09/20/2020

Group members

- Zack (project leader)
- Theo
- Kai
- Elijah
- … others???

CAD

- We will probably use Autodesk 360
    - Collaborative
    - Integrates with Autodesk Eagle
- Okay if you don't have CAD experience; we will teach you

About the ornithopter

- Wingspan will be in the 1' to 2' range
- Steering will be done using a tail wing

Ornithopter kits

- We will send out ornithopter kits some time this month
- See ornithopter kits document for kit options
    - Open for ideas for personalized kits because the group is relatively small
- We could also start with designing a more custom kit to send

Design questions to answer as a group

- Gearbox vs servos
    - Gearbox
        - More mechanically inclined project
        - More power
    - Servos
        - More programming inclined project
        - More control/maneuverability

09/26/2020

See the slides titled "Design Considerations"

New group members

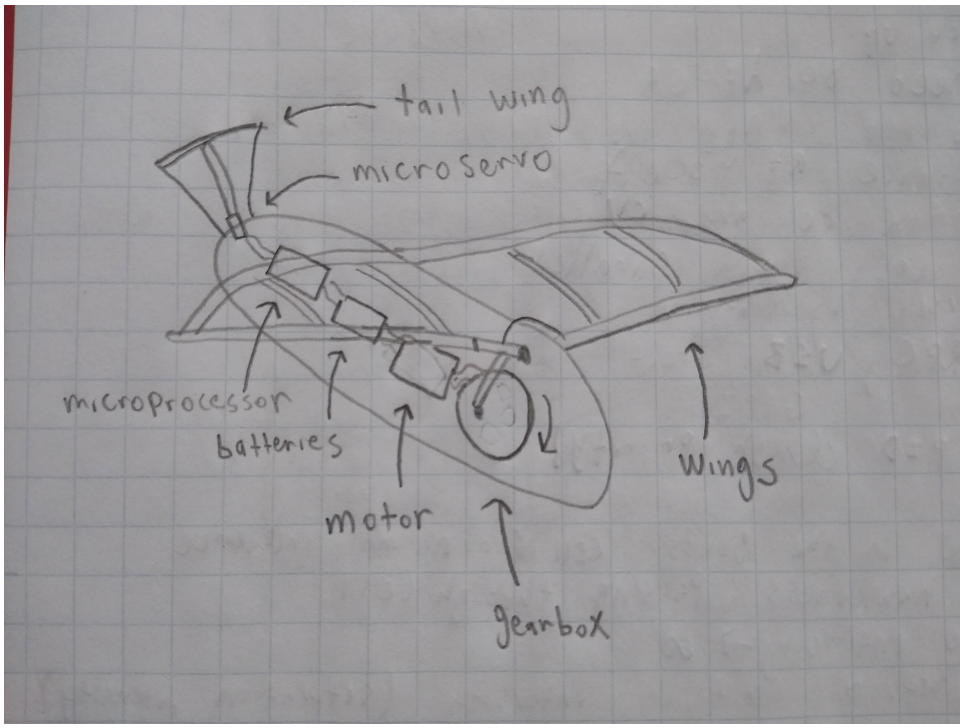
- Olivia

How do ornithopters fly?

- Downstroke

    - Wings twist to maintain angle of attack for providing thrust
- Upstroke
    - Outer wing lies parallel to direction of motion to minimize resistance
    - Inner wing still generates lift

Rudimentary sketch



Electrical components

- Microcontroller (Arduino nano)
- LiPo battery
- Servo
- Brushless motor
- Electronic speed control (ESC)

Mechanical components

- Wing spar (carbon fiber)
- Wings (ripstop or nylon)
- Gear box (transverse gear shaft)
- Frame (carbon fiber)

Kits

- Olivia wants the electronics kit

Tasks

- Olivia will look into necessary software
- Theo will mock up a gear design

Meetings
- We probably need to find a better meeting time
- Weekday schedules are more consistent than weekend schedules

General plans
- Each person will build their own basic ornithopter from kits
- Then we will each work on parts of the preliminary design
- Over winter break, we will consolidate the parts into a full ornithopter

10/04/2020

New group members
- Elsa Durcan
- Bill

Installing Autodesk Fusion 360
1. Go to this link.
2. Click 'Get Started.'
3. Follow the steps to create an Autodesk account.
4. Install Autodesk Fusion 360 and log in with your account information.
5. Let me know your email so that I can invite you to join the ornithopter project.

Design considerations
- We have decided on the servo method ornithopter

Budget
- We have a lot of money
- ~$3000
- We shall spare no expense!

Materials to send out
- Arduino kit
- Micro servos
- Materials to build the Freebird ornithopter (see resources page)
- Should be able to get materials to everyone in ~2 weeks

Tasks
- Servo software
    - Create the Arduino software that will control the wing servos
- Electronics

    - Use Autodesk Eagle to design a custom PCB
    - Arduino nano
    - Gyroscope
    - Servos
- Frame
    - Create a lightweight ornithopter frame
    - Initial prototypes will be 3D printed, but later carbon fiber
    - Servos and electronics should mount to frame
- Wing design
    - Material
    - Wing shape
    - Where to place wing spars
- Simulation
    - Aerodynamics simulations
    - Analytical models
- Testing
    - Design a testing rig for future prototypes
    - Ornithopter attaches to lever arm for testing thrust
    - Force sensor for testing lift

Sorry that I sounded like I was dying today!

