The goal of this project is to make a wearable glove that connects to any computer, laptop or smartphone device wirelessly via the Bluetooth 4.0 Low Energy Standard. Currently, the prototype is in its final stages of testing to meet the proposed objectives with some changes to the schedule.

1.0 Table of Performance Metrics

ID	FEATURE	RANGE	COMPLETED
1	All components must fit on all standard glove sizes (XS-XL)	Yes/No	Yes (L)
2	Design is able to send/receive information using the Bluetooth LE standard	Yes/No	Yes (nRF52 Bluetooth Module)
3	Design can move mouse cursor on a computer using hand movements	Yes/No	Yes (controlled by BNO055)
4	Design can perform mouse clicks on a computer using hand movements	Yes/No	Yes (Left and Right Click triggered by Flex)
5	Design can scroll/pan on a computer using hand movements	Yes/No	Yes (controlled by BNO055)
6	Design is able to be used in a 3D axis application	Yes/No	Yes (Windows 10 Application)
7	Design is powered by a portable power source	Yes/No	Yes (3.7V 110mAh LiPo battery)
8	User is able to turn on/off device to reduce power consumption	Yes/No	Yes (Switch)
9	Battery Life Specifications	> 2 hours	Yes (2h 20m)
10	Battery State of Charge Indicator	Percentage, or Segments/Low Warning	Yes (Green, Yellow, Red, with varying brightness)
11	Haptic feedback on mouse clicks	Yes/No	Yes (3V motor)
12	Hand gestures to enable laser pointer aid for presentations	Yes/No	Yes (triggered by pressure sheets)

2.0 Summary of Changes to Design:

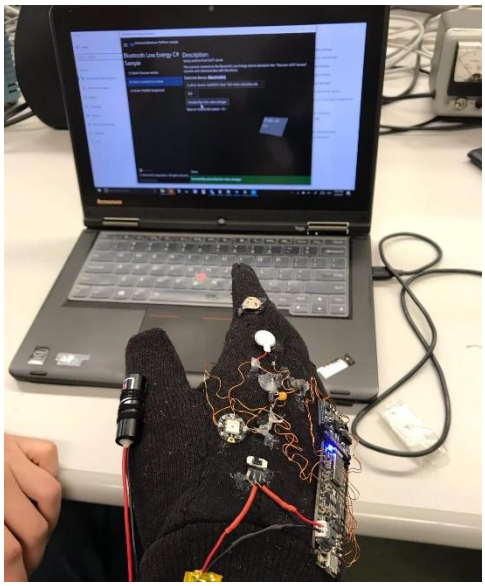
One of the major changes from the previous design review was the prototype fabric. A 100% cotton glove (L) was bought to replace the former nylon material since it produces unwanted static charge. This change led to dismantling the previous glove and reintegration and testing of all components. Jumper cables were substituted with insulated, enameled wires to secure connection. New flex sensors were tested for threshold values (A0 = 2.52V, A1 = 2.58V, A2 = 2.60V, A3 = 2.66V) and placed on the glove due to the older glove sensors being damaged in the process of their removal.

A different program for the nRF52 was written to communicate with the Windows 10 BLE example program. The nRF52 reads orientation angles and acceleration values from the BNO055 over I^2C. The acceleration values are high pass filtered to remove the gravity vector, then double integrated to obtain the position data. The position data is averaged over 5 samples and sent over the BLE UART service.

```
// EMA High Pass Filtering
// https://www.norwegiancreations.com/2016/03/arduino-tutorial-simple-high-pass-band-pass-and-band-stop-filtering/
EMA_S.x[0] = (EMA_a * accelSample.x[0]) + ((1 - EMA_a) * EMA_S.x[0]);
EMA_S.y[0] = (EMA_a * accelSample.y[0]) + ((1 - EMA_a) * EMA_S.y[0]);
EMA_S.z[0] = (EMA_a * accelSample.z[0]) + ((1 - EMA_a) * EMA_S.z[0]);

accelSample.x[0] = EMA_S.x[0];
accelSample.y[0] -= EMA_S.y[0];
accelSample.z[0] -= EMA_S.z[0];

// Naive integration with dt^2
posX += Kpos * dt * dt * accelSample.x[0];
posY += Kpos * dt * dt * accelSample.y[0];
posZ += Kpos * dt * dt * accelSample.z[0];
```

The Windows 10 application sample code was modified to support Adafruit's BLE UART service which allows it to receive commands for 3D applications.

```
1 reference | JohnChen, 15 days ago | 1 author, 3 changes
private void ParseCommand(string cmd)
{
    List<string> cmdList = new List<string>(cmd.Split('='));

    if (cmdList[0].Equals("eulerX"))
        bleRotationX = Convert.ToInt32(cmdList[1]);
    else if (cmdList[0].Equals("eulerY"))
        bleRotationY = Convert.ToInt32(cmdList[1]);
    else if (cmdList[0].Equals("eulerZ"))
        bleRotationZ = Convert.ToInt32(cmdList[1]);
```

