Virtual Reality Tracking and Haptic Feedback Gloves

Team 513

Team Introductions

Alexandra Hollabaugh
Project Manager

Jonathan Roberts
Hardware Engineer

Alex Erven
Systems Engineer

Jake Kennedy
Test Engineer

Kevin Lindquist
Software Engineer

Sponsor and Advisor

Engineering Mentor
Jeffrey Payne, PE
Staff Mechanical Engineer

Academic Advisor
Jerris Hooker, Ph.D
Teaching Faculty / Senior Design Coordinator

Objective

The objective of the project is to make a pair of gloves for Lockheed Martin that allow for the user to train in a virtual reality Abrams tank. The design will reduce the cost and size of current simulation systems while still providing feedback to the user.

Figure 1: A Lockheed Martin F-35 Flight Simulator

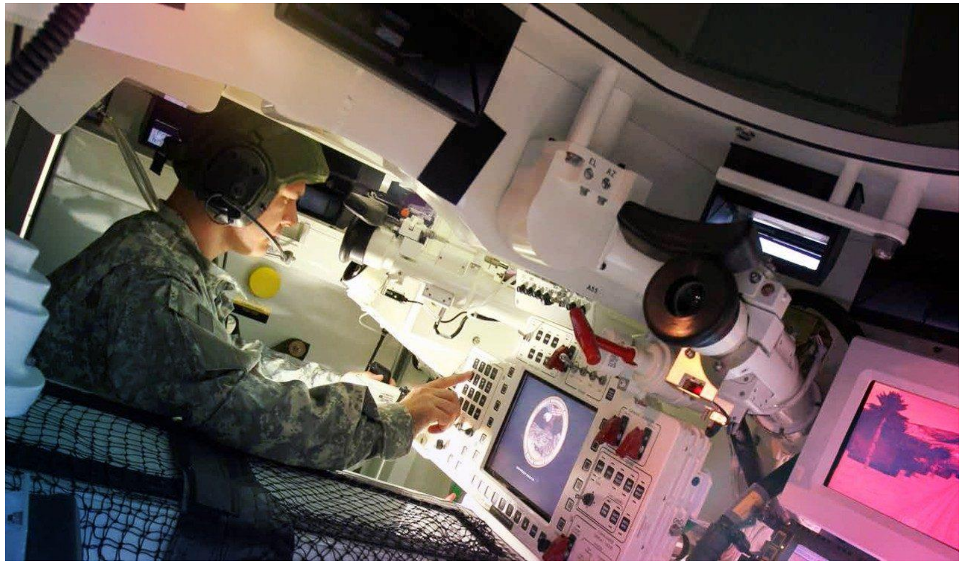


Figure 2: A Lockheed Martin M1A2 Tank Simulator

Project Background

Alex Erven

What is VR?

- VR stands for virtual reality and is a relatively new technology
- A headset allows for full emersion into a virtual world
- Wands are used as controllers to interact with the environment while providing limited feedback

Figure 3: HTC VIVE Pro Headset and Controller

Drawbacks of Existing VR Gloves

- Have numerous wires and tubes connected to the base
- Do not retain the ability to feel interactions with a non-virtual environment
- Use bulky tracking systems