10/11/2020

New group members

- Erick

Github

- We have a project github (https://github.com/zandalman/YUAA_ornithopter)
- Commit often and with meaningful messages
- Let me know if you don't know how to use github and I can teach you

Freebird ornithopter

- Watch video in resources tab
- Parts will hopefully arrive in 1-2 weeks

Parts

- We will probably use
    - Servo (https://www.servocity.com/hsb-9370th-servo/)
    - RC controller (https://www.racedayquads.com/products/flysky-fs-i6-6ch-2-4ghz-rc-transmitter-w-ia6-rx?variant=31607739383921&gclid=Cj0KCQjw2or8BRCNARIsAC_ppyZlZvy

VjFQtWn2D6Cq5RWLeTxrtjhKH7ACsuyGcYTnIrtvQOSKdmMEaAvhNEALw_wcB)
    - Accelerometer/gyroscope (https://www.adafruit.com/product/4692)

Simulation
- Still need to decide simulation software
- Matlab/simulink (https://www.mathworks.com/help/aeroblks/aerodynamics.html)
- Autodesk CFD (https://www.autodesk.com/products/cfd/overview?_ga=2.186200874.2037225500.1602442768-2115175104.1601829206)
- SimScale (https://www.autodesk.com/products/fusion-360/blog/simscale-launches-engineering-simulation-integration-autodesk-fusion-360/)

One-on-one meetings
- If you have any questions or don't know how to do something, we can arrange a 1-on-1 meeting
- Or if its something quick you can just messages me

Task channels
- Each task has its own channel in the Discord
- Use task channel to collaborate on tasks

Starter task assignments
- Olivia - software
- Bill - electronics
- Erick - wings
- Elsa - frame
- Kai - simulation

10/18/2020

Grant applications
- See in Google Drive
- Examples in case you are interested in becoming a YUAA project leader at some point

Electronics
- 5 V LiPo battery will last longer than a 9 V LiPo battery and will not require a regulator

Simulation
- AmSys and SimScale both provide educational licenses
- SimScale is hosted online and is more lightweight
- SimScale may be better for our purposes

- STP files are a universal 3D model file format that will probably work between different softwares

Parts
- We can finally order parts for the ornithopter
- Will send rubber band powered ornithopter parts to everyone
- Will send Arduino kit to everyone
- Will Bill teensy and gyroscope
- Will send Olivia servo arm, gyroscope, and RC controller
- Will send Erick carbon fiber wing spars

10/25/2020

General
- Reach out to me to set up a one-on-one meeting about advice for your specific task

Grants
- CT Space Grant submitted!

YUAA Talk
- Upcoming YUAA talk at 6 pm EST, Friday November 6th by NASA engineer Brandon Lloyd

Arduino Kits
- Arduino kits have arrived
- Distributing Arduino kits at 4 pm today at Cross Campus
- Unboxing video
- Kit includes Arduino, multimeter, USB cable, breadboard, battery, resistors, micro servo, and more
- Remember to always measure voltage in parallel and current in series with the multimeter
- Recommend trying LED tutorial to get used to Arduino https://www.arduino.cc/en/Tutorial/BuiltInExamples/Blink

Electronics
- Either attach RC receiver directly to the PCB or attach it with an IDC cable
- Gyroscope must use SDA and SCL ports on Arduino, only ports which support I2C protocol
- Will order RC system and gyroscope soon

Simulation
- Generative design is built into Fusion and will be useful for modelling wings
- Look into various wing shapes and wing spar layouts

- Possible meeting with Larry Wilen to discuss aerodynamics

11/01/2020

YUAA Talk

- Upcoming YUAA talk at 6 pm EST, Friday November 6th by NASA engineer Brandon Lloyd

Orders

- New order forms have recently been submitted
- See purchase list spreadsheet for more details
- Phoenix ornithopter kit (https://www.gyroscope.com/d.asp?product=PHOENIX)
- PVA glue for ornithopter kit
- Absolute orientation sensor
- Teensy
- RC transmitter and receiver
- Servos

GitHub

- Olivia, Bill, and Kai are now collaborators
- Download repo: git clone https://github.com/zandalman/YUAA_ornithopter.git
- Add changes to current commit: git add FILENAME
- Remove file from git tracking: git remove FILENAME
- Commit changes: git commit -m “DESCRIPTION_OF_CHANGES”
- Push changes to remote repo: git push origin HEAD (HEAD is an environment variable which represents the current branch)
- Update local repo: git pull origin HEAD
- New branch: git checkout -b BRANCH_NAME
- Switch branches: git checkout BRANCH_NAME

Fusion

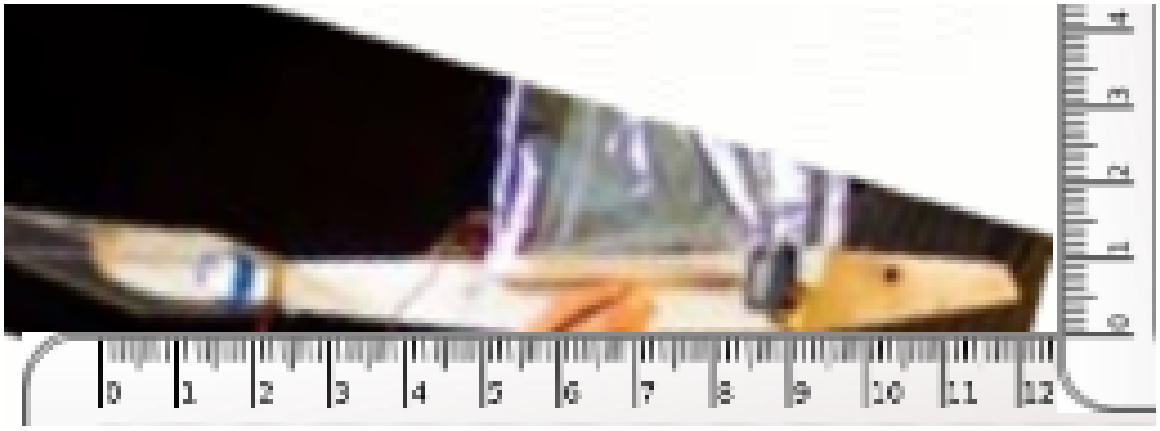
- Create a sketch
- Add points
- Connect points with lines to create a shape
- Extrude shape
- Fillet edges to make smooth
- Create a new design to combine multiple other designs
- Use joints to connect different components

Simulation

- Kai has gotten SimuLink working
- Create a wind tunnel out of a rectangular prism
- Equal mass of air flowing into front and out of the back