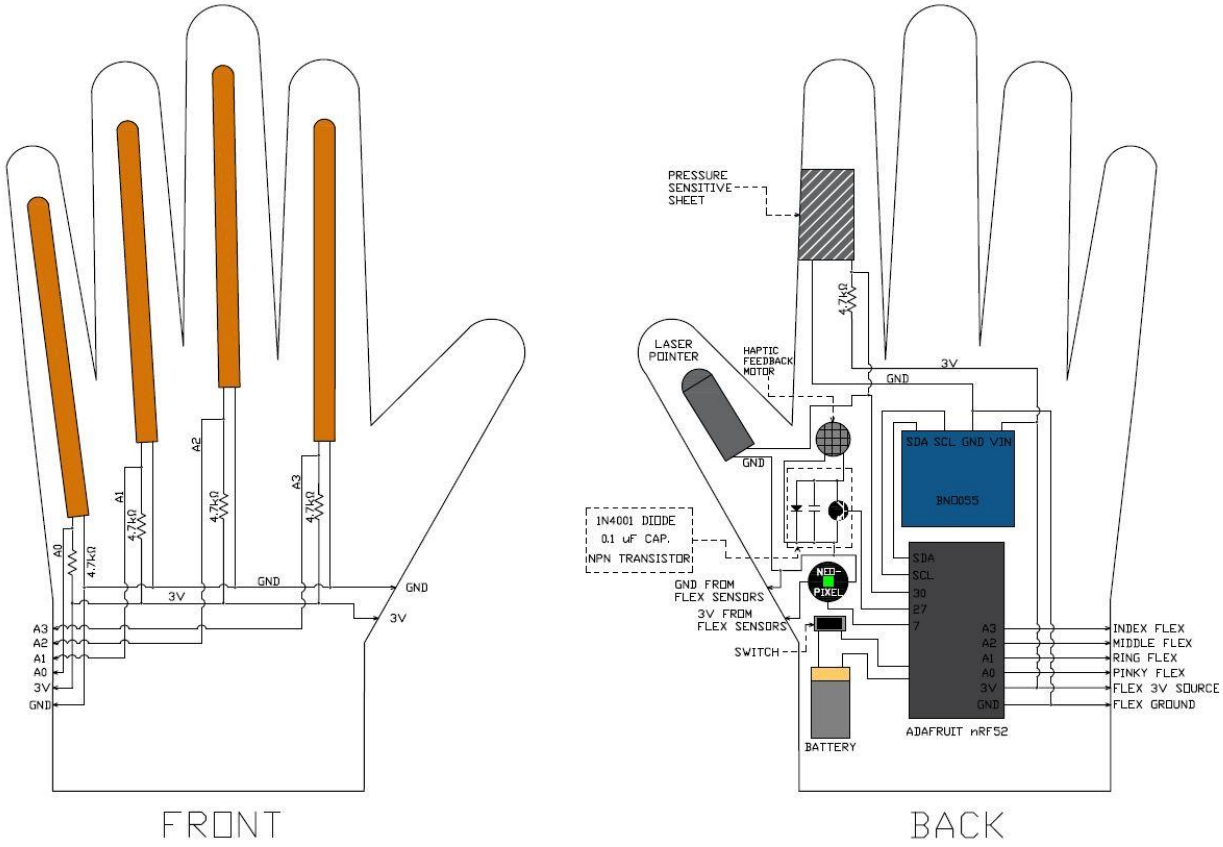


A panel window was added to the application to test the 3-D abilities of the Air Mouse. This demonstrates the rotational and spatial movement of the user's hand in the x, y and z axis in real time over Bluetooth LE. The state of charge can also be viewed from the Windows application.

A 650nm laser diode circuit was tested and added to this design to meet the requirements. Pressure sensitive sheets were reintroduced in the project as a control for the laser diode. The team also prepared a circuit to connect a haptic feedback motor to the glove. The motor is programmed to vibrate at every correctly executed left or right click.

3.0 Summary of Work to Complete and Detailed Timeline:

- **<u>Currently mouse cursor movement is working perfectly on the glove.</u>**
- Figure out how to improve spatial movement performance either by modifying the digital filter or introducing an additional component.



Improve battery life by reducing the Bluetooth transmit power from +4dBm to reduce the radio current consumption.

5.3.2. Radio Current Consumption (Transmitter)

Symbol	Description	Min.	Typ.	Max.	Units
$I_{TX,PLUS4dBM,DCDC}$	TX only run current (DCDC, 3V) P_{RF} =+4 dBm		7.5		mA
$I_{TX,PLUS4dBM}$	TX only run current P_{RF} = +4 dBm		16.6		mA
$I_{TX,MINUS20dBM,DCDC}$	TX only run current DCDC, 3V P_{RF} = -20 dBm		3.2		mA
$I_{TX,MINUS20dBM}$	TX only run current P_{RF} = -20 dBm		7.0		mA
$I_{TX,MINUS40dBM,DCDC}$	TX only run current DCDC, 3V P_{RF} = -40 dBm		2.7		mA

- Battery discharge curve.