Final Presentation Emergency Management Drone Team 307

Team Introduction


Haley Barrett
Project Manager


Matthew Roberts
ECE Lead


Kody Koch
ME Lead

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Josh Reid
Design/Aerodynamic Engineer


Juan Patino
Test Engineer


Francisco Silva
Programmer

Haley Barrett

Sponsor

Florida State University

Emergency Management and Homeland Security Program

- David Merrick, Director

Haley Barrett

Project Background

- Purpose
  - ➢ Design a drone capable of assisting search and rescue teams in finding targets.
- Requirements
  - ➢ The range needs to be at least 1 km, with an ideal range of 2 km.
  - ➢ The flight time should be greater than 20 minutes.
  - ➢ The camera needs to be stable at all times.
  - ➢ Object detection
    - There should be an algorithm that detects targets on the ground.
  - ➢ There is a weight constraint of 2 kg.

Haley Barrett

Mechanical Concept Generation

Mechanical Components	**Options**						
Vehicle Type	Multi-Rotor	Fixed Wing					
# of Motors	1	2	3	4	5	6	8
Motor Configuration	Quad Rotor "+" Configuration	Quad Rotor "X" Configuration	Y-6 Rotor	X-8 Rotor	Wings	Nose and Wings	Rear
Frame Material	Carbon Fiber	Foam	PLA Filament	Epoxy Fiberglass	Aluminum	PVC	
Airfoil	NACA 0012	NACA 1408	20-32C Airfoil	NACA 62(2)-615			
Fuselage	Blunt Body	Bluff Body	Narrow Body	Flying Wing			
Landing	Parachute	Belly Land - No Gear	Landing Gear				

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Mechanical Concept Selection

Mechanical Components	**Options**						
Vehicle Type		Fixed Wing					
Motor Configuration							Rear
Frame Material		Foam					
Airfoil			20-32C Airfoil				
Fuselage				Flying Wing			
Landing		Belly Land - No Gear					

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Electrical Concept Generation

Electrical Components	**Options**					
Battery	Single 3-Cell	Single 4-Cell	Single 6-Cell	Multiple 3-Cell	Multiple 4-Cell	Multiple 6-Cell
Power Management	Self-Made Power Converter	Multiple OTS Switching Mode Converters	Design around Power Controller - 1 Converter	Design around Power Controller - Multiple Converters		
Communication System	802.11 - WiFi	802.15.4 - Low Rate WPAN	LTE-Advanced - Cellular Connection			
Image Processor	NVIDIA TX1	Raspberry Pi 3B+	Raspberry Pi 2	Raspberry Pi 3B		
Capture Device	Thermal Camera	Infrared Camera	Webcam	Go-Pro	FPV	

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Electrical Concept Selection

Electrical Components	Options					
Battery	Single 3-Cell					
Power Management	Self-Made Power Converter					
Communication System		802.15.4 - Low Rate WPAN				
Image Processor		Raspberry Pi 3B+				
Capture Device			Webcam - Logitech C920 HD PRO			

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Concept Selection

Component	Selection
Vehicle Choice	Flying Wing
Motor Configuration	Rear
Airfoil	20-32C
Material	Foam
Power Management Systems	Buck Topology
Communications	TI CC1312R MCU
Processor	Raspberry Pi 3 B+
Battery Type/Number of Batteries	1 3s Battery
Camera	Logitech C920 HD PRO

