Barone2 Report (3/1/21 - 3/7/21)

Sprint 4,

Prepared by [Isaac Szu](mailto:iszu@ucsc.edu)

**Executive Summary of Progress:**

For this week’s sprint we wanted to distinguish and clarify our last milestones before we ended the quarter, and to see where we were and how much we have completed of those milestones. We realized that although our tasks throughout a sprint week were visible and tangible, our milestones were unclear or unachievable due to the fact that we were inexperienced when we created them. Therefore, revisions were made to rectify those milestones, and as a team, we now plan to reach those milestones with a greater velocity than previous sprints, with a clearer vision of what needs to be done and when.

After the previous design review, we were able to see in greater detail how much experience each member on our team had and how much work we need to divert to compensate for our technical difficulties. Because we are working in a larger team of six, we created sub-groups with separate meeting times to resolve and optimize all design changes and to answer design specific questions that would only address half of our group during team meetings. Although less slides were made due to less milestones being met and time being spent further on improving our previous slides, we have seen more progress being made throughout this sprint overall, likely due to better communication and clearer, approaching deadlines.

Progress in the CAD model is moving closer to fabrication, with motors and servos finalized and sensors we chose in place on the CAD with the group’s discretion. Most forces in the simulation are completed and working, except for the drag force due to remote control implementation precedence. State space form has been further implemented in Matlab and remote control tested in a rough Python simulation. The Raspberry Pi Compute Module has been chosen, but the libraries for sensor data input are still in the process of creation due to supply line delays. The PCB has been further updated by swapping the microcontroller to a more familiar design that fulfills more technical requirements. A more complete system wiring diagram is waiting on the balloon pressure sensor, but would otherwise indicate completion. Finally, the power budget has been reformatted and power requirements found for the motor and ESC.

**Progress made toward acceptance criteria:**

| Task Deliverable/  Acceptance Criteria | Status | Responsible Party | Anticipated Hours | Details |
| --- | --- | --- | --- | --- |

**CAD Design:**

| Finalize Motor & Servos  Chooses Motor and Servo based on analysis of parts. | Complete | Dylan | 2 | SK3 2822-1275kv, was chosen based on initial Matlab estimates, after choosing a data sheet was checked and it was determined that the motor would provide more than enough thrust with our propeller.  RedCon 360 Degree Digital Metal Gear HV Servo - DM 123 was chosen based off a torque analysis, showing that the torque applied by the servos load would be smaller the the servos stall torque |
| --- | --- | --- | --- | --- |
| Update Gondola to hold sensors, in Solidworks | Complete | Dylan | 3 | Updated gondola size in order to hold selected batteries, and downward facing ultrasonic. |
| All sensors placed into CAD in correct locations | Complete | Dylan | 3 | Added PCB with many of the sensor chips on them, as well as ultrasonic,and GPS transmitter. Placeholder camera was added until camera is finalized  Created ultrasonic holder for front of drone. |
| New motors and servos CAD models updated in Solidworks to reflect the finalized decisions | Complete | Dylan | 2 | New motor CAD was imported to match the diameter of the motor that was selected, sevo chosen happened to be the same size as previous servo model |
| Create 3D printing material pugh chart and decide on attachment methods for servo brackets and gondola | Complete | Dylan | 4 | Pugh chart was created looking at 3 different 3D printing materials and comparing their tensile strength, weight and price.  screws, washers, nuts, and standoffs were chosen. The washer chosen was a cushioning washer in order to reduce vibrations, and spread force. |
| Add screw holes and other fabrication related details to CAD | Complete | Dylan | 3 | CAD models for screws, nuts, standoffs, and washers were downloaded and added based on decision.Screw holes were added to all parts that needed them. |
| Create envelope Material Pugh chart (Call UHMWPE supplier for info) | Incomplete  (80% complete) | Dylan | 4 | A pugh chart was created, and suppliers were contacted, but many material strengths could not be found so estimates were used in the pugh chart, which compared weight, tensile strength, and price. |
| Contact Helium suppliers | Complete | Dylan | 2 | Helium suppliers were looked into. (campus and AGP) where contacted but a supplier is yet to be selected. |