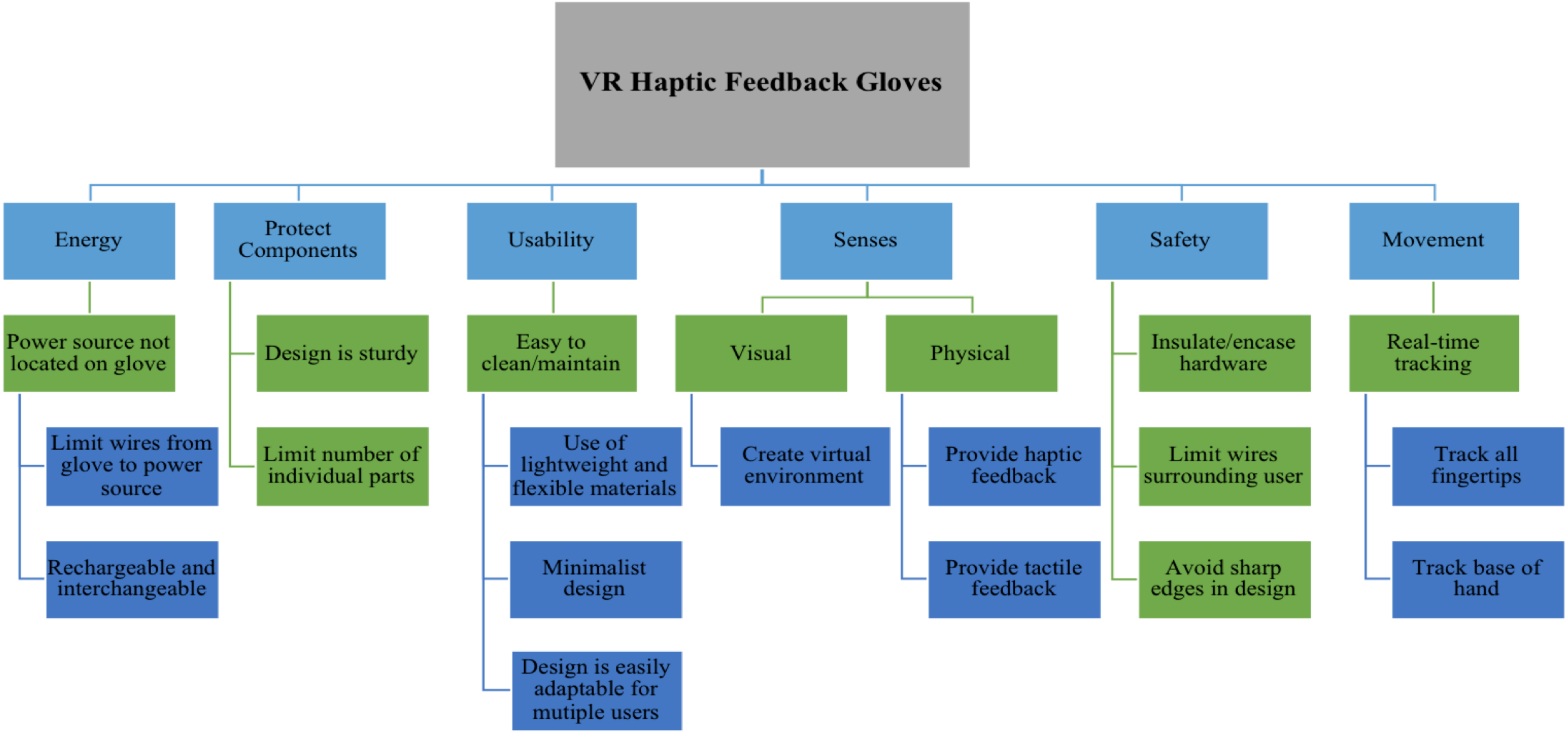
Figure 4: Example of current Haptic Feedback Glove. (HaptX glove)