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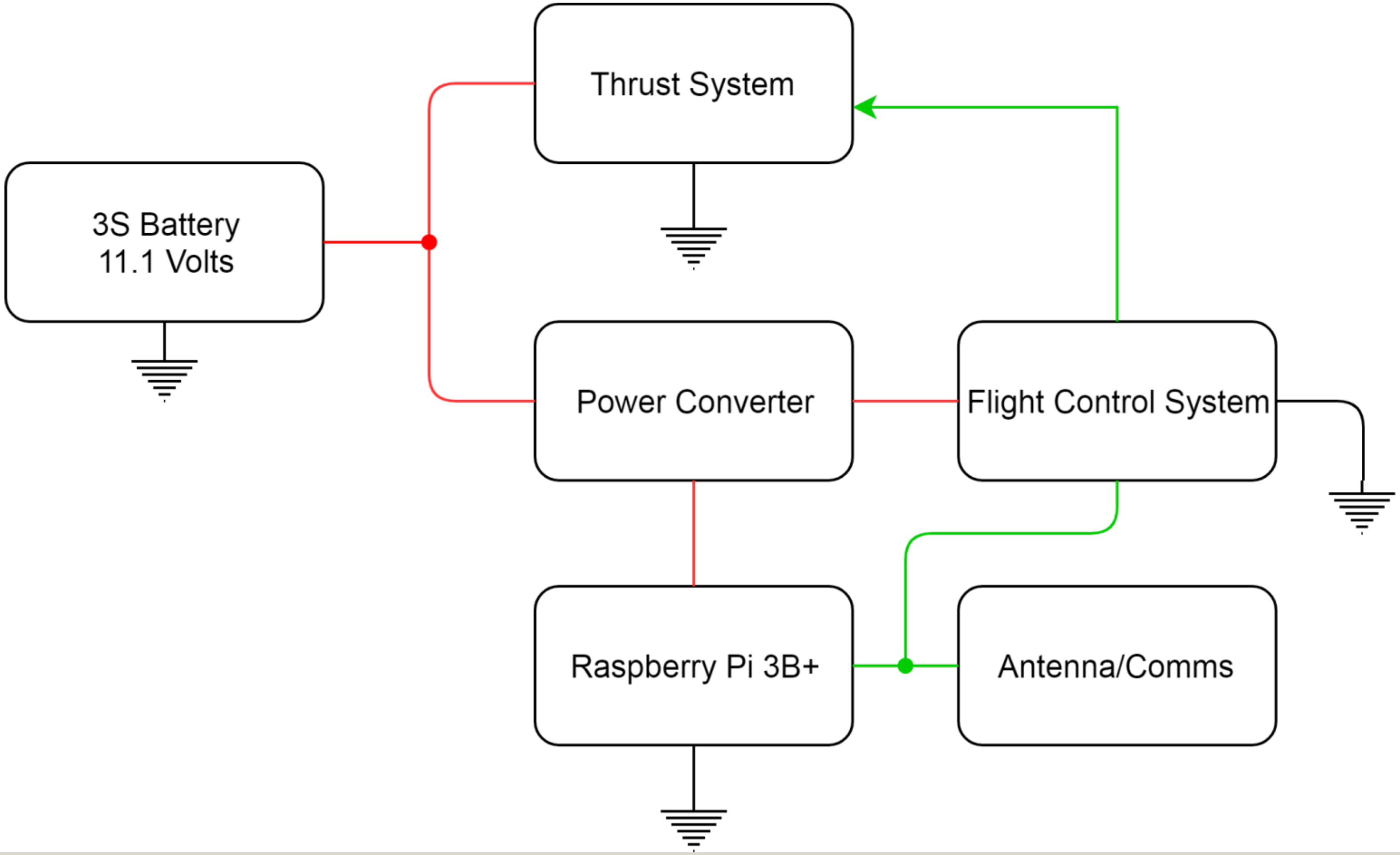
Block Diagram of Components



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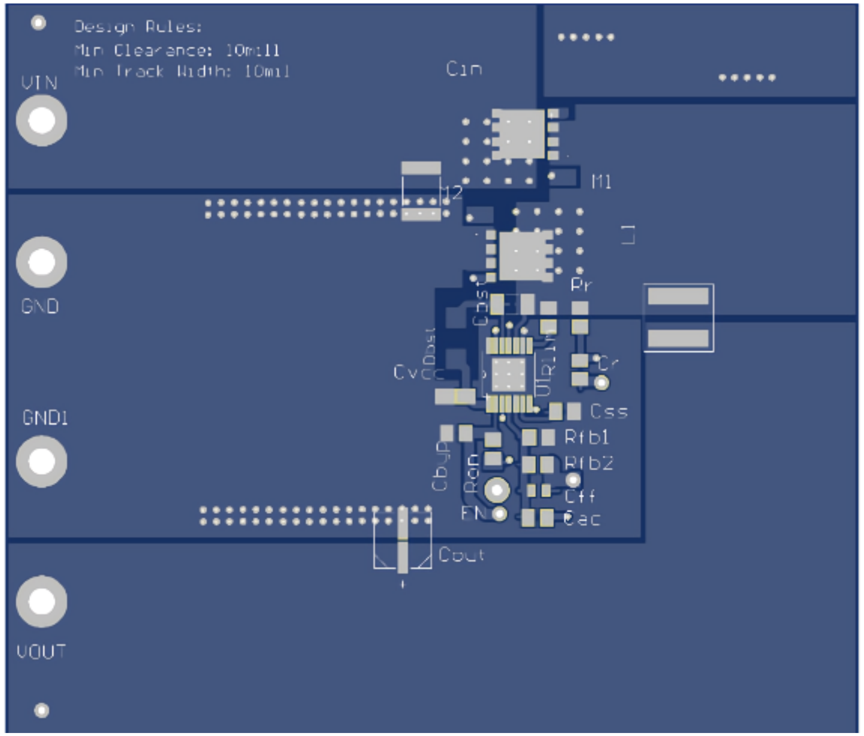
Power Management

- The power converter being used has a 93.7% efficiency and is rated for 5V/8A.
- A 8000mAh/11.1V LiPo battery is being used for the power source.
- Flight time calculations
  - Total power consumption: 153.08W (80% throttle).
  - Battery optimal capacity: 6400mAh
  - Total flight time at : ~40 minutes
  - Total flight time at max power: ~30 minutes
- The image shown is the view from the top side of the power converter.

