P11 Arm Exoskeleton

Team Members:

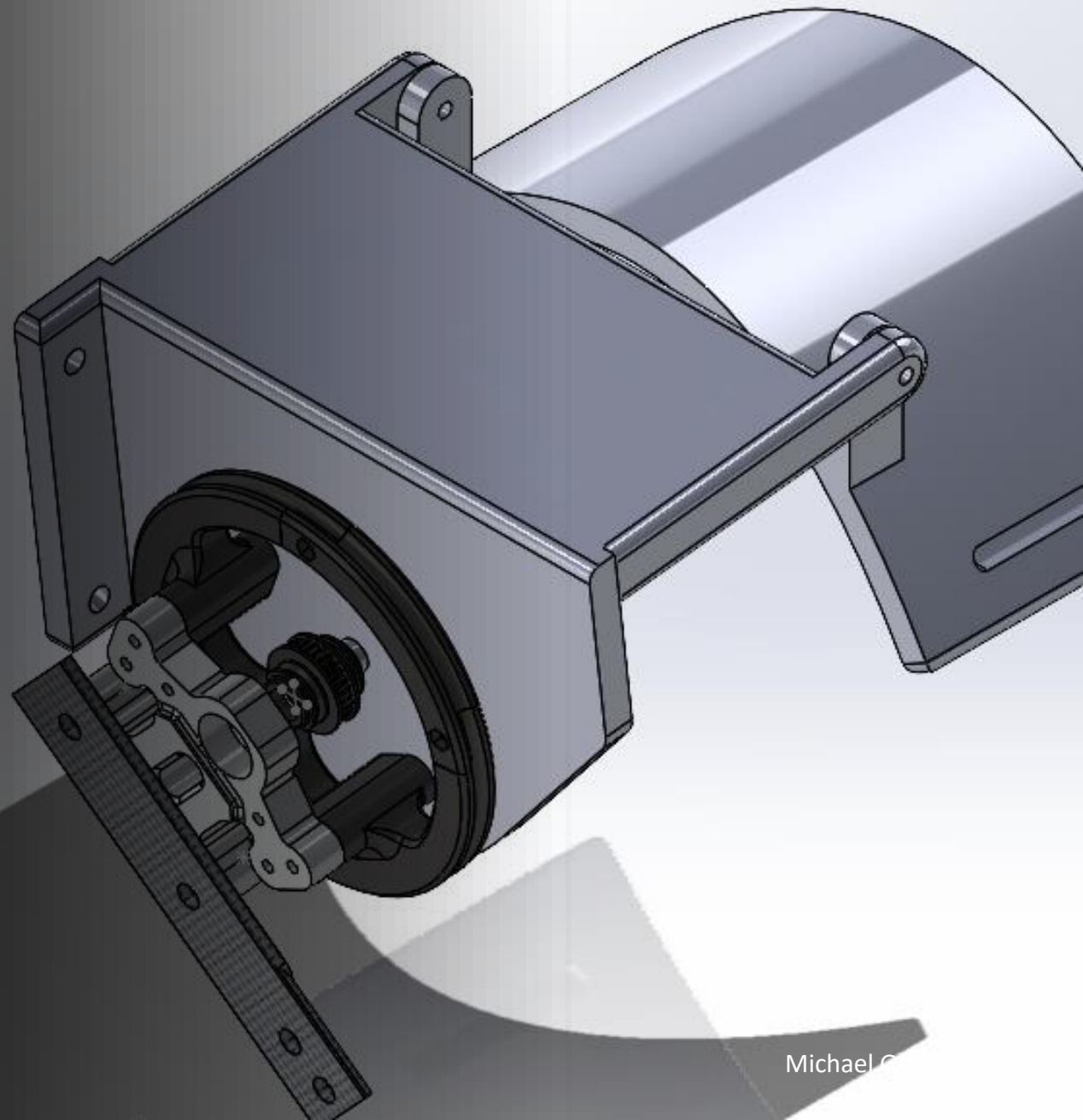
Michael George

Michael Marchica

Dylan Kurz

Colin Cipolla

Jordan Finger



Description of Project

- To improve upon and design a new version of the upper body arm exoskeleton called the Myoshirt, designed by ETH Zürich. The suit will assist the user's task of completing pull-ups and other daily activities.
  - Increase the number of pull-ups by 20%.
  - Lightweight: Must be </= 6lbs
  - Low profile: Cannot extrude >10 cm off the body.
- Client: Dr. Zachary Lerner
- Sponsor: W.L. Gore
  - Budget: $3,750