Customer Needs

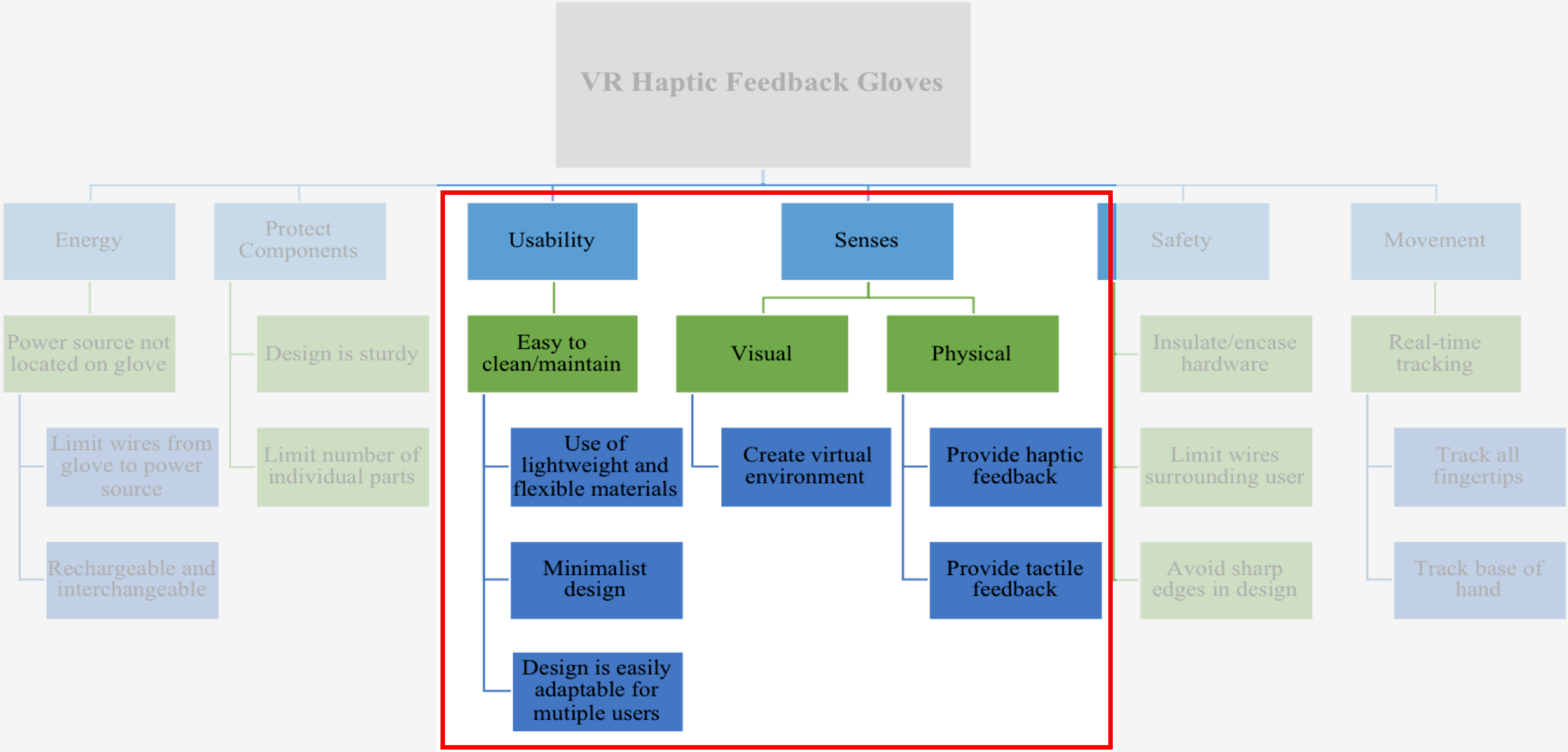
LOCKHEED MARTIN

- Provide haptic feedback when interacting with the virtual environment
- Provide tactile feedback when interacting with the real world
- Durable design while maintaining a low profile
- Able to easily transfer from one user to the next
- Allows for uninhibited range of motion
- Hypoallergenic and easily sanitized