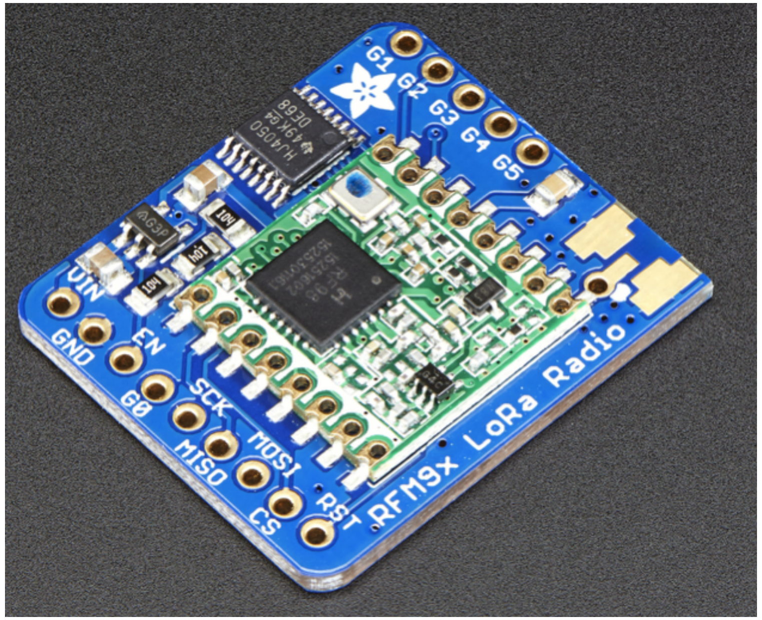


PCB of Power Converter

Matthew Roberts

Communication System

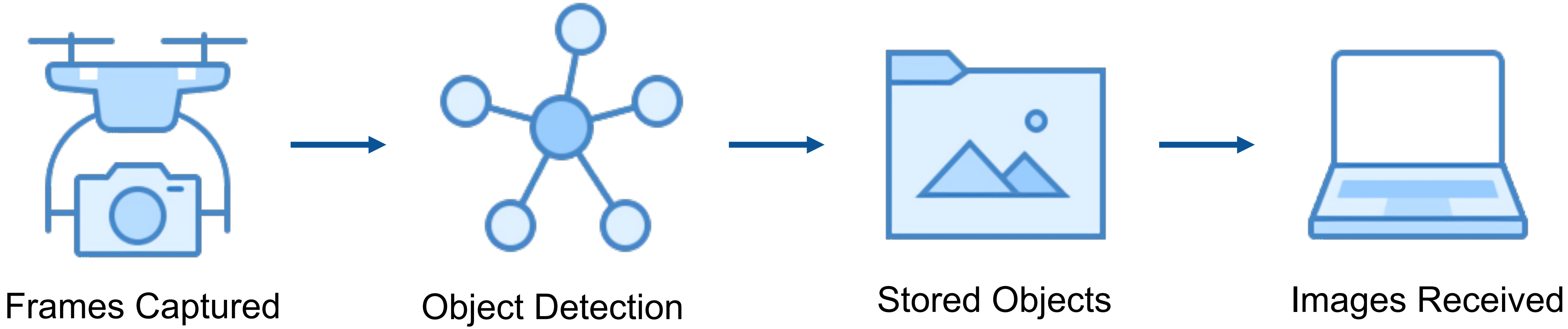
- The LoRa (Low data rate, long Range) communication module sends stored images to the ground station.
  - ➢ The transceivers provides 100 mW of transmit power and better compatibility with the Raspberry Pi.
- Two Adafruit RFM95W LoRa Radio transceivers were bought to prototype and design the communication process.
- Sending data at a lower data rate yields a lower chance of error while keeping the same range.



RFM95W Transceiver

Matthew Roberts

Object Detection



- Neural Network
  - The model selected for our objected detection was the Yolov3.
  - This model is easy to train and has a high mAP (mean Average Precision).
- Training Results
  - To train the neural network a diverse dataset is required.
  - Current model was trained once with failed expectations.

Francisco Silva

Object Detection Cont.

	Positive	Negative
Number of Images	TBD	TBD
Percentage (%)	TBD	TBD

- The number of images in the dataset will be distributed in the following manner:
    - Training: 60%
    - Validation: 25%
    - Testing: 15%
- Training the neural network will take around 200 epochs, or around 3 days.