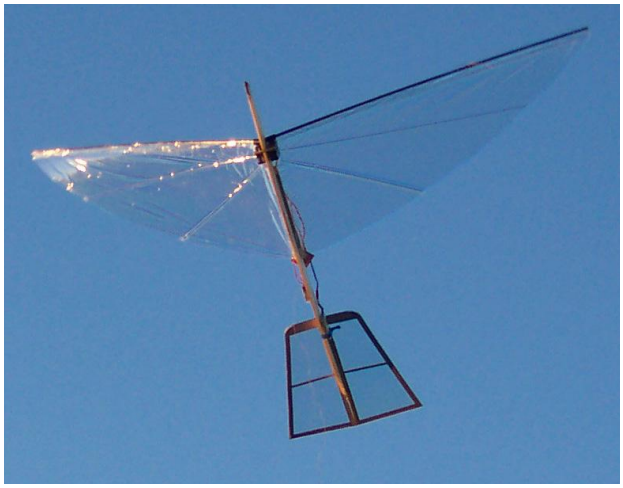
- Zero air flowing through sides (approximation)
- Trade off between size of wind tunnel and computational complexity
- Suitable for simulating frame + attachments + tail wing
- Doesn't work for simulating wings
- Determine optimal frame angle

Frame

- Elsa will complete S1 robotic bird frame design on Fusion
- Frame length is 900 mm (approximately 36")
- Connect servos to frame
- Create holes in frame to decrease weight
- Frame attachments include PCB, battery, servos, tail wing
- How far along the body should the center of mass and the Servos be?
- How can we position the frame attachments so that the center of mass is not too far to the side?
- 75mm to 1" scale of S1 robotic bird frame
- 

Wings

- Erick will complete the S1 robotic bird wing design in Fusion
- S1 robotic bird wings



Electronics

- Bill has finished finding all the electronics parts
- Bill will begin creating connections on the PCB
- RC controller can probably be directly attached to the PCB

Software

- Olivia has written preliminary code for controlling the wings
- 6 channels on the RC receiver: 2 for each joystick and 2 sliders
- One possible configuration is one joystick for amplitude modulation and another joystick for frequency modulation

11/08/2020

Materials

- Kits have not arrived yet but are still on their way
- Glue for kits has been distributed to all on-campus team members
- Bill has a teensy
- Olivia and Bill have orientation sensors
- Olivia has the RC controller
- Erick has his Arduino kit

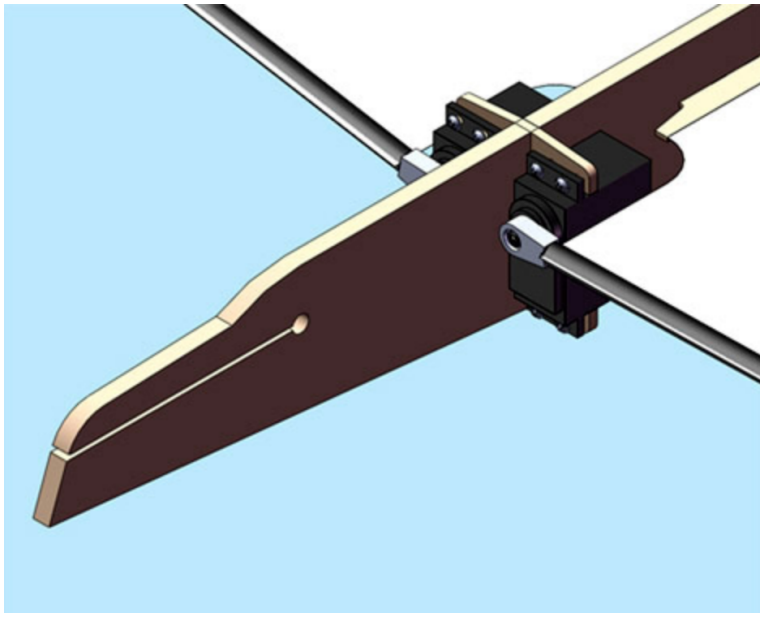
Electronics

- Servos take 6 - 7.4 V
- Teensy takes 3.3 - 5 V
- We need a step-down buck converter (https://www.adafruit.com/product/1385)
- Each servo pulls up to 2 amps (stalls at 2.1 amps) (https://hitecrcd.com/products/servos/digital-brushless-servos/hsb-9370th-multi-purpose-brushless-titanium-gear-servo/product)

- We need a high-amperage 7.4 volt battery (possibility https://www.maxamps.com/rc-battery-lipo-6500-2s-rc-7-4v-battery?gclid=Cj0KCQiAy579BRCPARIsAB6QoIYKOQVezT03-l3f8dImmDQwtt1hdDrGO9Lj5xLm6FgBuSWlyKX10XcaAuH7EALw_wcB)
- RC receiver can either mount directly on the board or be connected via an IDC cable

Frame

- We need to mount the servos sideways so that they can flap the wings



- We will need a separate piece which fits into the frame
- This piece could potentially include a more aerodynamic cover for the servos

Wings

- Discount photoshop website (https://pixlr.com/x/)
- Erick will design the wings in Fusion
- 67” wingspan, translates to 1675 mm in our design

Simulation

- Kai successfully ran an aerodynamics simulation of a simple stp file
- We will set up a meeting with Larry to talk about aerodynamics
- Simulation tests on more complex and 3D frame design
- Holes vs no holes
- Aerodynamic cap for servos?
- Try using a smaller box for the simulation to speed it up

Software

- Successfully controlling micro servo using Arduino
- Olivia will test code for orientation sensor

11/15/2020

CAD tips

- Use McMaster to find CAD files for parts like nuts and bolts (https://www.mcmaster.com/)
- Go “back in time” to edit sketches and other design elements

Wings

- The robotic bird website claims that for the servos we are using, 1.2 meters is the optimal wingspan (https://www.the-nref.org/content/building-robotic-bird)
- Benefits of the shorter wingspan include longer and faster flight
- The original wingspan of the S-1 robotic bird design was 1700 mm. The new wingspan is 1200 mm. Therefore, we can scale down the wingspan by a factor of about 1.4.