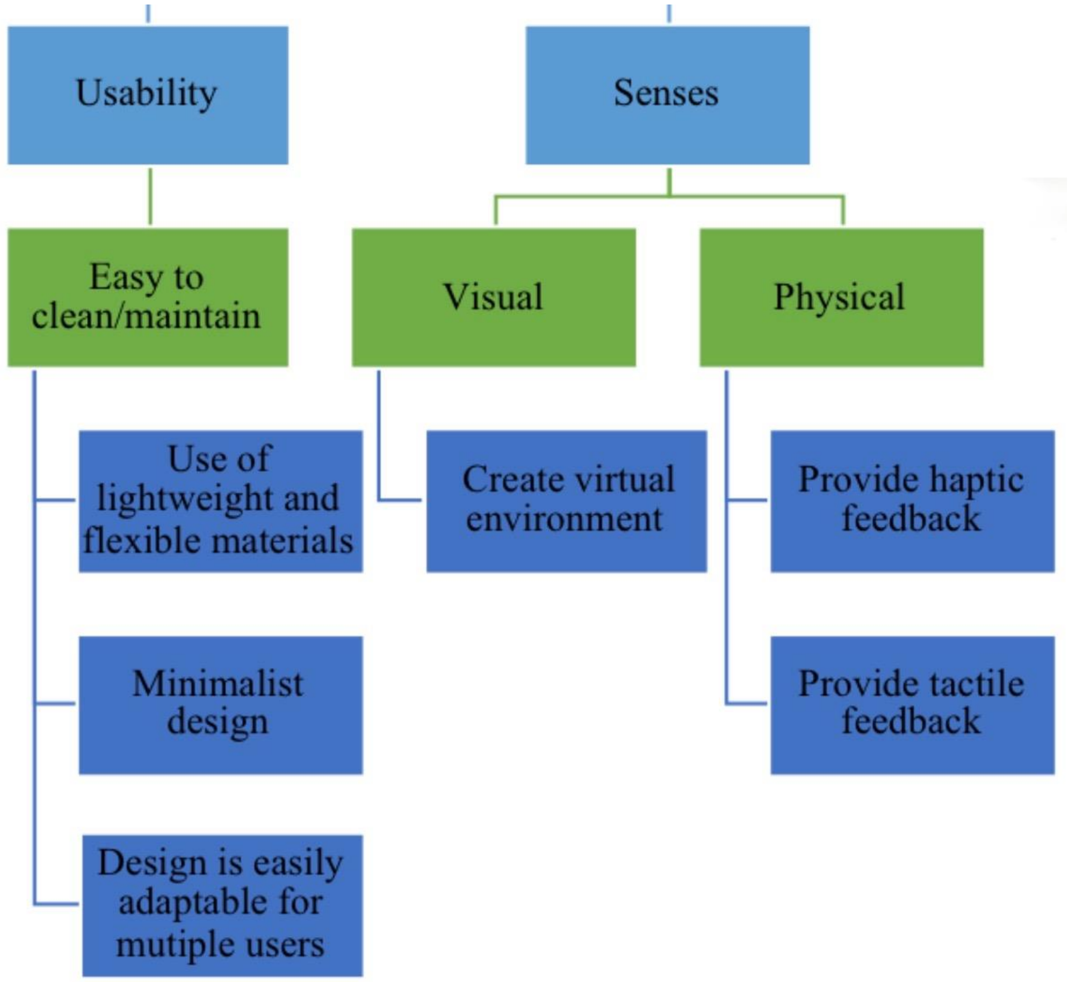
Functional Decomp



Functional Decomp

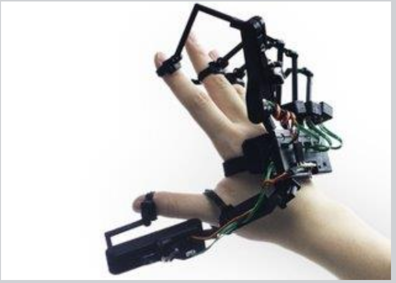


Functional Decomp



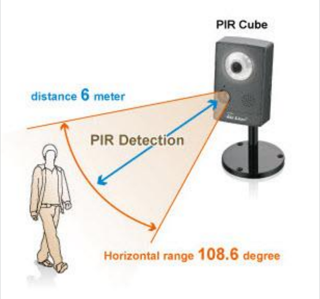
Concept Generation

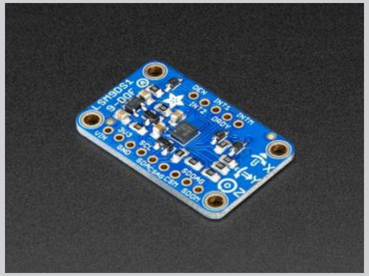
Haptic Feedback



Gloves

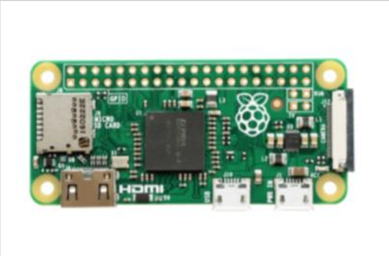
Tracking





Concept Generation

Microcontroller


Power Supply


Concept Selection

Table 1: Components Breakdown

Subsystem	Final Selection	Placement
Haptic Feedback	(10) Linear Resonant Actuators (LRA)	(1) on inside of each finger
Gloves	Fingerless gloves	N/A
Tracking	(10) 9-axis Inertial Measurement Units (IMU)	(1) on the back of each finger
Microcontroller	Raspberry Pi Zero	(1) on the back of each hand
Power Supply	Removable Rechargeable Battery	(1) on the back of each hand

Figure 5: Final concept components

Component Layout

1) Inertial Measurement Units (IMU)
2) Linear Resonant Actuators (LRA)
3) Battery & Microcontroller Encasement
4) Raspberry Pi Zero
5) Fingerless Gloves

