotorcraft", IEEE Transactions on Control Systems Technology, Vol 12, No 4, July, 2004.

McKerrow, P. (2004), "Modelling the Draganflyer four rotor helicopter", 2004 IEEE International Conference on Robotics and Automation, April 2004, New Orleans, pp. 3596.

Dorf, R. C. *Modern Control Systems*. 1995. 10th. isbn 0201845598 . Addison-Wesley Longman Publishing Co., Inc. Boston, MA, USA pp. 660-672