Frame

- CAD design now includes pieces for the servos to mount which wedge into the frame
- We can also scale down the frame length to match the shorter wingspan
- We cannot scale down the frame height because the frame is already about the height of the servos
- The original frame length is 900 mm. After scaling down by a factor of 1.4, the new frame length is 650 mm
- We will use the custom servo arms from BirdKit.com to connect the servos to the wings (http://www.birdkit.com/robotics.parts.html)
- Servo datasheet (https://hitecnology.com/images/products/pdf/7_HSB-9370TH_Drawing-2017.pdf)
- The servo arms fit with BirdKit.com’s hollow carbon fiber spars (http://www.birdkit.com/robotics.spars.html)
- Dimensions for the wing spars are given by Goodwinds, which appears to sell the same product for a higher price (https://goodwinds.com/product/wct-sky-shark-3pt-32-5/)
- The wing spar is in the CAD design. For the shortened wing span, we will need to cut off the wing spars
- Hollow wing spars will save weight over solid wing spars

Center of Mass

- We will use the frame design to fix the center of mass
- We will mount batteries, PCB, and other items to maintain the center of mass set by the frame
- We can calculate the pitch of the ornithopter in flight based on the distance between the center of mass and the servos
- Battery weighs 42 grams
- Servos weigh 68 grams each
- PCB will probably be lighter than the batteries

Simulation

- Kai is running a simulation on the updated frame design

Software

- Olivia is working on getting the RC system connected to the micro servo

11/29/2020

Software

- Olivia can read inputs from the RC receiver
- Gyroscope giving garbage data
- Maybe gyroscope needs to be calibrated

Frame

- Ornithopter should fly at 20 to 30 degrees off the horizontal
- Tail wing is 10 to 15 degrees off the frame
- Center of mass on weird ornithopter video guy's ornithopter is very far forward
- Skeptical about his claims
- Fusion can calculate center of mass
- Must insert correct density from frame material
- Calculate center of mass for frame alone. Include other parts of calculation afterwards
- Elsa will upload design files from weird ornithopter guy's webpage

Wings

- Zack working on implementing wing design in Fusion

Electronics

- Bill has created a prototype of the board design

12/06/2020

General

- Optional meeting next week

Frame

- Aerodynamic cap
- Attached to servo mounting screws?
- Needs side hole for wings
- Which shape is the most aerodynamic?

Electronics

- Bill finished board design
- Fits nicely on ornithopter frame

- 4-40 screws in corners
- Need to switch servo connections to other side of board so that they are closer to the servos on the ornithopter
- Need to choose 3 x 1 pinhead on RC receiver connections with smaller pads
- Bill has soldering equipment and can solder and test the board over break

Wings
- Wing design fully implemented in Fusion
- How to attach the tail wing to the ornithopter?

Simulation
- Kai and Zack met with Larry Wilen
- Use the scientific method to get full use of aerodynamics simulation
- Get total drag as a single number
- Use simplified version of ornithopter for testing
- Use software to make comparisons, because it can't be fully trusted quantitatively
- Tilt ornithopter at an angle
- Try different wind speeds
- Servos are causing a lot of drag

01/10/2021

Generel
- Hope everyone had a nice holiday season
- We will start putting the ornithopter together this semester!
- Will be sending out a Facebook post to recruit sophomores to group
- Feel free to reach out to me if you want to help in recruiting
- Applications for YUAA Eboard will open soon
- Happy to give advice for the applications
- All of you would make great project leaders, outreach directors, etc.

Ornithopter kits
- Zack and Erick have built ornithopter kits
- They are really cool!

Electronics
- Test circuit on breadboard before doing any soldering
- Send Bill step-down converter, batteries, and Servo
- Bill needs code from Olivia; can collaborate to figure something out

Wings
- Erick will build the wings over break
- Wing design complete in Autodesk Fusion

- Can use Canvas feature in Fusion to
- Send Erick ripstop nylon and carbon fiber wing spars
- Erick is driving to campus in the spring, so sending him stuff is no problem
- Carbon fiber rods will slide into pockets in the wings (like a tent)
- Anyone know how to sew?

Frame

- Theo will 3D print parts for the frame to make sure that they fit together
- An option for our final design: use a company to professionally manufacture custom carbon fiber parts (Custom carbon fiber parts http://www.protechcomposites.com/custom-orders/)
- Theo and Bill have 3D printers

01/17/2021

General

- YUAA pre-interview questions now available in Discord
- Application due February 28th
- Reach out to me with questions or for brainstorming
- There will be whiteboarding sessions coming up soon

Frame

- Theo will 3D print parts for testing
- Gap in frame is 5 mm wide

Electronics

- Bill has received the Servo and step-down converter
- Zack will upload a PDF of the servo instructions
- Servo comes with a PAD, which we might want to use to help the step-down converter handle back currents

Software

- Zack will create a simple version of the code for electronics testing purposes

Wings

- Wing materials have been shipped to Erick and should arrive soon
- Carbon fiber tubes, 3 mm carbon fiber rods, and duralar from Birdkit.com

Simulation

- Kai will run some ornithopter simulations with the wings
- Test different tail wing configurations, angles, sizes, etc.

01/24/2021

New group members

- Aliza

Frame

- Standardize widths to ⅛’ or ¼’ for easier laser cutting ability
- Need to make pieces slightly small to allow for manufacturing defects
- Interlocking u-shapes for servo mount to frame connection
- Prevents side-to-side motion
- Shorten slots along vertical direction so servo mount pieces can stay the same size
- For first prototype, glue alone might work
- To mount tail, create a hole in the rear of the ornithopter
- Create a hole for the battery to allow battery to be in-line with the center of mass

Electronics

- Servo works with Arduino
- How many rotations per second can we get at 60 degrees of rotation?
- Figure out how PAD works
- Get Teensy working
- Test step-down converter using multimeter

01/31/2021

ISC Conference

- Register at https://tinyurl.com/IvySpace4
- It’s free and there is no obligation to attend once you register

CEID

- Sign up to be a CEID member
    - Go to https://yaleconnect.yale.edu/student_community?club_id=38455
    - Click “Join”
    - Check the checkbox and click “Join” again
- Do the laser safety training (https://ehs.yale.edu/trainings/embedded-laser-safety-program)
- At some point, events will start appearing under the CEID page on Yale connect
- You will be able to sign up for a laser cutting tutorial
- 3D printing tutorials could also be helpful, but not necessary

Frame

- Updates to the frame from last meeting have been made
- How do we keep the battery in the battery hole?
- Adjust thickness of carbon fiber above tail wing slot to 1/8”
- Possibly adjust thickness of frame to 3/16” rather than 1/8”

- In a future design, add a mechanism to adjust tail wing angle before flight
- For now, simplicity is better

Simulation
- Simulate ornithopter at different body angles and tail wing angles
- Zack will send Kai STP files

Electronics
- RC receiver will not be soldered to the board
- Instead, 8 male-to-female cables will go from the board to the RC connector (6 channels + GND + VCC)
- Zack created custom device in Autodesk Eagle for switch
- Ship Aliza an Arduino kit (Franklin college)