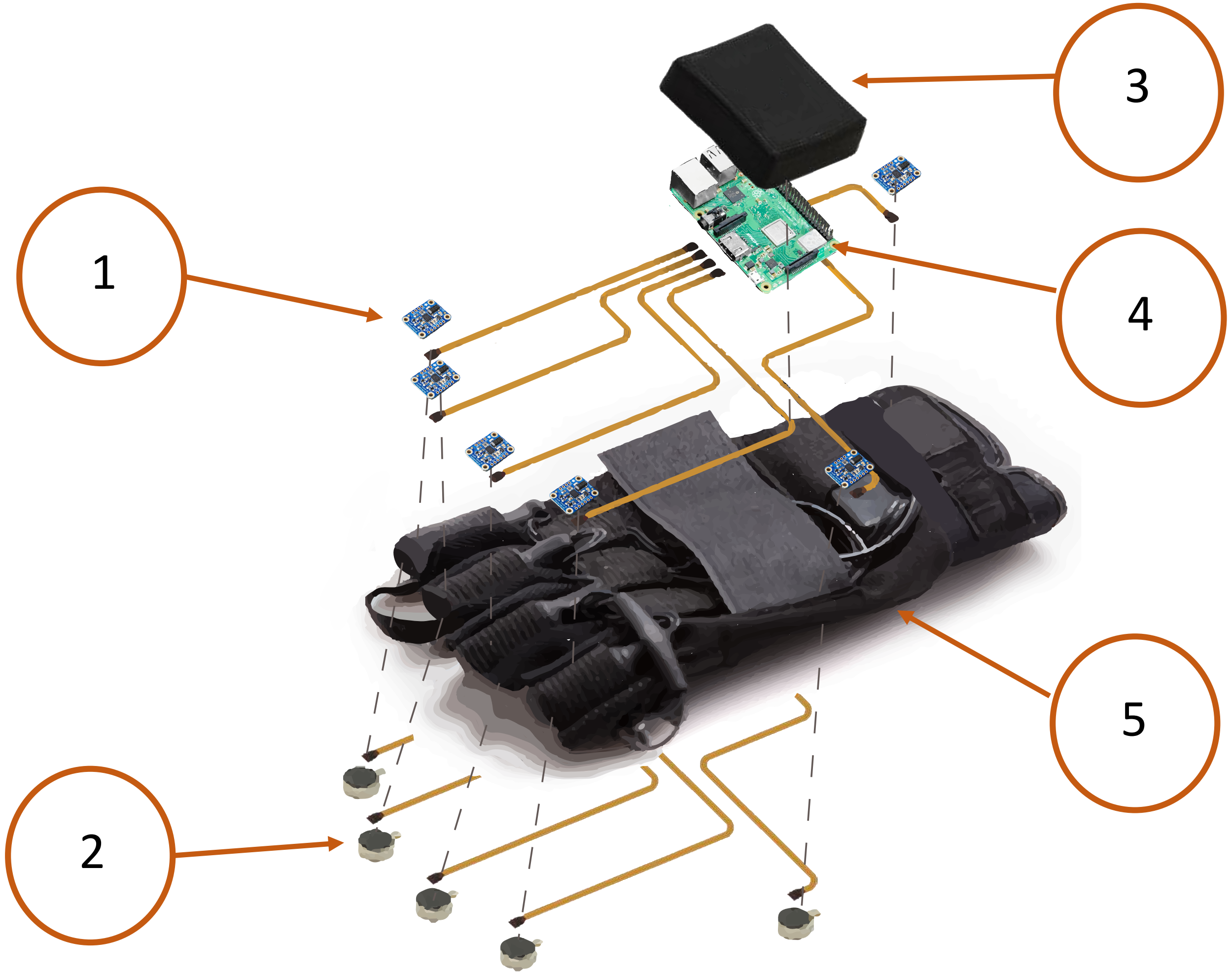


Figure 6: Layout of components for glove design

Testing

Kevin Lindquist

Component Layout Testing

LOCKHEED MARTIN

1) Inertial Measurement Units (IMU)
2) Raspberry Pi Zero
3) Linear Resonant Actuators (LRA)
4) Flex Sensors

