GyroGlove
Preliminary Design Review

Senior Design Project ‘21
Team #21

University of Massachusetts Amherst
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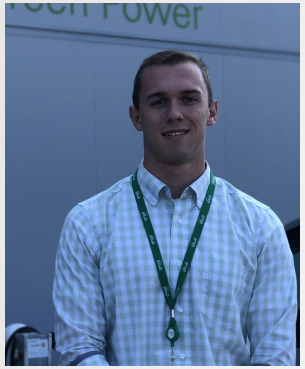
Meet the team



Bradley Spillert
CSE

Jacob Moynihan
EE

Son Pham
EE

Professor Do-Hoon Kwon
Team Advisor

Problem Statement

Having a reliable flight control system is paramount for the success of any manned aircraft. While the current convention of using control mechanisms akin to analog sticks and steering wheels has proven to be timelessly effective, such mechanisms can often lack one valuable prospect: The immersion factor.

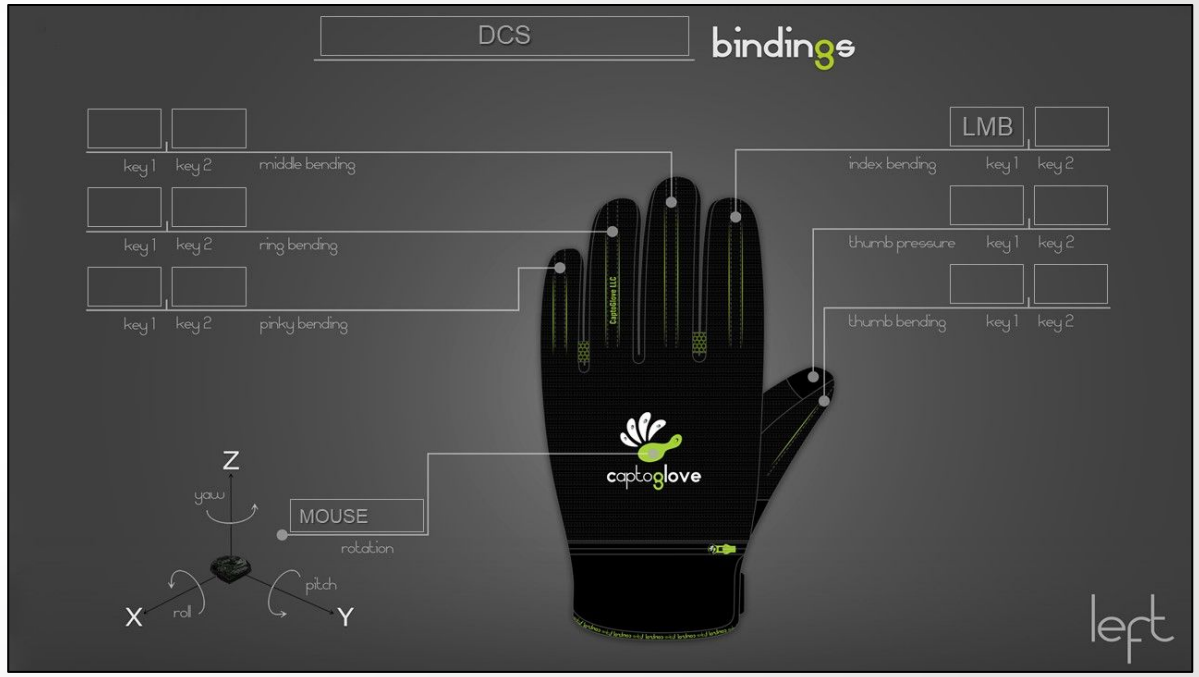
Problem Statement (cont'd)

This is where GyroGlove comes into play. GyroGlove is a modern alternative to the classical stick-lever-wheel approach to flight control, which ultimately allows the pilot to control the aircraft simply by rotating their hand in the same way they wish the aircraft to rotate.

When coupled with integrated thrust control, these systems work elegantly in tandem, allowing the pilot to transcend the levels of immersion previously made available and to ultimately become "one with the aircraft".