Positive Image

Negative Image

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Flight Control

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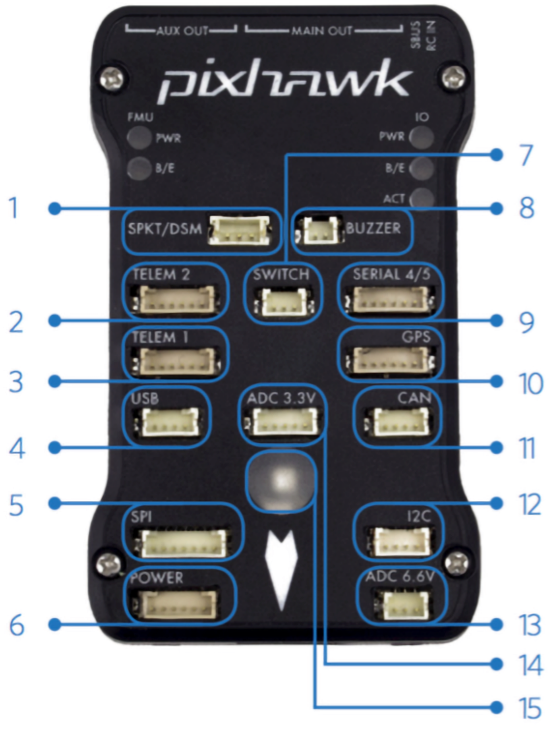


1 Spektrum DSM receiver
2 Telemetry (radio telemetry)
3 Telemetry (on-screen display)
4 USB
5 SPI (serial peripheral interface) bus
6 Power module
7 Safety switch button
8 Buzzer
9 Serial
10 GPS module
11 CAN (controller area network) bus
12 I^2C splitter or compass module
13 Analog to digital converter 6.6 V
14 Analog to digital converter 3.3 V
15 LED indicator

mRo Pixhawk with corresponding legend

- The Pixhawk autopilot runs on the PX4 open source software.
- It takes GPS and command signals from the receiver.
- The autopilot control can be managed through the ground station's installed software.
- RFD900 modems will be used to communicate with the drone through the QGroundControl software at long distances.