**Drone Simulation:**

| Import new CAD design | Complete | Isaac | 3 | The CAD model was imported as a URDF file and its individual parts were fitted together. The design is ready to have force code implemented in it. |
| --- | --- | --- | --- | --- |
| Implement buoyancy control | Complete | Isaac | 3 | Actuation forces were applied continuously by adding those forces into a seperate function. |
| Implement drag forces in simulation | Incomplete  (0% completed) | Isaac | 7 | Remote Control needed before drag implementation can be completed. Current simulation work will be focussed on remote control design. |
| Implement Thrust forces in simulation | Complete | Isaac | 10 | Propeller forces move along a radial direction following the servo movement of the shaft. This is accomplished by providing a parent frame to the propeller forces, so the z-direction always points in the same direction as the propellers do. |

**Controls Design:**

| Remote Control Testing in rough Simulation to confirm responses to driver inputs | Complete | George | 6 | Modified the ECE 163 (Intro to Small Scale UAV’s) code to test RC equations written for design reviews 1 and 2. Identified moments acted on drone as well as physical movement to ensure the drone was controllable and stable |
| --- | --- | --- | --- | --- |
| State Space form of the Plant in linearized form | Complete | George | 20 | Expanded the force equations for all the states of the drone, north east down pitch yaw and roll, and applied a small angle approximation to simplify the rotation matrix. From there, partial derivatives were taken of all forces in order to linearize force contributions from each input. The matrices were not generated since the equations are very big and we don’t know all the constants yet, so it’s just impractical and unhelpful, although all contributions to outputs are isolated so it can be done quickly in the future. Currently just in normal equation form. |

**Sensors:**

| Write own libraries for reading data from sensors with interrupts | Incomplete  (20% complete) | Leon | 15 | Implemented interrupt procedure only for the ultrasonic sensor, not yet tested. |
| --- | --- | --- | --- | --- |
| Make one file for calling all sensors at same time using written libraries and verify that data is accurate | Incomplete  (0% complete) | Leon | 5 | Not able to start yet because previous task of writing libraries to read data from each sensor was incomplete |
| Decide on exact Raspberry Pi Compute Module model and find connections for PCB | Complete | Leon | 2 | Decided on Raspberry Pi Compute Module CM3+ |
| Assist with interrupt driven Sensor Libraries | Complete | Ryan and Jeremy | 5 | Provided ultrasonic and servo/motor interface code from ECE 121, and set up uC32 |
| Setup GitHub | Complete | Ryan, Jeremy, Leon | 1 | Upload files to github and verify the repository can be cloned to PC |

**PCB Design:**

| Wire up the power bank to PCB, and find power bank port model | Complete | Ryan | 1 | Eagle CAD header pin of power bank library included in schematic and connected to voltage rails. |
| --- | --- | --- | --- | --- |
| Assign ports for 4 servo PWM output capture ports from the microcontroller | Complete | Ryan | 1 | Have 4 pinouts connected to 4 PWM pins on the microcontroller |
| Assign ports for 4 ESC PWM output capture ports from the microcontroller | Complete | Ryan | 1 | Have 4 pinouts connected to 4 PWM pins on the microcontroller |
| Wire up SPI from microcontroller to Raspberry Pi Compute Module | Complete | Ryan | 1 | Show schematic of CS, MISO, MOSI, and SCK pins connected between the microcontroller and microprocessor |
| Write up documentations for all sensors to the microcontroller | Incomplete (0% complete) | Ryan | 3 | Schematic of pins are connected in PCB design but documentation in the notebook is not done. |
| Write up documentation for Raspberry Pi Compute Module and pin configuration to the microcontroller | Complete | Ryan | 3 | Write up documentation for Raspberry Pi Compute Module and pin configuration to microcontroller  Show drawn schematic of SPI protocol between microcontroller and microprocessor |
| Finalize decision on camera live stream solution | Complete | Ryan and Leon | 3 | Have the transmitter, receiver, and camera parts added to BOM |