Solutions in the Marketplace - CaptoGlove

- **Designed for VR and gaming applications**
- **Not modular for multiple scenarios**
  - Can not be used for applications not designed for by CaptoGlove
- **Not in full productions (and design system design unknown)**
  - Available information states that it uses bending for the separate keys, and rotation for “mouse” movement in gaming applications
- **Can not control an RC plane**



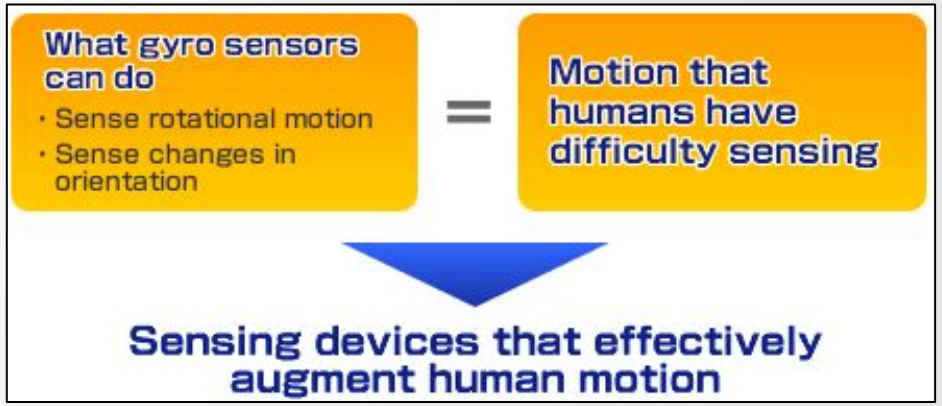
Solutions in the Marketplace - Haptx

- **While designed for VR applications, the development kit includes an SDK allowing it to be used with other applications**
  - Build in exoskeleton can apply up to 4 lbs of force to the user
  - Magnetic motion tracking system with 6 degrees of freedom
- **Large, bulky and lots of wires**
  - Not easy to transport, possibly heavy, ie. user fatigue
  - Hard wired to computer

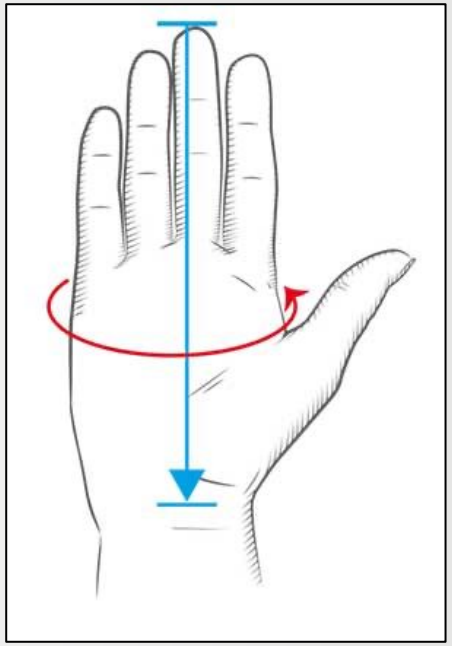
Our Solution - GyroGlove

Our solution is GyroGlove, which differs from other solutions on the market in the following ways:

- **It offers the benefit of modularity, so that it can be retrofitted for commercial/hobbyist/entertainment applications**
  - Open source design platform to allow for ease of customization
  - Ideally, would be able to interface with RC protocols *and* work with completely customized protocols & hardware configurations
- **It's not cumbersome to use and transport**
  - Does not require exoskeleton to function
  - Does not pose the risk of user fatigue



GyroGlove - Preliminary System Specs



At the bare minimum:

- **Flight glove will have at least 18 hour battery life on a full charge[1]**
- **Flight glove will be able to control, and employ the calibration mechanism (0° +/- 5°).**
- **GyroGlove will comply with all FCC standards and regulations (see Reference slide).**
- **GyroGlove will have a software & hardware emphasis on modularity**

Time permitting:

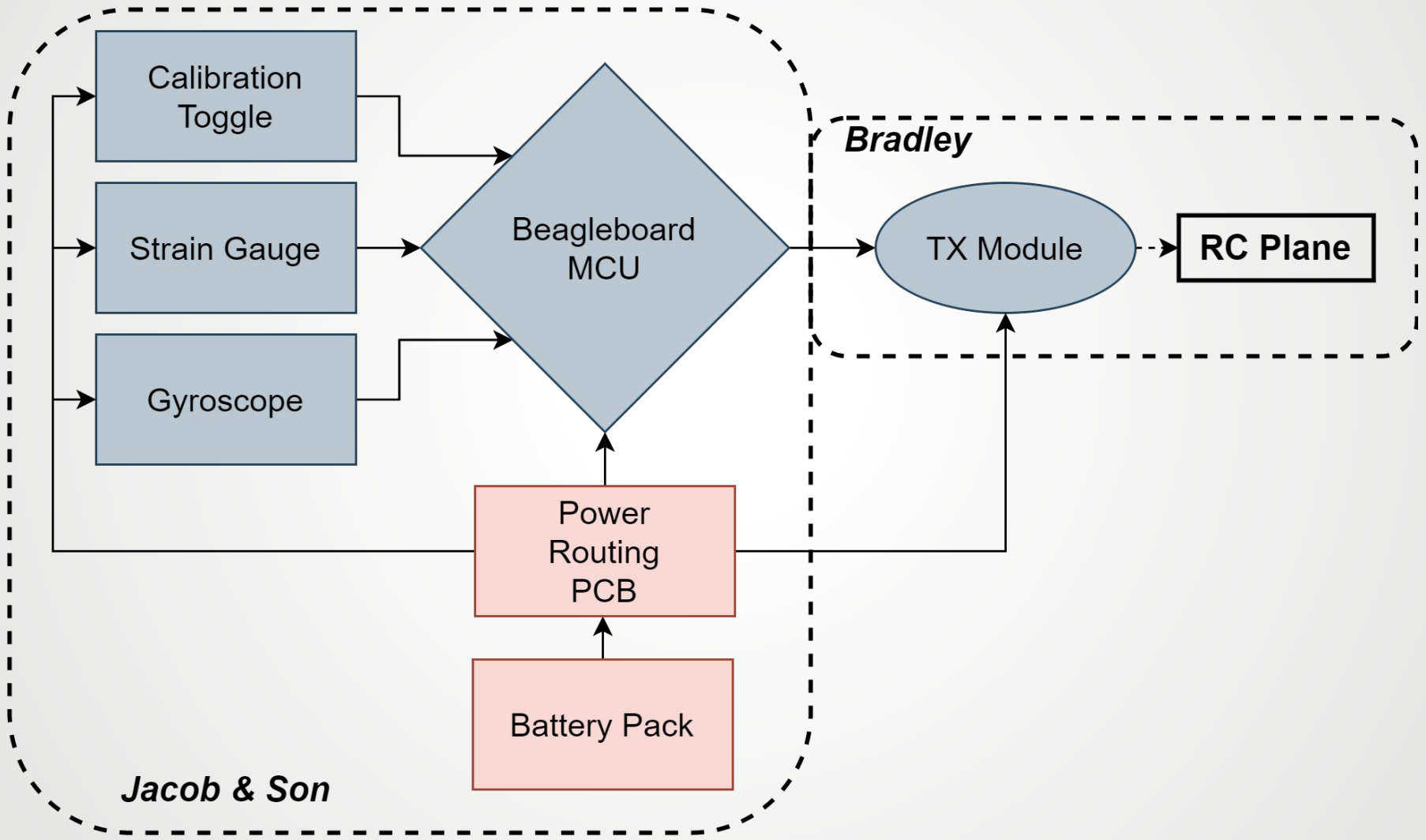
- **GyroGlove will employ haptic feedback mechanisms to relay wind/turbulence data back to pilot at a latency of no more than 250ms**

[1] Should be able to function seamlessly for any realistic commercial flight length (current longest commercial flight is 15 hours 45 minutes) and allow for unforeseen extensions -- Subject to change