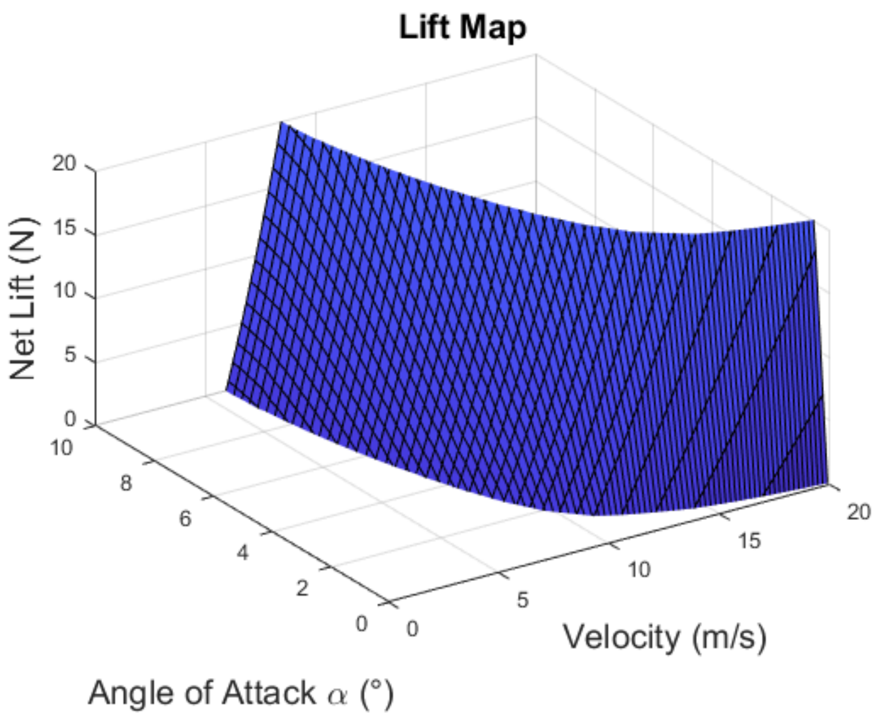
Kody Koch

Airframe - Wings

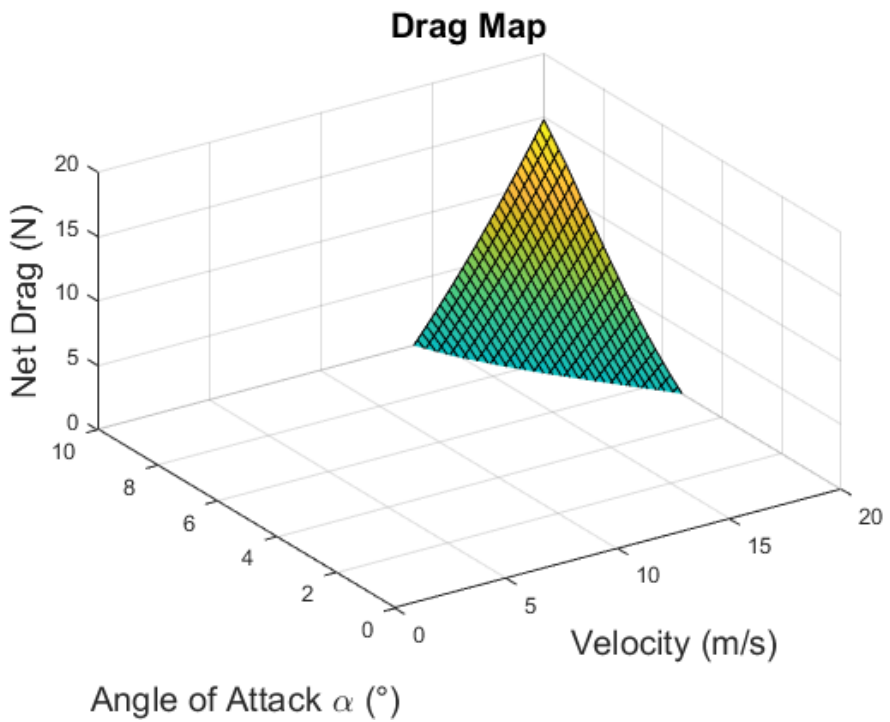
- Airfoil templates laser cut from 6 mm plywood.
    - Root chord: HS522.
    - Tip chord: MH60.
- Wings were cut using hot wire foam cutter.
- They were taped over with packing tape to reduce skin friction and reduce flexing.
- Wings were attached to the fuselage via wooden dowels and hot glue.

Kody Koch

Airframe - Lift and Drag Estimates



- On the lift map, 0 net lift represents the velocity and angle of attack where the drone flies at steady speed (trim condition).



- On the drag map, 0 net drag represents the velocity and angle of attack where the drone flies at its maximum speed.

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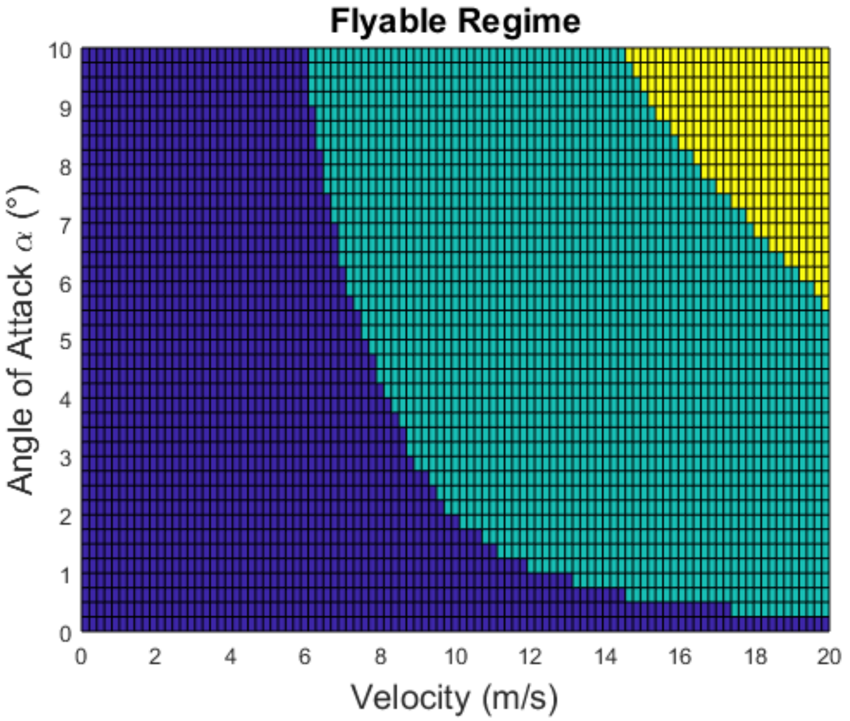
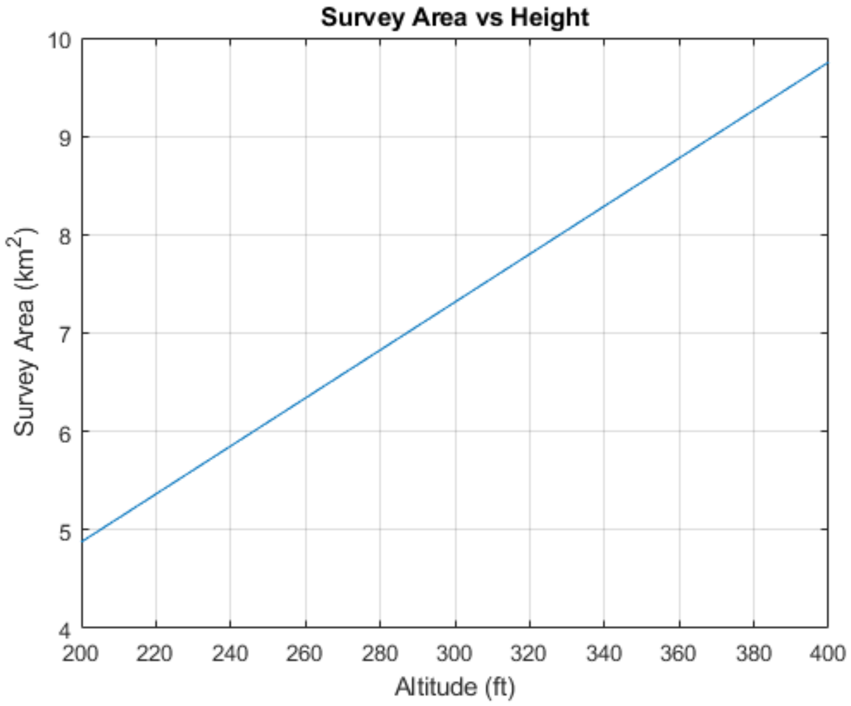
Airframe – Flight Estimates