Wings
- Changed address for duralar material
- Working on changing address for wing spars

02/07/2021

CEID
- Go here do get all the info about doing CEID training (https://yaleconnect.yale.edu/student_community?club_id=38455&menu=blog)
- Laser cutting certification requires 4 steps
    - Complete laser safety training
    - Complete embedded laser safety training
    - Email training certificates to CEID
    - Complete CEID laser safety training
- Also a good idea to do the makerbot training

Electronics
- Bill tested Teensy, step-down converter, gyroscope, and servo working together
- Bill will add the switch to the PCB
- Bill will replace the through hole array with 8 pins
- May use a smaller version of the RC receiver (https://www.amazon.com/Flysky-FS-A8S-Receiver-i-BUS-Transmitter/dp/B0761N3FFC)
- Can be paired with our RC transmitter (see https://www.amazon.com/Flysky-FS-A8S-Receiver-i-BUS-Transmitter/dp/B0761N3FFC https://www.youtube.com/watch?v=nGTxIjDLY34)
- Will send Olivia the small receiver to test
- Big boy battery has arrived, very powerful and a little scary

Software

- Smaller receiver uses IBus protocol (developed by Flysky) which carries all channels in one digital signal
- There are Arduino libraries to decode with IBus protocol (https://www.arduino.cc/reference/en/libraries/ibusbm/, https://www.arduino.cc/reference/en/libraries/ibustrx/)

Wings
- Duralar has arrived, wing spars are on their way
- Use sewing to create sleeves in the wing
- Aliza has some sewing experience
- Erick will go over video and write down steps for wing construction procedure (https://www.youtube.com/watch?v=ufjvmdAXyZs)
- Use tape to make wing more stiff at wing spar sleeves

Simulation
- Current design may be too complex for simulation to work
- Zack will send a more abstracted version of the design to Kai to test

Frame
- Hold battery in place using zip ties and small holes in the frame
- Inspiration taken from https://www.thingiverse.com/thing:1324260
- Similar set-up could work for receiver if smaller receiver doesn't work

02/14/2021

General
- Happy Valentine's Day
- Apply for Eboard positions!
- The application questions are uploaded to the google drive

Simulation
- Abstracted design still did not work
- There may be a problem with the intersection of the wing spars and the wing material in the design
- Zack will send Kai an updated design

Frame
- Triangular holes instead of square holes in frame
- Need to fillet the edges of the holes
- Basswood is on its way to the CEID
- Unlike plywood, basswood takes a larger load parallel to the grain vs perpendicular to the grain

- We should have the grain go vertically along the frame because most of the load from the servos will be vertical

Wings

- Before mounting the wings on the servos, we should set the servos into a position in the middle of their range
- Erick, Aliza, and I will meet in the CEID this week to discuss the wings
- Erick has the procedure for creating the wings

Testing rig

- For a first pass, we can use a vice to clamp the ornithopter to a table
- Eventually, we may want a more complex design which can incorporate a force sensor

Electronics

- Bill finished the PCB design
- Zack will place the order for the PCB board
- May have to order from an American manufacturer to avoid funding restrictions about Chinese manufacturers

Software

- Bill will share how to read data from the gyroscope with Olivia
- The left stick on the RC controller will be for steering and the right stick will be for throttle
- For now we will ignore the horizontal position on the right stick and the vertical position on the left stick
- Olivia will work on implementing the throttle functionality
    - Find the default reading when the right stick is in the neutral position
    - Create a linear map from the difference between the current and default readings to the flap frequency
    - Max flap frequency of 7 Hz
    - Possibly include a “buffer zone” around the neutral position of the right stick where nothing will happen to avoid accidentally triggering the throttle
    - Example code

```
float normalizedReading = abs(currentReading - defaultReading) / (maxReading - defaultReading);
float frequency = normalizedReading * maxFrequency;
float delay = (1000 / frequency) / 2; // divide by 2 because each cycle has two servo commands, up and downt
```

- The servos should rotate through an angle of 45 degrees, with 15 degrees acting as a “neutral” position
- When the new RC receiver arrives, Olivia will test it

02/21/2021

Simulation

- New frame design is not working in Simscale
- Holes in the frame could be the problem

Frame

- Erick 3D printed the servo mounts
- May have to 3D print a second time because the supports are attached tightly
- Test servo mounts in CEID
- Still waiting for basswood

Wings

- In the CEID, Aliza and Zack worked on the wing
- Half the wing is complete, we will finish the other half next week
- Going to the CEID on Thursday @ 2:30 pm
- Finish wings in CEID
- Use superglue or gorilla glue to fix the wing spars onto the custom servo arms