**Power Management:**

| Get motor/ESC power requirements once motors are decided | Complete  /Needs Testing | Jeremy | 3 | Motor Power has been Sufficiently Estimated, ESCs will be driven with the motor power and will distribute accordingly |
| --- | --- | --- | --- | --- |
| Re-work power rails according to regulated current | Complete | Jeremy | 4 | Rails have been decided with maximum current and with an appropriate regulator |
| Reorganizing Power budget with 1 hr cycle power requirements | Compete | Jeremy | 2 | Power budget has been fixed with everything operating on a 1 hr flight time cycle |
| Find current estimated to be used in I/O pins(I2C, SPI) | Complete | Jeremy | 5 | I/O pin requirements have been identified when they are used for I2C or SPI |

**Calculate sprint velocities:**

| Velocities | Estimated Hours | Total Hours | Velocity  (Total Hours/ Est. Hours) | Description (Reasoning for velocities < 1 |
| --- | --- | --- | --- | --- |
| Dylan | 23 | 19 | 0.83 | Envelope material pugh chart needs better data due to issues finding accurate strength information from suppliers  Once better data is found will be complete. |
| George | 26 | 26 | 1 |  |
| Isaac | 23 | 16 | 0.70 | Remote Control needed prior to adding drag forces. Time estimated to be spent for adding drag forces were put into implementing a remote control interface and fixing operation controls. |
| Jeremy | 19 | 19 | 1 |  |
| Ryan | 19 | 16 | 0.84 | Documentation of sensors is absent |
| Leon | 22 | 7 | 0.31 | Switched to uC32 microcontroller halfway through the sprint, so had to wait for uC32 from school to come before being able to work with the microcontroller, and then spent a long time figuring out how to print anything out before being able to do anything with sensors. |
| Team | 132 | 103 | .78 | Since we redefined our milestones, there was a lot of catching up to be done, especially in the sensor’s department of our project. |

**Product Owner, Teaching Team, Client Feedback:**

| Functionality Demonstrated | Feedback | Team Response |
| --- | --- | --- |
| RC Testing in Simulation | N/A Not shown in office hours/progress review yet | It is controllable and responds predictably. Needs to be tested in more detailed environment for confirmation, VREP |
| Accurate Power Budget with System Requirements | Cycle time should have been updated on the older version, with a 1 hour cycle based on the flight time of the drone and operation of each component during the cycle | Each component of the drone has been specifically identified in the power that it will require for the 1 hour cycle, based off the power needed for their specific functions on their datasheets |
| Basic simulation forces are implemented in V-rep. | N/A Not shown in office hours/progress review yet | Forces can be seen to be applied along the direction of the propellers. Remote control is still needed to be implemented to further functionality demonstration. |

**Possible Sprint Improvements:**

* **Team Improvements** 
  + Overall improved in general as a team
  + One improvement is estimating hours better
    - Another thing is pacing throughout the week so tasks get done consistently
  + Sub-team meetings work well with communication
* **Individual Improvement** 
  + Dylan
    - Envelope material put off, issues with getting material strength from suppliers
    - Look into process of each tasks to delegate time better during sprint
  + George
    - Start developing work to be more pleasing to the eye, make more graphs
  + Isaac
    - Have to start working on practical things instead of modeling the drone
  + Jeremy
    - Get a better understanding of how much time each task will take
      * Work more consistently to accomplish tasks with evenly spaced out time intervals
  + Ryan
    - Verify tasks better, such as making sure connections are correct
    - Versioning & documentation also needs improvement with his work
  + Leon
    - Make better use of time for tasks
      * Lots of time wasted on debugging without getting anywhere