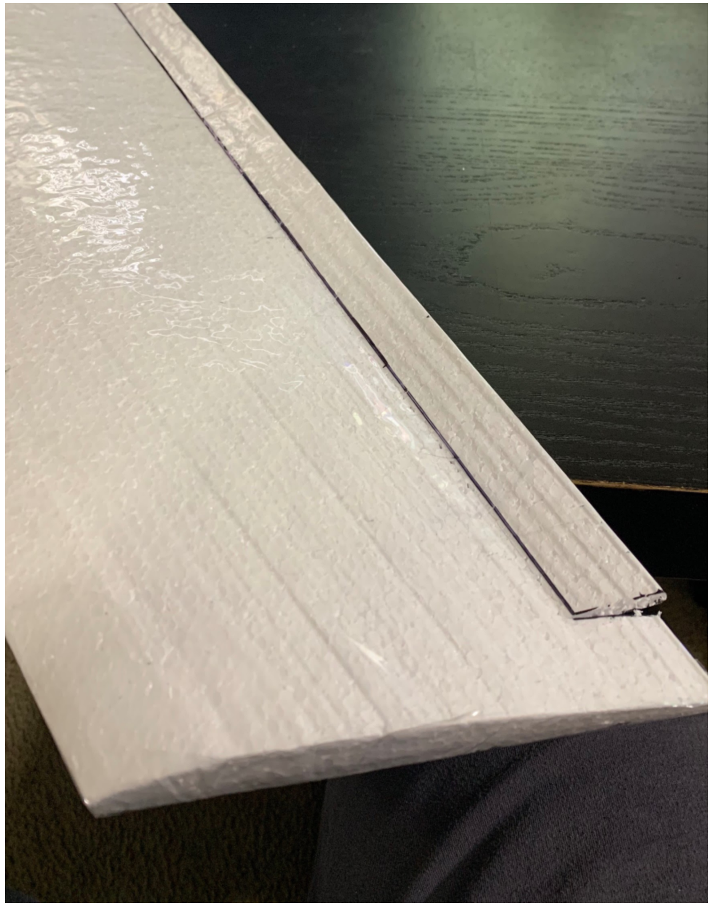


- This regime map represents how the drone will operate at a given velocity and angle of attack.

- This graph show how the survey area scales with altitude. In this case, with an angle of attack of 0°.

Kody Koch

Airframe - Control Surfaces



- Flight control systems are controlled by a device called an elevon.
    - The elevons are given commands via the Pixhawk.
    - Elevons act as both an elevator and aileron, controlling pitch and roll respectively.
    - Servo motors are used to move the elevons via a thin linkage rod.
- No rudder is needed as the drone uses a pusher propeller in order to supply thrust.
    - Flying wings typically do not have rudders.