Figure 7: Layout of components for glove design

Sensor & Unity Testing

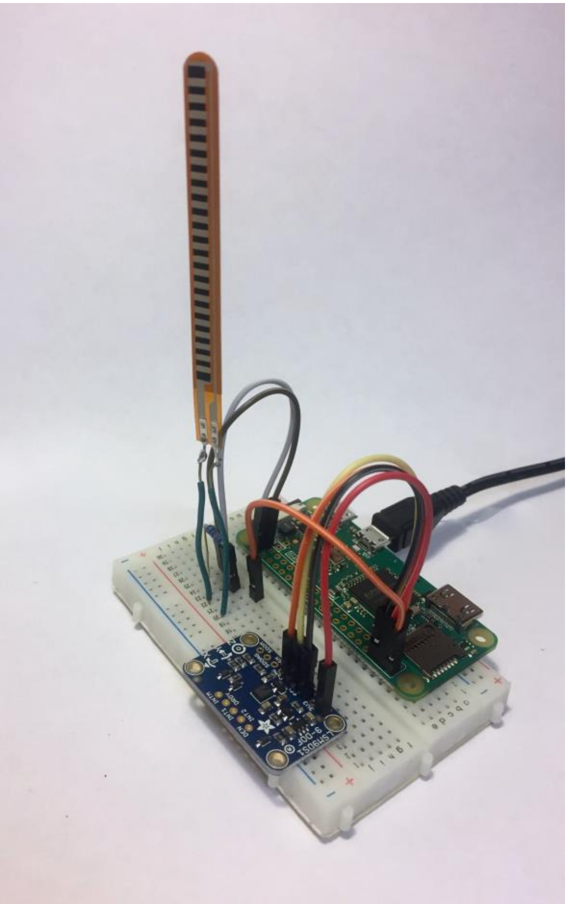


Figure 8: Inertial Measurement Unit & Flex Sensor Circuit

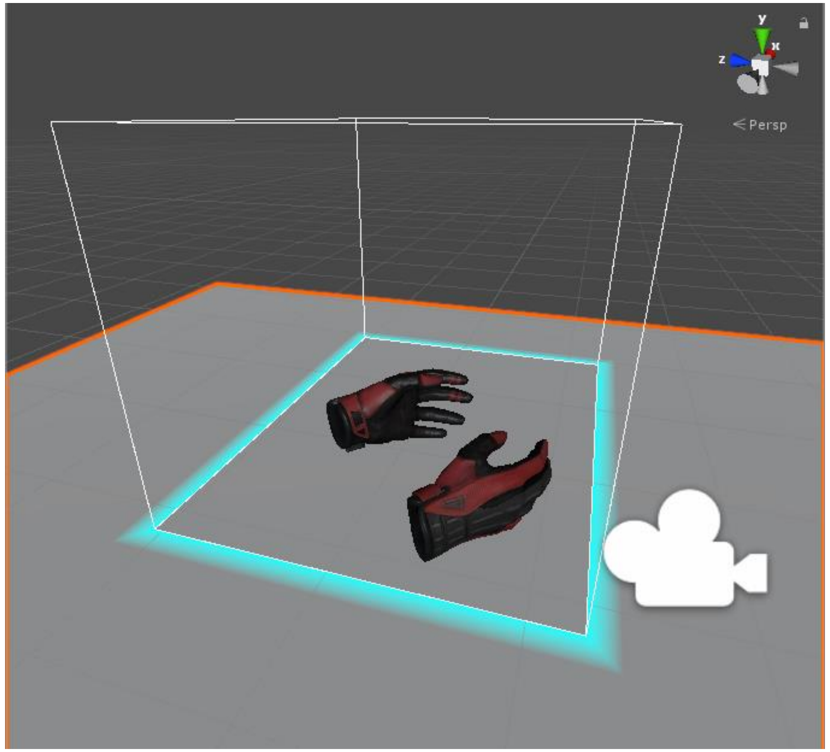


Figure 9: Hands In Unity VR Environment

```
20:25:02.269 -> G: 3.60, 66.98, 4.66 DPS
20:25:02.269 -> A: -0.62, -0.13, 0.92 g
20:25:02.269 -> M: -0.27, 0.11, -0.27 gauss
20:25:02.269 -> Pitch, Roll: 33.66, -8.29, Heading: 331.21
20:25:02.512 -> G: 21.27, 60.14, 4.29 DPS
20:25:02.512 -> A: -0.24, -0.17, 0.92 g
20:25:02.512 -> M: -0.19, 0.14, -0.39 gauss
20:25:02.512 -> Pitch, Roll: 14.24, -10.47, Heading: 317.47
20:25:02.754 -> G: -15.27, 34.09, 13.80 DPS
20:25:02.754 -> A: 0.06, -0.21, 0.88 g
20:25:02.754 -> M: -0.08, 0.16, -0.46 gauss
20:25:02.754 -> Pitch, Roll: -4.09, -13.43, Heading: 290.13
20:25:02.997 -> G: -16.30, 8.61, 6.84 DPS
20:25:02.997 -> A: 0.02, -0.10, 1.02 g
20:25:02.997 -> M: -0.10, 0.13, -0.44 gauss
```

```
21:27:05.400 -> Flex sensor reading: 982
21:27:05.503 -> Flex sensor reading: 771
21:27:05.606 -> Flex sensor reading: 735
21:27:05.708 -> Flex sensor reading: 710
21:27:05.812 -> Flex sensor reading: 673
21:27:05.915 -> Flex sensor reading: 567
21:27:06.019 -> Flex sensor reading: 425
21:27:06.123 -> Flex sensor reading: 269
21:27:06.192 -> Flex sensor reading: 319
21:27:06.297 -> Flex sensor reading: 255
21:27:06.401 -> Flex sensor reading: 288
```

Figure 10: Reading Data From Sensors

Project Management

Kevin Lindquist

Targets

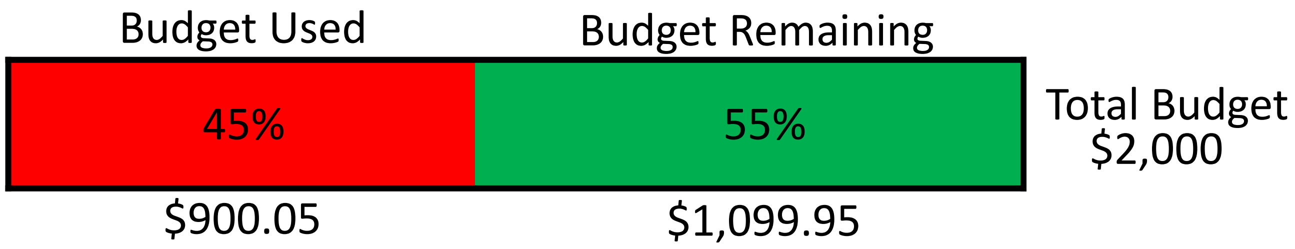
Table 2: Most Important Targets and Metrics