**End of Quarter Goals:**

* Prep for design review, add slides
* Finish Final report outline
* Dylan
  + Finalize all parts and retailers. Includes deciding on materials based on pugh charts and other analysis. Ensuring weight requirements are met for system weight requirements. Finding suppliers, for all parts and ensuring feasible price and shipping times. 3/14/21
* Leon
  + Implement event-driven programming with sensors using interrupts by 3/19/21
  + Have all sensors working at the same time and showcase trial run around the neighborhood by 3/19/21
* George
  + Path Following and Terrain Tracking in Matlab Simulation. Include calculations for power usage to confirm power budget values. Use the linear MIMO state space discrete time-Zero Order Hold model for control, but use a nonlinear model for physical responses to commands to check for stability and controllability. Only the ideal sensor model is tested, but disk margin should be tested as well in preparation on stochastic sensor error testing over break. 3/19/21
* Ryan
  + Make final changes to schematic by 3/12/21
  + Complete board design by 3/19/21 (verify with Professor Petersen)
  + Include all electronic parts lists into BOM by 3/15/21
* Isaac
  + Finish remote control (joy-stick implementation) 3/12/21
  + Finish implementing drag forces 3/19/21
* Jeremy
  + Finalize Power Budget by completing uncertainties, such as the transmitter power and the servos by 3/12/21
  + Start working on how to simulate wiring diagrams using a power source in Eagle CAD spice simulation by 3/19/21

**Meeting Minutes for Sprint 4 Week:**

Sprint 4 Start

Long Flight Time Buoyant Drone March 1, 2021 7:30(PST)

horizontal lineATTENDEES

* Excused absences: N/A
* Unexcused absences: N/A
* Late: N/A

## AGENDA

* Administrative Stuff 7:30pm
  + Define Milestones (General, see where we need dependencies etc)
  + Dylan:
    - Fabricatable CAD design
  + Isaac:
    - Working Simulation (thrust, drag, buoyancy, throttle)
  + Leon:
    - All sensors sending data to Arduino at the same time with interrupts implemented
  + George:
    - Remote Control Implemented in 163 Simulation
    - State-Space Math Fully Defined
  + Ryan:
    - Entire system wiring complete
  + Jeremy:
    - Cycle-Based Power Budget Completed with decided power source
* Define End Date: 8:12pm
  + Sprint end: 3/7/21
* Tasks (Specific) List Requirement ID if available. Time estimate.
  + Leon (22 hours)
    - Write own libraries for reading data from sensors with interrupts (15 hours)
    - Make one file for calling all sensors at same time using written libraries and verify that data is accurate (5 hours)
    - Decide on exact Raspberry Pi Compute Module model and find connections for Ryan (2 hours)
  + Jeremy: (19 hours)
    - Get motor/ESC power requirements once motors are decided(3 hours)
    - Re-work power rails according to regulated current(4 hours)
    - Reorganizing Power budget with 1 hr cycle power requirements(2 hours)
    - Find current estimated to be used in I/O pins(I2C, SPI)(5 hours)
    - Assist with interrupt driven Sensor Libraries(5 hours)
  + Isaac (23 hours)
    - Import new CAD design (3 hours)
    - Implement buoyancy control (3)
    - Implement drag (7)
    - Implement thrust (10)
  + Dylan (23 hours)
    - **Finalize Motor & Servos (2 hours)**
    - Updated Gondola to hold sensors in correct locations (3 hours)
    - Add sensors to CAD (3 hours)
    - Add new motors and servos to cad (2 hours)
    - Create 3D printing material pugh chart and decide on attachment methods for servo brackets and gondola (4)
    - Added screw holes and other fabrication related details to CAD(3)
    - Create envelope Material Pugh chart(4)
      * Call UHMWPE supplier for info
    - Contact Helium suppliers (2)
  + George (26 hours)
    - RC implementation (6 hours)
    - State Space math(20)
  + Ryan (19 hours)
    - Wire up the power bank to PCB, and find power bank port model (1 hour)
    - Assign ports for 4 servo PWM output capture ports from ATMega2560 (1 hour)
    - Assign ports for 4 ESC PWM output capture ports from ATMega2560 (1 hour)
    - Wire up SPI from ATMega2560 to Raspberry Pi Compute Module (1 hour)
    - Write up documentations for all sensors to ATMega2560 (3 hours)
    - Write up documentation for Raspberry Pi Compute Module and pin configuration to ATMega2560 (3 hours)
    - Finalize decision on all-in-one camera live stream solution with Leon (3 hours)
    - Setup Git Hub with Jeremy and Leon (1 hour)
    - Assist with interrupt driven Sensor Libraries (5 hours)