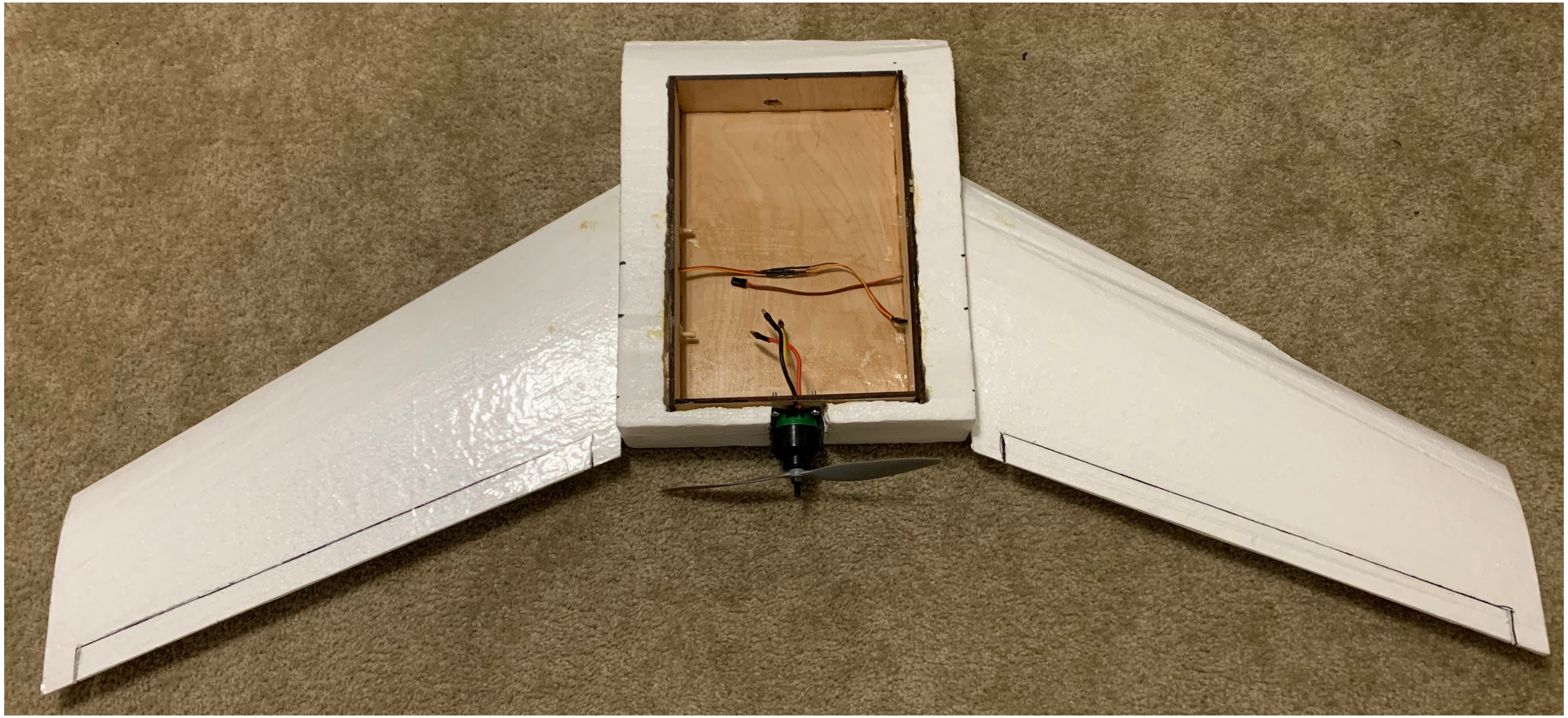
Joshua Reid

Airframe - Fuselage

- The fuselage was shaped using two rectangular blocks of foam that were hot glued together.
- The front curve was shaped by using a separate laser cut template.
- The interior cavity was initially removed using a modified hot wire wand to cut at a constant depth.
    - Individual blocks were then removed by hand to create the cavity.
- A plywood box was later added for structural support.