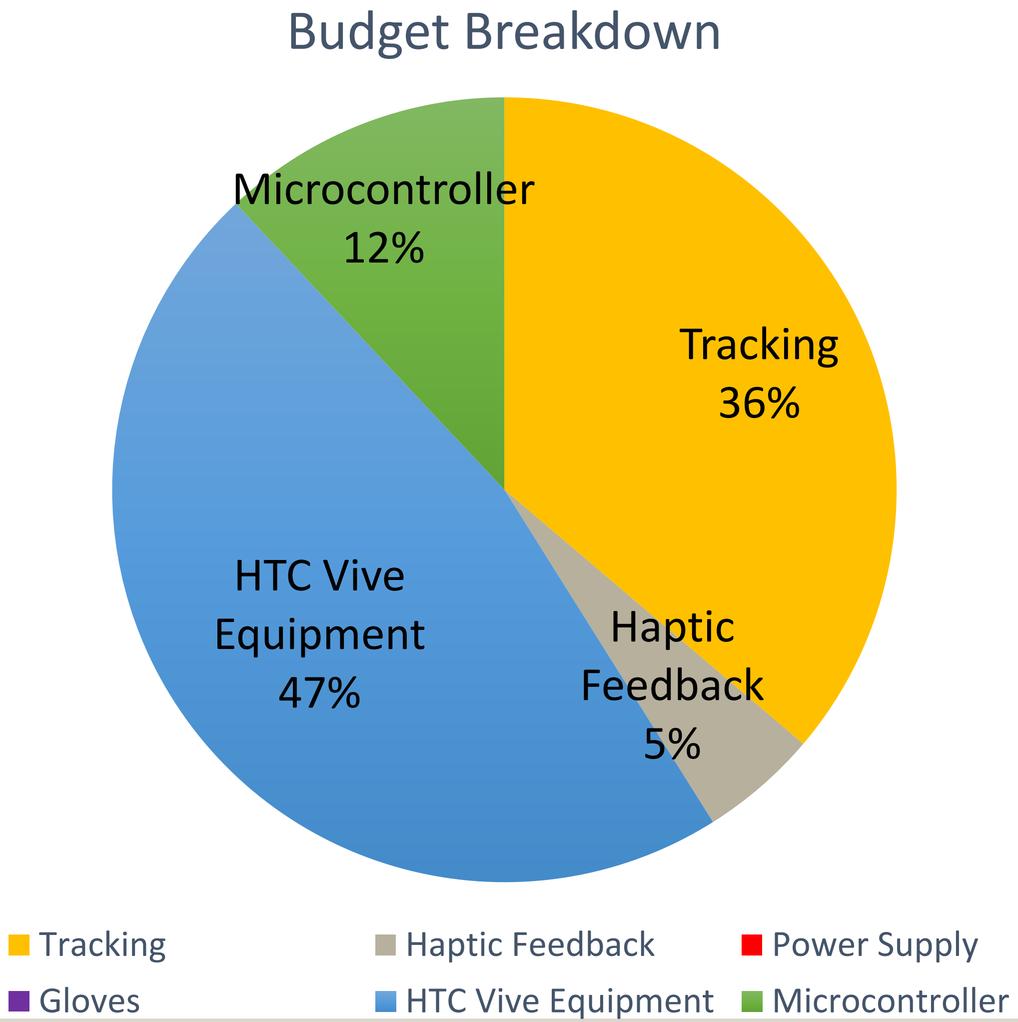
Metric	Target
System latency	20 milliseconds
Tactile feedback	Sensation of touch retained
Haptic feedback	Physical response to interaction with virtual environment

- From the customer needs the following targets were determined
- These were then used to determine the engineering characteristics