Meeting End: 8:41

# Stand-up Meetings During Sprint

**3/2/21 7:30 - 8:30p**

* Leon: working with getting the arduino connected with MPlabX
* Jeremy: Working on getting the power required from motors
  + May need help from the force analysis of the motors
* Isaac: Buoyancy no longer instantaneous in simulation
  + Adding joints to attach propeller forces to
* Dylan: Decided on motors, replaced in BoM
  + Working on finding the correct ESC that can control the motors, new one added to the BoM
    - Make sure ESC is able to communicate with the Arduino
  + Moment of inertia of motor and shaft helped decide servo, not finalized yet
* George: Debugging simulation, fixed buoyant moments on drone
* Ryan: Working on wiring diagrams
* Sub-team meetings having good effect
* Edited Gantt Chart

**3/3/21 7:30 - 8:30p**

* Leon: Microcontroller switched to Uc32 from ECE121, should get it from school
  + Github created for the whole group
* Jeremy: Battery selection limited from 7.4V or 11.1V batteries
  + Will need to add more weight for batteries to power motors
* Isaac: Propeller force still being investigated in simulation
  + Milestone: remote control done before drag force is preferred
  + Applying all forces milestone will have to be pushed back
* Dylan: Added sensors and PCB to CAD Design
  + Updated motors and motor mount in the gondola
  + Weatherproofing measures added to CAD design
  + Issues with moment of inertia calculations in CAD for servo finalization
* Ryan: Added another ultrasonic sensor, 7.4V will be changed in the PCB
  + New ultrasonic sensor placement, 3 in the front, 1 below

**3/4/21 7:30 - 8:30p**

* Leon: Working with getting a new Pickit with Uc32 board
  + Receiver, Transmitter, and camera all in one decided
* Jeremy: 2 batteries instead of 1 has been decided
  + One 11.1V battery for motors
  + Another 5V battery for peripherals
* Dylan: Servos have been decided, will be run off of 5V battery
  + Also looking for new helium supply
* Isaac: Working with new CAD design bugs
* George: Linearizing equations from the force analysis for use in servo calculations
* Ryan: ESCs still unknown as to how to control them, PWM is most likely the solution

7:45

* PCB will need standoffs from aluminum sheet
  + Shouldn’t affect any heat issues with the battery
* Gondola will be expanded to account for the battery

7:51

* Started the final report outline

**3/5/21 4:30 - 7:00p**

* Alexey Meeting 4:30
  + Make sure milestones are shown what percentage each is on
  + Show updated Gantt Chart
  + Keep better meeting notes
    - Keep timestamps for each comment/argument made
  + Base the chapters of the final report on the system technical requirements

4:50

* ESCs controlled by microcontroller
  + ESC controls are unknown with what pins do what

5:10

* Gondola will probably not need standoffs
  + Although will improve safety in edge cases

5:27

* ECE121 code can help program microcontroller
  + Code tweaked to new motors/servos and other sensors

5:41

* We should message Mircea again to see if we can use Helium from Delaware labs
  + Helium would be very expensive to buy online

6:01

* Funding may be available from residential colleges for design expenses

6:10

* Alexey meeting over, now on sprint progress meeting

6:15

* + Leon: Code from ECE121 can help immensely

6:19

* + Jeremy: Will have to update power budget and weight allocation for new parts and batteries

6:22

* + Isaac: Working on applying all forces in the simulations

6:26

* + Dylan: Will have to estimate material strength because supplier doesn’t have specifications for them

6:29

* + George: Can now State space plan fully defined with Yaw measurements

6:34

* + Ryan: Ultrasonic input captures connected, GPS also connected through UART
    - Chose standoffs and screws in PCB

**3/6/21 7:30 - 7:45p**

* Sprint End meeting 7:30
  + Leon: Working with Ryan’s code into the Uc32 microcontroller