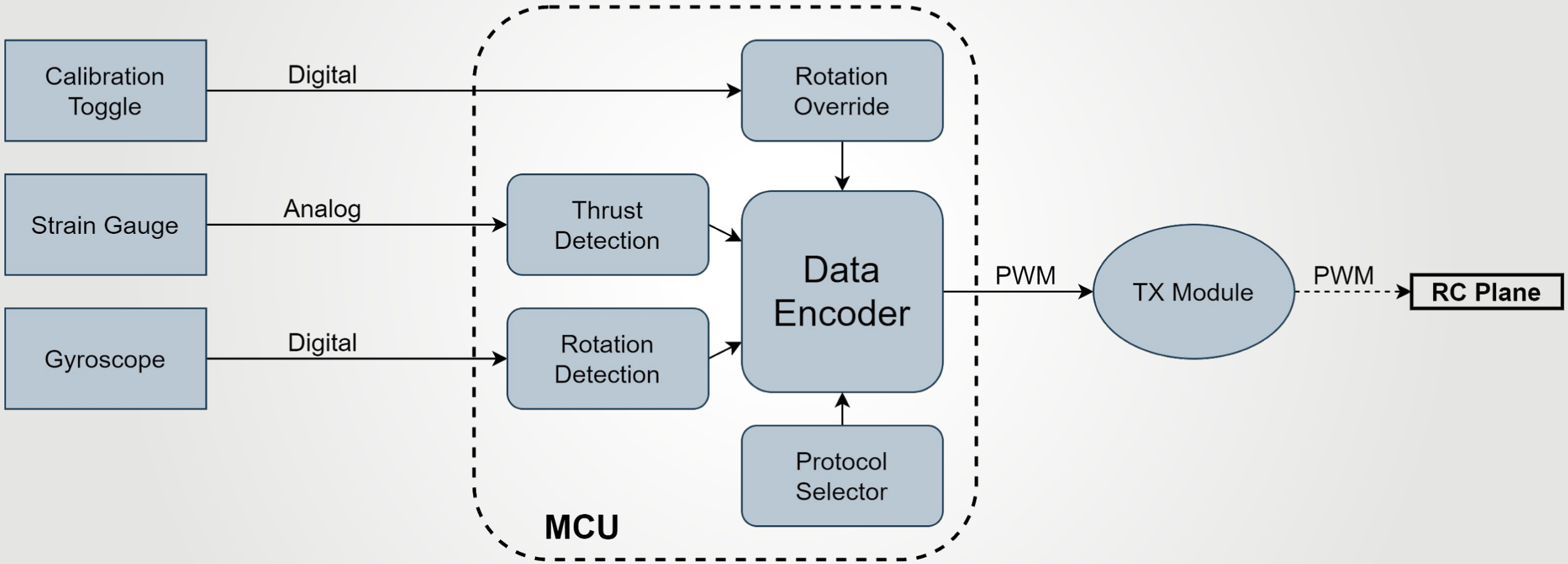
Subsystem Overview

1. **Flight Glove: Captures rotational movement of the pilot's hand and encodes data for suitable TX protocol**
   1.1. Movement capturing: Will use hand-mounted gyroscope
   1.2. Power Routing: Will be realized via custom PCB
   1.3. TX protocol: Segments/multiplexes data for TX and RX between Flight Glove and Demo Aircraft via existing or proprietary communication protocol
      - Ideally, this would allow for modularity towards new/custom applications, as well as being able to interface with existing platforms/protocols
2. **Demo Aircraft: Receives encoded data from Flight Glove and converts this into actuation signals**

Block Diagram - Flight Glove (Hardware)



Block Diagram - MCU/Data Flow (Software)



Protocol Selection - Pseudocode

```
#include protocolTX.h
void loop(){
        transmit(data);
}
void transmit(data){
        PWM(data);
        //PPM(data);
        //CCPM(data);
        //DSM(data);
        //IBUS(data);
        //SBUS(data);
}
```

Defined in “protocolTX.h”

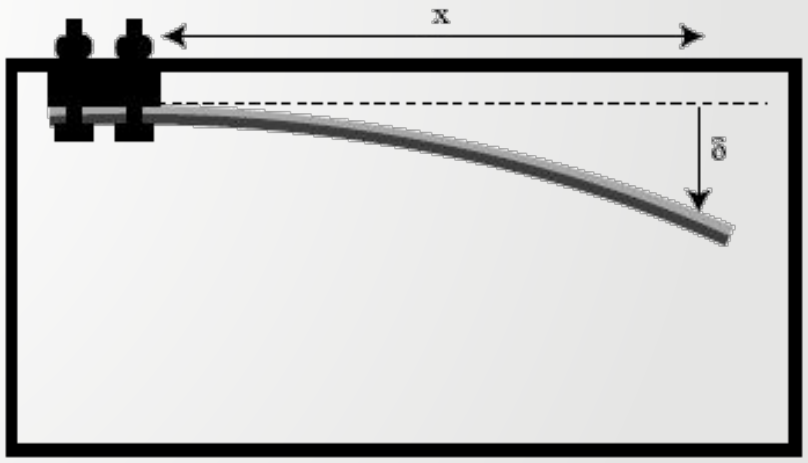
- **User would uncomment desired protocol**
- **Custom protocols could be added to “protocolTX.h” file for use**
- **This sets up the modularity framework, even if it’s not *fully* implemented for the project**
  - E.g. Even if we’re not able to create a comprehensive “protocolTX.h” file, one could still theoretically implement any protocol if they wish to define it themselves