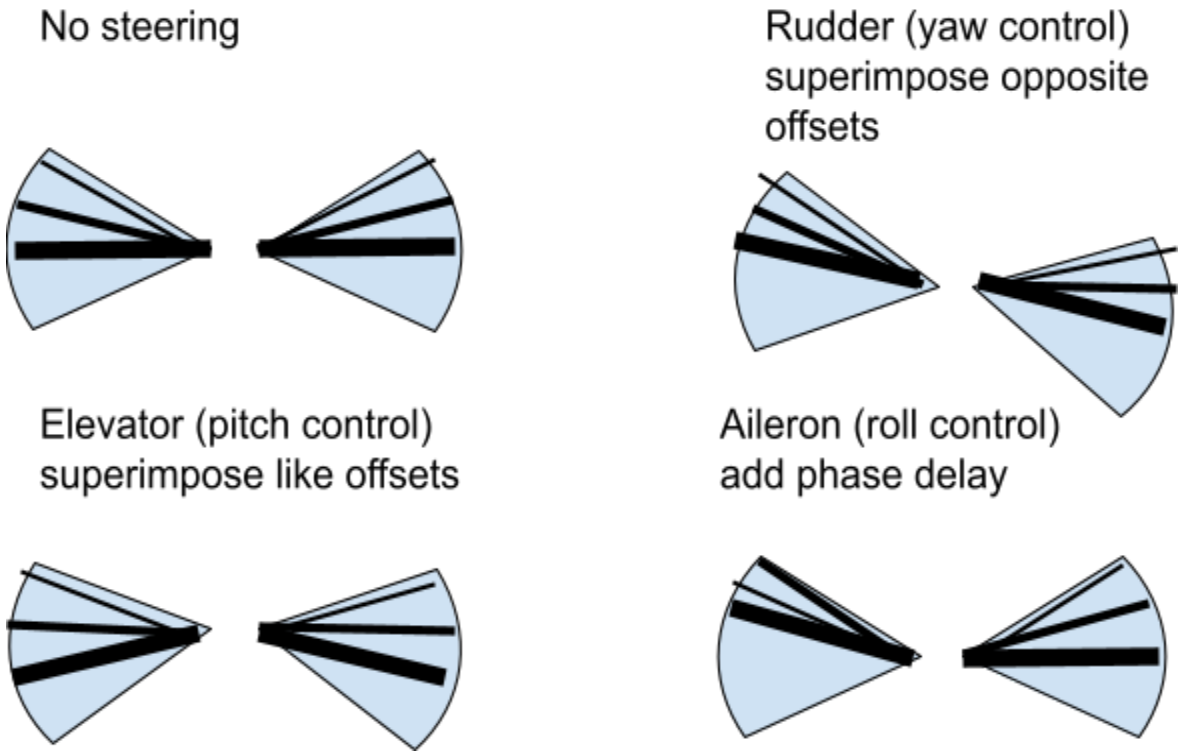
Electronics

- PCB has not arrived yet
- Solder teensy on top of male-to-female connectors for ease of detaching and programming
- Still waiting for mini RC receiver

Software

- Zero position of the servo is only relevant insofar as we want the full range of motion of the servos
- Servo arms can be detached and reattached at any angle
- Throttle mechanism is up and running
- Code needs to be commented to make readable
- We need a simple version of the code for basic testing in the CEID this Thursday
    - Input a frequency
    - One servo flaps in a sinusoid at that frequency
- Look up table for sine and inverse sine functions
- One servo rotates clockwise, another servo rotates counterclockwise. Therefore, different signals need to be written to each servo
- When throttle is zero, wings should default to 15 degrees above the horizontal
    - Rudder and elevator steering mechanisms should work in the same way
- Three steering mechanisms (in order of importance)
    - Rudder (yaw) - superimpose flapping with positive offset on one wing and negative offset on the other
    - Elevator (pitch) - superimpose flapping with a positive or negative offset on both wings
    - Aileron (roll) - add a phase shift to the flapping

- Olivia will figure out what the usual mapping for steering to channels is
- Bill and Kai will join Olivia in working on the code
- Code can be broken up into implementing look-up table, working on steering, and working on IBus protocol decoding



02/28/2021

General

- Apply to Eboard positions
- Deadline for applications will probably be extended
- You can apply for non-project-leader positions and still be a part of the project

Software

- Olivia made an excellent summary of the code and its current problems (https://docs.google.com/document/d/1VA-EAru0-6IPIT6ASaZQ7ZtNaGr3ZuQab4mmbTLjAoA/edit?usp=sharing)
- The ‘writePos’ function is taking 150 ms for some reason
- sin and asin functions can be sped up by using the fast trig library
    - Search for fastTrig in the Arduino library manager
    - Add the line #include "FastTrig.h" at the top of the script
    - Replace sin and asin with isin and iasin
- Declare specific pin numbers as global variables at the beginning of the file

- Possibly get rid of four loops with only two iterations (but maybe not if it's not the source of the slowdown)
- To determine the source of the slowdown, remove levels of complexity until the slowdown disappears
- Aliza will help implement steering functionality
- In the future, we can detect when we are in freefall and implement an overriding behavior to try to save the ornithopter

Wings

- Wings have been completely cut out of duralar
- Servo + custom servo arm + wing spar apparatus is working perfectly
- Zack will reach out to the CEID for guidance on cutting wing spars
- Inhaling carbon fiber dust is extremely dangerous
- Will have to cut wing spars outside of CEID
- Use a wet paper towel and a razor blade (https://www.flitetest.com/articles/how-to-cut-carbon-fiber-rods)
- Zack will order extra wing material just in case
- We will go into the CEID this Thursday at 2:30 pm

Frame

- Custom servo mounts fit servos
- Wood still has not arrived
- Ian said that there may be wood we can use in the aerospace room
- Zack will contact Ian to find a time to meet in the CEID and look for wood

Electronics

- Bill received the PCBs
- Teensy does not lay flat on connectors; Bill will have to sand the side of the connectors
- Don't sand the top of the connectors (from personal experience)
- Attach male connectors everywhere
- Step down converter will hang down off of the PCB
- Bill will keep orientation sensor with him so that he can do tests with it to help with software
- Bill can just check the connections to the orientation sensor without soldering since he has already tested it
- Switch is not flush to the PCB, but it's not a big deal

Simulation

- Frame without holes worked, which indicates that the problem has something to do with the holes
- Kai will test the frame design with one hole as a check

03/07/2021

General

- Last day for Eboard applications
- Check email for YUAA t-shirt and jacket order form

Frame

- Steps to get laser cutter certified
    - Yale Laser Safety Awareness Training (https://ehs.yale.edu/laser-safety-training)
    - Yale Embedded Laser Safety Training (http://ehs.yale.edu/training/embedded-laser-safety-training-ceid-personnel)
    - Safety training checklists should be accessed through http://www.yale.edu/training/ and may be taken online. Please save the quiz transcript post-completion and email it to ceid@yale.edu
- Basswood has arrived
- Will laser cut the frame this week

Wings

- We cut 4 of 6 wing spars last time at the CEID; will cut remaining two wing spars next time
- Mudi mentioned a strategy for attaching the win spars while maintaining tension in the wing
- Zack will discuss with Mudi privately

Software

- Mini RC receiver has arrived
- Olivia will work on binding RC receiver to RC transmitter and decoding IBUS signal
- Kai will work on implementing the steering system
- Zack and Kai will meet to discuss the code

Electronics

- Soldering of the PCB is almost complete
- When soldering is complete, Bill will send the PCB to Yale campus
- Package carefully and don't forget to send the servo as well
- PCB will probably be incorporated into the second ornithopter prototype

03/14/2021

General

- Happy pi day!
- Make sure to fill out YUAA t-shirt order form
- It's okay to prioritize midterms over ornithopter!