Joshua Reid

Airframe - Assembled Structure



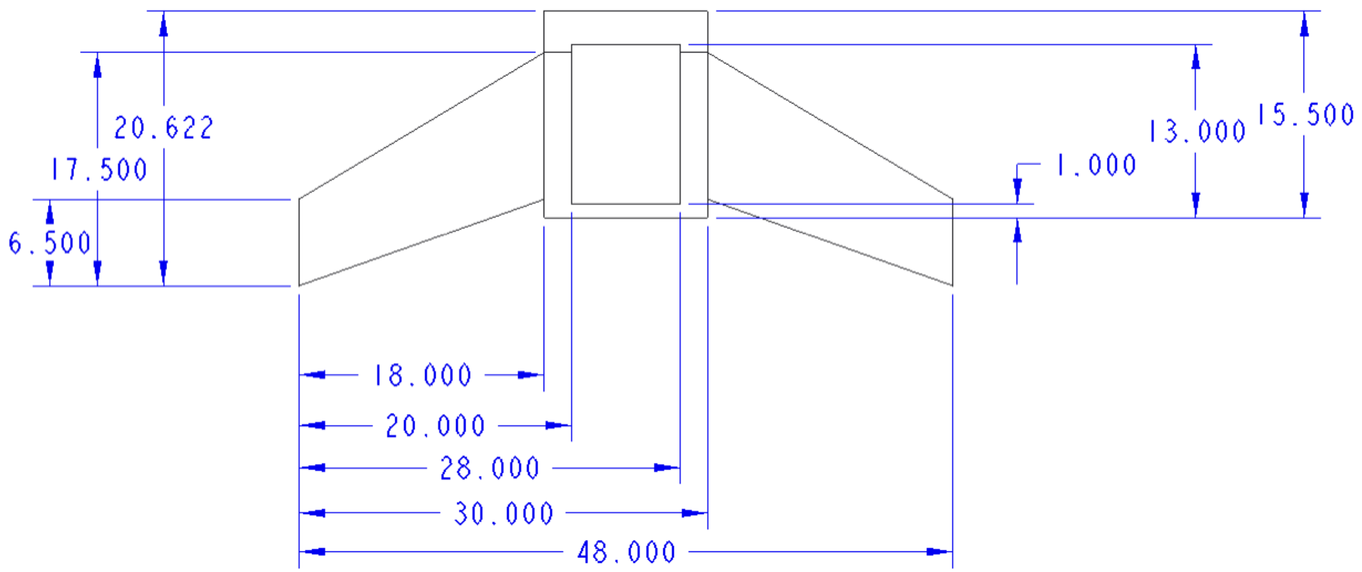
Constructed airframe with motor and propeller attached

Joshua Reid

Vehicle Specifications

Component	Total Weight (g)
Pixhawk/Accessories	38
Battery	493
Processor Buck Controller	10
Omnidirectional Antenna	28
Main Processor	50
Neural network stick	18
720p Webcam	162
Telemetry Modem RFD900	14.5
Motors/Propellor	68
Airframe	TBD
Connectors/Accessories	TBD

- Vehicle weight totals TBD g (TBD kg) which is under the target weight.
- The lateral length of the drone measures 48 inches.
- The box encasing the electronics measures 8 inches in width and 13 inches in length.



Joshua Reid

Performance

- (This will consist of the final test results)

Juan Patino

Lessons

- Initial design work should have taken manufacturing and transportation constraints into further consideration.
    - The initial design called for high lift avian wings which were cut too thin by hot wire cutter.
    - They were exchanged for a more conventional airfoil with less lift.
    - The initial design called for a 84” wingspan which would have been difficult to transport.
    - The final design consists of a 48” wingspan which will be significantly easier to transport.

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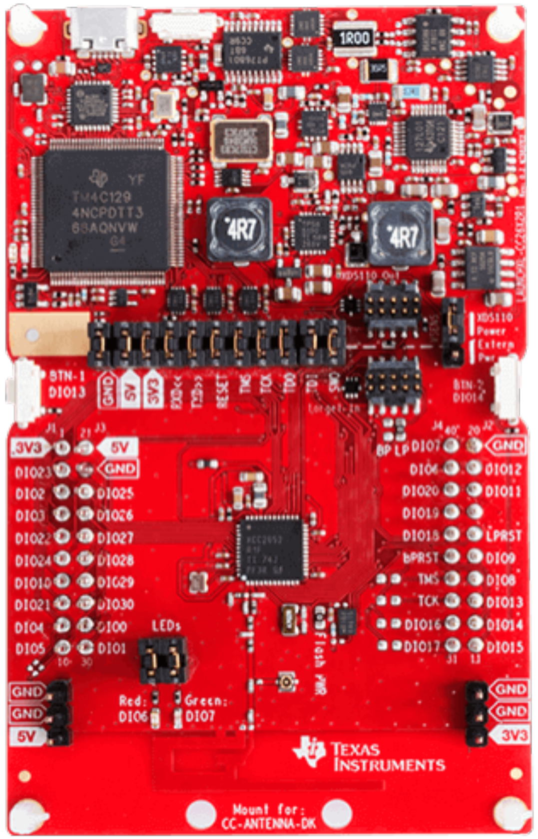
Juan Patino

Lessons Cont.

- The communication schema had to be redesigned multiple times due to technical limitations and poor planning.
  - The initial components often underperformed or simply did not work in multiple cases.
  - Technical manuals for components should have been read thoroughly in order to use each component correctly.
    - An example is the case of the yagi antenna which was initially tested in the wrong orientation.



Old Communication System (TI CC1310)

Juan Patino

Questions?