Potential Challenges

- **Signal encoding & modularity**
  - How will we approach data encoding such that GyroGlove is able to “mimic” the signals generated by multiple different TX protocols?
  - How will we ensure that GyroGlove can be compatible with different types of aircraft, regarding both hardware and software components?
  - What requirements does an aircraft have to meet in order to be compatible with GyroGlove, and the FCC regulations?
- **Demo aircraft**
  - If required due to budgeting constraints, what considerations need to be taken into account when designing/building a custom aircraft (RC plane)?

MDR Goals

1. Have the ability to read the gloves gyro serial data on a monitor
2. Be able to control all and fully move servos on the plane from the RC receiver
3. Have designs and preliminary prototype for stress sensor to control the throttle of the plane



Rough Preliminary Cost Estimate

- **Beagleboard MCU - $65**
- **Strain Gauge - $21**
- **Nitrile ESD Glove - $7**
- **Hi-Precision Gyroscope - $20**
- **Push Button - $6 per pack**
- **Custom PCB - $25**
- **600mW Video Transmitter - $26**
- **Video Screen (Receiver) - $20**
- **Transceiver Module (x5) - $100**
- **Barometer - $15**

- **Demo Aircraft (kit)[1] - $110**
  - Servo
  - Motor
  - ESC

Total: ~$415

->> Cut down on costs by creating custom aircraft body?

->> Cut down on costs by using cheaper MCUs?

->> ie. arduino nano

[1] To demo this project, we will use an RC plane as our aircraft.

HAPTIC FEEDBACK (Time Permitting...)

1. **Introduction:**

- **Simulating the sense of touch or feeling, in our project, we want to simulate the vibration caused by the wind, and the 'resistance' of the plane.**

2. **Project Description:**

- **Attempting to use on the glove after finishing RC**
- **What type of feedback is uncertain! :**
  - **Tactile Feedback: Act as like sensors.**
  - **Force Feedback: Motorized the motion, resistance**