Frame

- Frame is finally laser cut
- Frame design is slightly longer than 24” (the length of our wood) so we had to cut in two pieces
- For the final ornithopter iteration, we will order a long piece of carbon fiber so we don’t run into the same problem
- We can attach the pieces together with glue and possibly with short CF struts
- Tasks for next time in the CEID
    - Attach the frame pieces together
    - Attach the tail wing to the frame with glue
    - Attach the battery to the frame with zip ties
    - Attach the servo to the frame
    - Attach the RC receiver to the frame
- Aliza will get laser cutting trained this week

Wings

- Tail wing is small; maybe next iteration we can make a larger tail wing
- Next time in the CEID we will attach the duralar to the tail wing piece (https://www.youtube.com/watch?v=wipw5tMYNWM)
- We will wait until we have both servos before we attach durular to main wings

Software

- Mini RC receiver is working
- Requires a manual installation of a library into the Arduino IDE (https://github.com/Nikkilae/PPM-reader)
- For roll, pitch, and yaw, we will update the position function every cycle under the assumption that the joysticks are being moved smoothly
- For throttle, we will update the position function only when |sin(2pi * frequency * t)| < epsilon. Note that we ignore phase shift

Electronics

- Bill will solder the orientation sensor onto the PCB and we will send him a replacement
- The PCB is almost complete and Bill will ship it early this week
- Bill will be reimbursed for shipping costs
- Use lots of packaging to keep parts from getting damaged

03/21/2021

General

- Timeline (tentative)
    - April 1st
        - Finish first ornithopter iteration
        - Finish minimal working version of code with steering and RC control
    - April 15th

        - Finish second ornithopter iteration
        - Finish polished version of code with steering and RC control
    - April 29th
        - Finish final ornithopter iteration
        - Test launch
        - Finish minimal incorporation of orientation sensor data into code
    - May 10th (approximately)
        - Finish code adjustments
        - Final launch!

Electronics

- PCB and servo are shipped and should arrive by Monday
- Zack will order an extra orientation sensor for Bill
- Olivia will hold on to the RC equipment for the time being
- Now that electronics are basically done, Bill will shift over to the software side of the project

Software

- Olivia will make a very simple sketch which flaps both wings simultaneously (for testing purposes)
- Incorporate gyroscope into code
    - Critical angle for roll, pitch, and yaw
        - As the ornithopter gets closer to some critical angle, we will dampen steering in that direction
        - For example, if the ornithopter is rolled far to the left, attempts to roll further to the left by the user will be ignored
    - Fail safe for falling
        - When the acceleration reaches close to 9.8 m/s^2, we will override user control to either
            - Position the wings optimally to prevent damage upon hitting the ground
            - Restore flight
- To prevent people from waiting on each other to implement the steering, we will have a “whoever gets to it first” policy
    - Make sure to put a blurb about what progress you made in the Discord
- For questions about software, use the software channel in the Discord so everyone can read / answer the question

Frame

- All pieces fit together spectacularly in the frame
- Zip Tie method for battery works well
- Aliza will go into the CEID to attach the tail piece to the main ornithopter frame

- Second ornithopter iteration will have larger tail wing (scaled by 1.5 x) and a hole which properly gives room for the Lipo battery wires

Wings
- Aliza put together the tail wing using the method discussed last week

03/28/2021

General
- We will try to complete our first prototype this week!

Frame
- Purchased carbon fiber with foam core material for ornithopter frame (https://dragonplate.com/carbon-fiber-prepreg-last-a-foam-core-sheet-0125-x-24-x-36)
- Foam core is ⅛", so foam core with carbon fiber plating will be slightly thicker than our current design
- Not a bad thing because current frame has been a little shaky when the servos are going at 7 Hz

Software
- Kai updated the control software
- Each timestep, an angle delta theta is added to the argument of the sine function
- The size of delta theta will depend on the throttle
- Kai will test the updated script on the servos
- Bill will work on implementing the gyroscope in the code
- The first step will be making a circuit which flashes an LED when the magnitude of the linear acceleration gets close to free fall
- The next step will be making a circuit which flashes an LED when the gyro is tilted at a certain angle
- Keep in mind that the gyro will be oriented sideways on the ornithopter
- The gyro code could include a calibration step
- Get orientation data from the gyro as Euler angles (https://en.wikipedia.org/wiki/Euler_angles)
- Olivia will create a minimal working version of the code using the RC controller (doesn't necessarily have to have all steering functions yet)
- How should we implement timesteps in the code? Right now we are using the delay function, but maybe we should implement a system that ensures that each loop occurs in a definite amount of time?

Electronics
- Olivia will give Zack the RC equipment for testing on the first ornithopter prototype
- The PCB arrived and fits neatly on the ornithopter frame
- The PCB works perfectly

- Next time, we will attach the RC controller to the PCB

Wings
- This week in the CEID, Aliza and Zack will construct the ornithopter wings
- We will film the wings using a slow motion camera to understand how our design is currently working and where it can be improved

04/04/2021

Software
- Bill created a working code which outputs to serial when the magnitude of the acceleration passes a certain threshold
- Euler angles may have a gimbal lock; should not be an issue
- We can always use quaternions if we need to
- To read two types of data at once, we may have to modify the Wire Arduino library for faster I2C communication (https://forum.arduino.cc/index.php?topic=410787.0#msg282675)
- Bill will get Euler angles working
- Kai will implement his new control code on micro servos as a proof on concept
- Olivia will create a minimal working version of the RC control code before Wednesday
    - Code does not need to have full throttle functionality (i.e. throttle stick can just function as an on-off switch)

Wings
- Created an initial wing design using tape
- Wings were nowhere near as taut as they need to be
- Possible solutions
    - Create tension in wings before attaching wing spars
    - 3D print a piece to connect all wing spars together
    - Make center of wings triangular instead of rectangular
    - Poke holes in the wing and attach wing spars to the wing with zip ties
- Aliza and Zack will do more research about common methods for mylar wings

Electronics
- Burned out the buck converter by accidently putting it on backwards
- Not an issue because we have another one
- Zack may solder buck converter directly onto board to avoid future confusion
- Zack will solder connector for RC converter onto PCB

