**Pre-defined project milestones –**

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| **Milestone** | **Deliverable** | **Due Date** |
| Software for data communication/debugging | Code, documentation & screenshots | 4/16/2021 |
| Bring-up plan (hardware & software) | Written test plan | 4/21/2021 |
| Build Mechanism and PCB | Photos of mechanism and PCB | 4/26/2021 |
| Test hardware | Results of your tests | 4/28/2021 |
| Motor and thrust modeling | Documentation on tests and results | 4/30/2021 |
| Dynamics tests (hanging down) | “ | 5/04/2021 |
| Apply state feedback, “hand placing” poles | Code, documentation & videos | 5/12/2021 |
| Place poles using LQR | Documentation & videos | 5/17/2021 |
| Full Order Observer | Code, documentation & videos | 5/21/2021 |
| Reduced Order Observer | “ | 5/21/2021 |
| Kalman Full Order Observer | “ | 5/26/2021 |
| Final Documentation | “ | 6/02/2021 |

**Plans for completing each milestone –**

Software for data communication/debugging:

* See Milestone One submission

Bring-up plan (hardware & software):

* This document
  + Think together on all parts of the project and the processes required to complete the milestones and write them down
  + More information may be added as we learn more about what we need to complete for a given milestone

Build mechanism and PCB:

* Assemble PCB, following the schematic part values
  + Use solder mask to apply solder
  + Place SMD components carefully, making sure they are in the correct spot
  + Solder THT components
  + Test connections, check for shorts
  + Test that the motor control output can be properly enabled and would turn on the motor
* Put together mechanism:
  + Get parts from drone (if not already disassembled), assemble motor arm with the shaft angle encoder (SAE) at the pivot and mount motor at the end of the arm
  + Connect the motor with the propeller, making sure it will spin the correct way to produce upward force

Test hardware:

* Use modified example code to read the SAE angle to see if it is aligned and measuring with appropriate precision.
* Apply proper power to the motor to ensure that it works and that the propeller spins in the right direction

Motor and thrust modelling:

* Write code to control the motor speed by changing the duty cycle
* Use motor thrust measurement device to determine the thrust produced when the motor has been on for a long time
* Get a characterization of the thrust as a function of the duty cycle of turning the motor on and off
* Measure/find/calculate the wind-up and spin-down time of the motor

Dynamics tests (hanging down):

* Test system input by swinging the motor arm slightly from the vertical downward position (with the motor off)
* Calculate (?) the friction force from the SAE
* Measure time to settle after impulse

Apply state feedback:

* After modelling the dynamics and motor characteristics, we can get the state model and then the transfer function (should be similar to that in the homework)
* Solve for the poles of the system and then find zeros that will make our system stable
  + Apply feedback to implement

Place poles using LQR:

* Use linear-quadratic regulator (LQR) to find the control parameters
* Implement these new parameters and/or functions into the system for control
* Test to see how it affects the functionality of the hovering

Full order observer:

* Implement a full order observer for the system (most likely in discrete time)
* Test how the system functions after implementation

Reduced order observer:

* Implement a reduced order observer
* Test how the system responds

Kalman full order observer:

* Implement Kalman full order observer
* Test system response

Final documentation:

* Assemble all test results into project archive
* Report on the ability to control the system based on the control methods used in the different milestones
* Summarize lessons learned and valuable take-aways