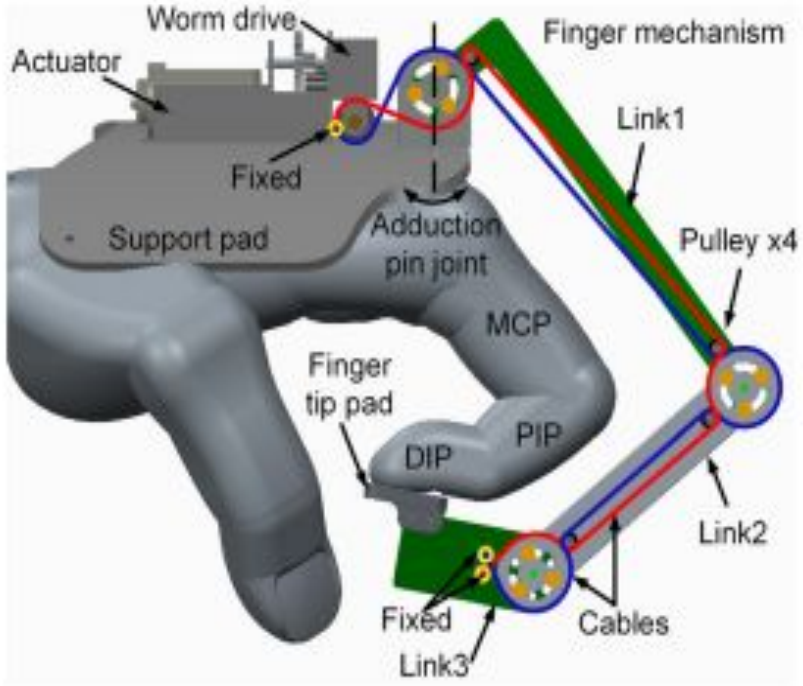


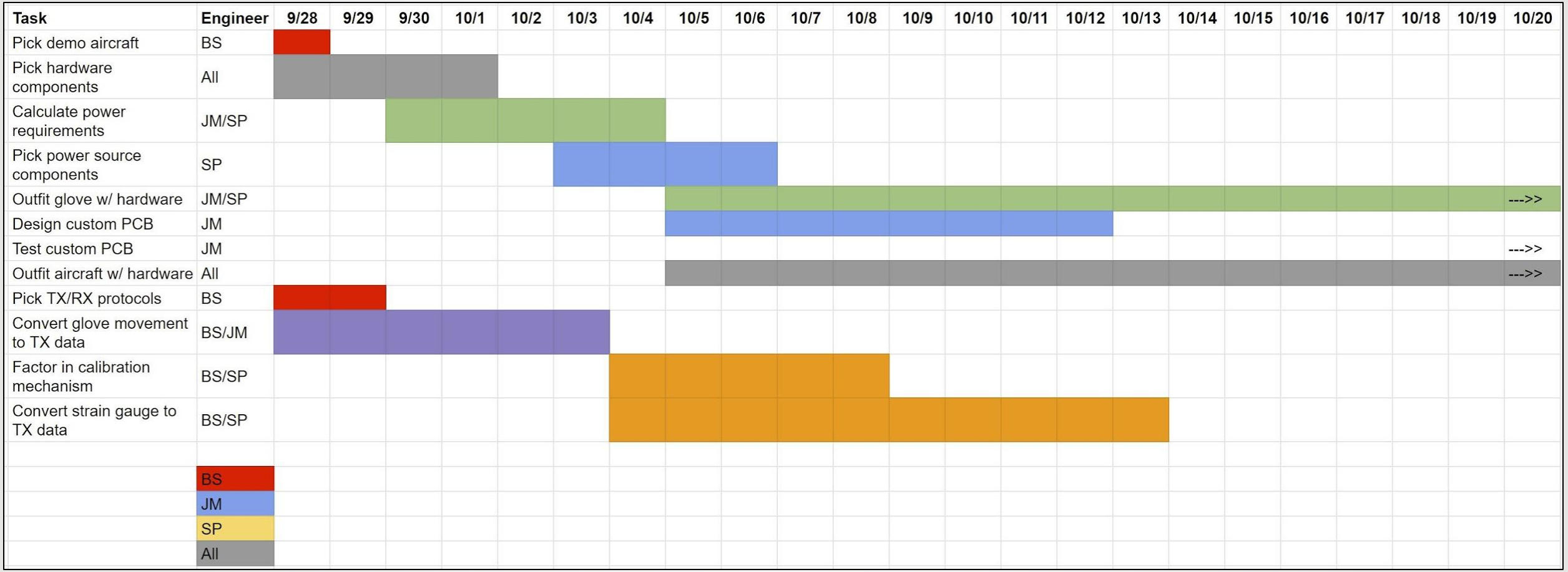
Fig. 2 CAD model of the index finger mechanism of the glove

Responsibilities

Bradley	Jacob	Son

- Primary software lead
  - Will develop software architecture and implement MCU functions
- Will work with Jacob to design modular signal encoding technique
- Will implement modular signal encoding technique
- Will provide hardware support as needed
	- Secondary software lead
	  - Will provide insight regarding hardware/software interface
	- Will design custom power routing PCB & coordinate with PCB fab house
	- Will work with Bradley to design modular signal encoding technique
	- Will provide software support as needed
		- Secondary software lead
		  - Will provide insight regarding hardware/software interface
		- Will pick hardware components and determine respective power requirements
		- Will design glove hardware layout
		- Will provide software support as needed

Gantt chart


Task
Engineer
9/28
9/29
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10/9
10/10
10/11
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10/14
10/15
10/16
10/17
10/18
10/19
10/20
Pick demo aircraft
BS
Pick hardware components
All
Calculate power requirements
JM/SP
Pick power source components
SP
Outfit glove w/ hardware
JM/SP
--->>
Design custom PCB
JM
Test custom PCB
JM
--->>
Outfit aircraft w/ hardware
All
--->>
Pick TX/RX protocols
BS
Convert glove movement to TX data
BS/JM
Factor in calibration mechanism
BS/SP
Convert strain gauge to TX data
BS/SP
BS
JM
SP
All

Reference

All the papers and images used for presentation are in our Google Drive Folder

https://drive.google.com/drive/u/1/folders/1XaEm85V7oxypnJD0gEVh795xm4RhIrzb

FCC standards and regulations:

https://www.faa.gov/uas/media/Part_107_Summary.pdf


Questions?
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