04/11/2021

Wings
- We tried two techniques to make the wings more taut

    - The lashing technique: use a thread to tie wing spars togethers and dunk in glue
    - The connector technique: 3D print a connector for the wing spars
- We are leaning towards the connector technique because it makes it easier to remove the wing spars after we are done
- Next time in the CEID, we will construct the second pair of wings using the 3D printed connectors
- It is important that the back of the wing is attached to the frame
- Last time, we used a clothes pin. We will probably continue to use a clothes pin because it is convenient and easy to implement
- Another option is to add a hook into the frame design to allow the back of the wings to attach easily

Frame

- We will weigh the frame and send the data to Bill
- Bill will do some back-of-the-envelope calculations to determine how much work we expect to do and compare it to the work required for flight
- Aliza is laser cutter certified
- Aliza will laser cut the second iteration of the frame which includes a larger tail wing and a different hole placement around the battery
- Zack will send Aliza the dxf files for the laser cutting
- We will test the ornithopter by attaching it to a string and letting it execute circular motion
- We may add a hole in the top of the frame to make it easier to attach the string

Electronics

- Zack soldered a crimp connector onto the spare step-down converter
- The leads were too thick for the crimp connector, so Zack needed to solder the leads to smaller leads first and cover up the connections with heat shrink
- The electronics are now completely functional
- We tested the RC receiver and it works

Software

- Kai tested the servo control code on real servos and it worked the first time (a miracle!)
- Kai will work with Olivia to incorporate the RC control into the code
- Kai will add comments to his control code
- Kai may take photos or videos to document his tests on the servos
- The original PPM reader library does not work with Teensy, so we need to switch the code to use a new library which is included automatically with Teensyduino (https://www.pjrc.com/teensy/td_libs_PulsePosition.html)
- Disadvantage of new library is that we may have to read each channel separately instead of reading all channels simultaneously
- Olivia will install Teensyduino to do debugging with new library
- Teensyduino installation instructions (https://www.pjrc.com/teensy/td_download.html)
- Random idea: a switch on the RC controller can flip between different control modes

    - Normal mode: joystick channels are frequency, roll, pitch, and yaw
    - Amplitude mode: joystick channels are frequency, amplitude, roll, pitch, and yaw
    - Manual mode: joystick channels are left and right wing positions
- Bill is still working on Euler angles in orientation sensor
- By making a few assumptions, two of the Euler angles correspond directly with pitch and yaw
- Bill wrote a function which returns a boolean based on whether we are falling or not
- We need to make sure that acceleration measurements are not just noise. We can do this by averaging the sensor outputs over multiple measurements
- When we are falling, we can move the wings to some nominal position and cease flapping

04/18/2021

Wings

- Switched from 3 mm diameter wing spars to 2 mm diameter wing spars for interior wing spars to increase flexibility
- Updated wing design slightly to make attaching interior wing spars easier
    - Interior wing spars now lie at 15 and 30 degrees respectively
    - Intersection point of interior wing spars and main wing spar is 30 mm from the servo to prevent the spar connector from hitting the servo
- 3D printed new spar connector to account for smaller interior wing spar diameter
- Wing spars fit snugly into the holes in the spar connector, although if new version are required we may want to increase clearance on the holes slightly (current clearance is diameter plus 0.25 mm)

Frame

- Will get frame weight measurement soon
- There was a delay in shipping the carbon fiber foam for the frame, but it should ship by early next week at the latest
- Methods for adjustable center of mass
    - Multiple possible battery locations
    - Some kind of slider
- We will laser cut new frame design this week

Software

- Bill successfully can read Euler angles for pitch and roll, but not for yaw
- We only need the critical angle feature for pitch and roll, so we can ignore the yaw Euler angle
- RC control and steering functionality are fully implemented
- Kai will add two control modes in the code. One control mode will map roll to channel 4 and amplitude to channel 5. The other control mode will switch roll and amplitude
- Channel 5 is controlled by a knob on the top of the RC controller

- We can switch between control modes by mapping the control mode to a switch on the RC controller

04/25/2021

General
- Zack is giving a 5-minute presentation on the ornithopter on Thursday at the (virtual) YSEA grant recipient annual meeting
- Register here (https://www.eventbrite.com/e/2021-ysea-annual-meeting-networking-online-event-only-tickets-144200787437)

Frame
- Carbon fiber has arrived!
- We will wait to laser cut the carbon fiber until we know for sure that the prototype design is capable of flying

Wings
- Ian says there may be extra ripstop nylon in the CEID
- If there is, we may switch from duralar to ripstop nylon
- New wing design was a huge improvement, but the inner parts of the wing are still not taut enough
- New 3D printed parts and new frame design will allow a new bracing wing spar which connects to the back of the frame to be installed

Software
- Euler angle measurements fail to be independent
- Bill will try an approach using quaternions
- Bill will add acceleration kill switch code into the main script
- Kai will add manual kill switch code into the main script
- Kai mapped amplitude to channel 5 and added a second control mode
- To fully implement the control modes, we need to figure out how the switches on the RC controller manifest in the ppm reader

Documentation
- Bill and Kai will update the README.md file on the github with documentation about their work on the software and electronics

05/02/2021

Frame
- Cutting carbon fiber frame at Makehaven this Friday
- Carbon fiber is 4.5 mm thick as opposed to ⅛” thick

- Frame design, including 3D-printed parts, needs to be updated to account for new thickness

Wings
- Ripstop nylon arrived
- Add an additional thicker wing spar near the body of the ornithopter
- This will allow each wing to be constructed individually
- Wings will be connected by a flap of ripstop nylon

05/09/2021

General
- Final meeting
- Thank you everyone for being a part of this group!
- I encourage everyone to join YUAA again next year

Frame
- New frame and tail cut out of carbon fiber using water jet cutter at MakeHaven
- Need to 3D print new parts for servo connectors and screw connectors
- Small parts did not work well with the carbon fiber foam material because the carbon fiber layers break apart

Wings
- New wing design was tested and it works well
- New wings are very stable
- Next time, we will sew a connector flap of ripstop between the wings

Launch
- Soft launch to see if flying is feasible
- If soft launch is successful, we will move to a full launch event
- Launch event will be streamed on Zoom and anyone is welcome to attend
- If soft launch does not go well, I will be here in the summer to tinker with the ornithopter and the launch will occur sometime over the summer