7:32

* + Jeremy: Decided provisional battery selection
    - Also looked at servo and motor power
      * Motor power decided, servo is unknown with no datasheet

7:35

* + Isaac: Worked on Sprint report format
    - Also got forces applied into simulation

7:37

* + Dylan: Added standoffs into gondola
    - Gondola size increased to 7x7 inches, small cost increase
    - In process of making servo connector

7:39

* George: Using Matlab to help with matrix equations for forces

7:41

* Ryan: GPS module, ultrasonics, I2C, SPI all connected
  + Still need interrupt pins for sensors and connecting the 5V battery

Sprint 4 Conclusion Meeting

Long Flight Time Buoyant Drone 3/7/2021 7:30 - TIME(PST)

horizontal lineATTENDEES

* Excused absences: N/A
* Unexcused absences: N/A

## AGENDA

* **Review of progress:** 7:30
  + Dylan - 7:36
    - Ultrasonics and camera implemented in CAD and in weight allocation
    - Screws, Nuts, and Washers picked for attachments
    - Pugh chart made for 3D printing
  + George - 7:40
    - Controls working in updated version of 163 simulation
  + Isaac - 7:35
    - Propeller forces complete in simulation
    - Buoyancy forces completed in simulation
    - Servo movement adjusted and fixed
  + Jeremy - 7:33
    - New Microcontroller added to power budget
    - Power rails updated with new voltage regulators
    - Only missing from budget is transmitter, servo, and ESCs
  + Ryan - 7:54
    - Finished wiring schematic 1.9
  + Leon - 7:30
    - Got output from UART on Uc32
    - Ultrasonic code gotten with help from Ryan
* **Team Improvements** - 8:01
  + Overall improved in general as a team
  + One improvement is estimating hours better
    - Another thing is pacing throughout the week so tasks get done consistently
  + Sub-team meetings work well with communication
* **Individual Improvement** - 8:04
  + Dylan
    - Envelope material put off, issues with getting material strength from suppliers
    - Look into process of each tasks to delegate time better during sprint
  + George 8:05
    - Start developing work to be more pleasing to the eye, make more graphs
  + Isaac 8:06
    - Have to start working on practical things instead of modeling the drone
  + Jeremy 8:07
    - Get a better understanding of how much time each task will take
      * Work more consistently to accomplish tasks with evenly spaced out time intervals
  + Ryan 8:08
    - Verify tasks better, such as making sure connections are correct
    - Versioning & documentation also needs improvement with his work
  + Leon 8:09
    - Make better use of time for tasks
      * Lots of time wasted on debugging without getting anywhere
* **Next Goals**- 8:10
  + Dylan 8:15
    - Finalize all parts and retailers. Includes deciding on materials based on pugh charts and other analysis. Ensuring weight requirements are met for system weight requirements. Finding suppliers, for all parts and ensuring feasible price and shipping times. 3/14/21
  + Leon 8:24
    - Implement event-driven programming with sensors using interrupts by 3/19/21
    - Have all sensors working at the same time and showcase trial run around the neighborhood by 3/19/21
  + George 8:30
    - Path Following and Terrain Tracking in Matlab Simulation. Include calculations for power usage to confirm power budget values. Use the linear MIMO state space discrete time-Zero Order Hold model for control, but use a nonlinear model for physical responses to commands to check for stability and controllability. Only the ideal sensor model is tested, but disk margin should be tested as well in preparation on stochastic sensor error testing over break. 3/19/21
  + Ryan 8:39
    - Make final changes to schematic by 3/12/21
    - Complete board design by 3/19/21 (verify with Professor Petersen)
    - Include all electronic parts lists into BOM by 3/15/21
  + Isaac 8:42
    - Finish remote control (joy-stick implementation) 3/12/21
    - Finish implementing drag forces 3/19/21
  + Jeremy 8:46
    - Finalize Power Budget by completing uncertainties, such as the transmitter power and the servos by 3/12/21
      * Start working on how to simulate wiring diagrams using a power source in Eagle CAD spice simulation by 3/19/21
* **Other Business**- 8:51
  + Completed sprint 4 report

Meeting End: 9:34