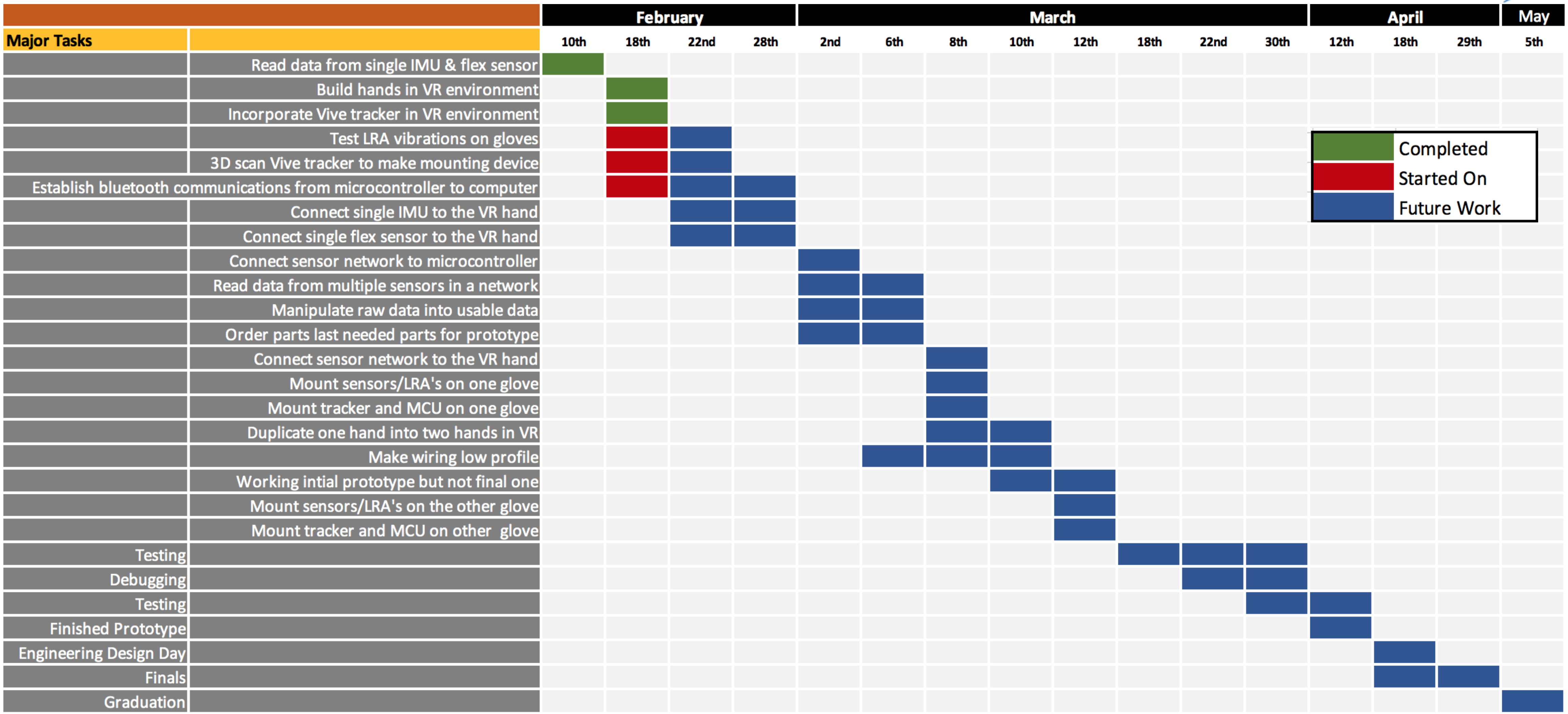
Budget Report

LOCKHEED MARTIN





Timeline



Major Tasks
February
March
April
May
10th
18th
22nd
28th
2nd
6th
8th
10th
12th
18th
22nd
30th
12th
18th
29th
5th
Read data from single IMU & flex sensor
Build hands in VR environment
Incorporate Vive tracker in VR environment
Test LRA vibrations on gloves
3D scan Vive tracker to make mounting device
Establish bluetooth communications from microcontroller to computer
Connect single IMU to the VR hand
Connect single flex sensor to the VR hand
Connect sensor network to microcontroller
Read data from multiple sensors in a network
Manipulate raw data into usable data
Order parts last needed parts for prototype
Connect sensor network to the VR hand
Mount sensors/LRA's on one glove
Mount tracker and MCU on one glove
Duplicate one hand into two hands in VR
Make wiring low profile
Working intial prototype but not final one
Mount sensors/LRA's on the other glove
Mount tracker and MCU on other glove
Testing
Debugging
Testing
Finished Prototype
Engineering Design Day
Finals
Graduation
Completed
Started On
Future Work

Acknowledgments

- Thank you to Lockheed Martin for their sponsorship
- Thank you to Jeff Payne and Adam Bojanowski of Lockheed Martin for their guidance and direction
- Thank you to Dr. Hooker for his expertise on our project

References

Burnett, Richard. “Lockheed F-35 Training Work Gets Big Boost.” *OrlandoSentinel.com*, 18 Aug. 2014, www.orlandosentinel.com/news/os-lockheed-f35-simulator-contract-20140818-story.html.

Catanzarite, M. (n.d.). Lockheed Martin displays fighter jet simulator for Arconic employees, Rep. Walorski. Retrieved from https://www.wndu.com/content/news/Lockheed-Martin-displays-F-35-simulator-for-Arconic-employees-Rep-Walorski-489797411.html

Lee, N. (2017, November 20). HaptX promises to make your virtual hands feel like real ones. Retrieved from https://www.engadget.com/2017/11/20/haptx-gloves-vr/

Horsey, J. (2018). *HTC Vive Pro Headset Unveiled Offering Improved Audio And Higher Resolution - Geeky Gadgets*. [online] Geeky Gadgets. Available at: https://www.geeky-gadgets.com/htc-vive-pro-headset-09-01-2018.eky-gadgets.com/htc-vive-pro-headset-09-01-2018/

Horsey, J. (2014). *Dexmo Exoskeleton Provides Touch Feedback In Virtual Worlds.* [online] *Geeky Gadgets*. Retrieved from https://www.geeky-gadgets.com/dexmo-exoskeleton-provides-touch-feedback-in-virtual-worlds-27-10-2014/

Holley, R. (2017). *The least painful way to set up HTC Vive Lighthouses.* [online] *VR Heads.* https://www.vrheads.com/least-painful-way-set-htc-vive-lighthouses

Senso Glove. (n.d.). Retrieved from https://senso.me/