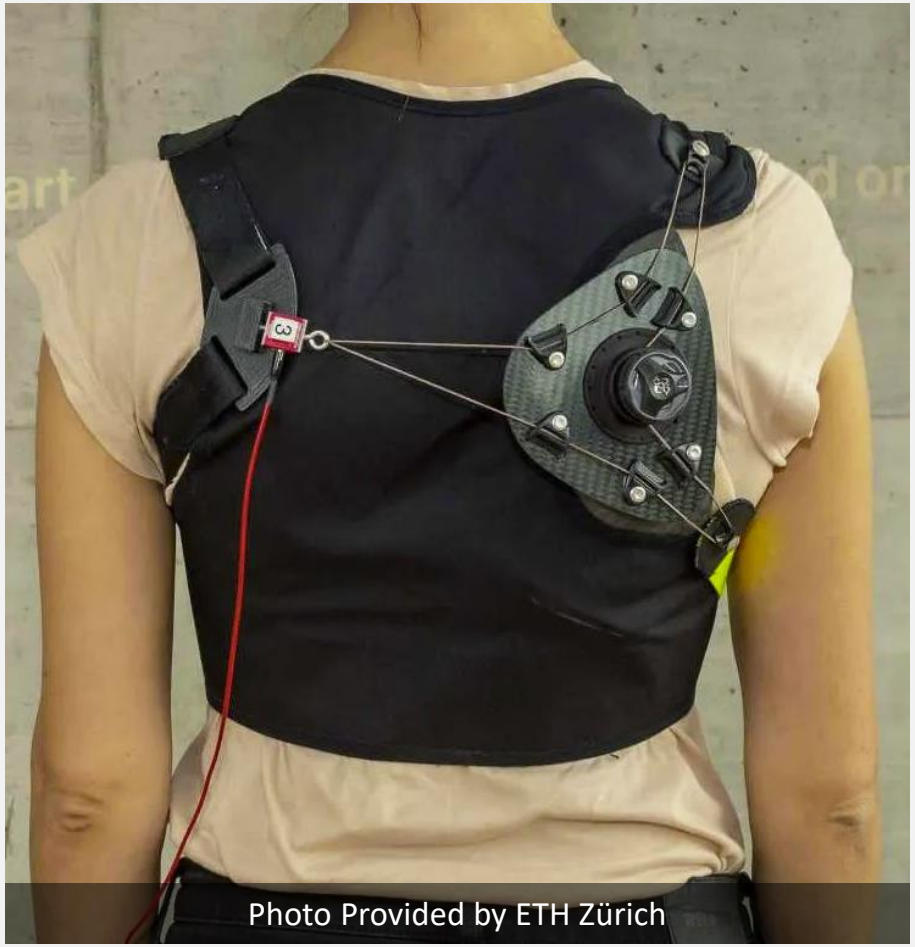


Photo Provided by ETH Zürich

Prototype, CAD Package and BOM

- Shoulder Plate
- Hinge Bearing Plate
- Flat Anchor
- Shoulder Lever
- Large Pulley Lever Bridge
- Large Pulley

Michael
Marchica 3

Design Description

- Current Design features a pulley cable system.
  - A shoulder plate is worn allowing for comfortable and effective rotation of the pulley.
  - A hinge plate is worn on the top of the shoulder to allow for lateral movement.
  - The cables flow along the outer arm and will connect to motors on the back.
  - A bicep cuff is worn to provide needed stability. The cuff was designed to integrate flawlessly into an existing elbow exoskeleton.

Design Function Description

(1) System On

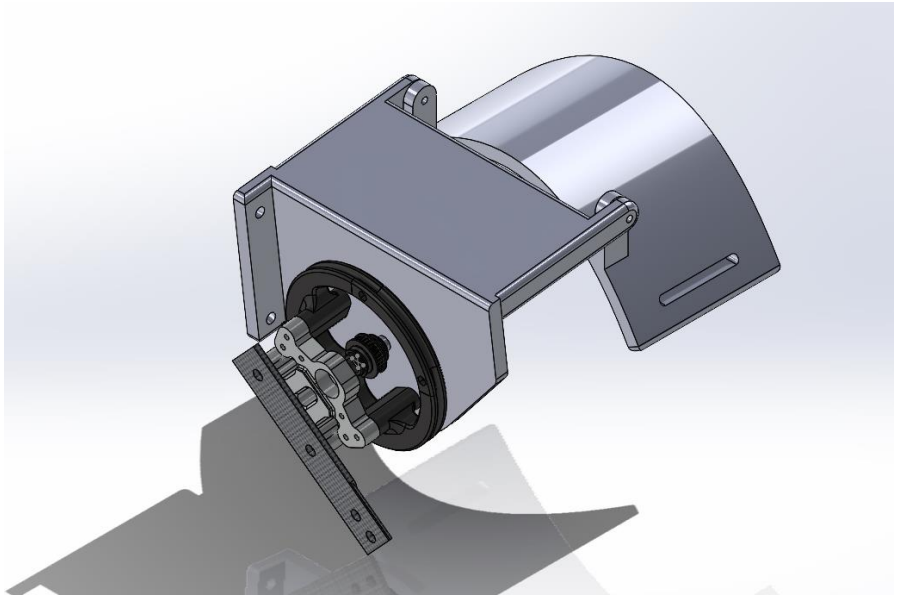
(2) Clockwise or counterclockwise rotation of motor depending on if the arm wants to be raised or lowered, also dependent on which side of the body.

(3) One of the cables within the pulley will be applied with tension causing movement.

(4) Once the arm is lifted, the elbow subsystem will need to be integrated to perform a pull-up.

(5) Pull-up ascent and descent

(6) System Off



Assembly

Design Requirements

Customer Requirements

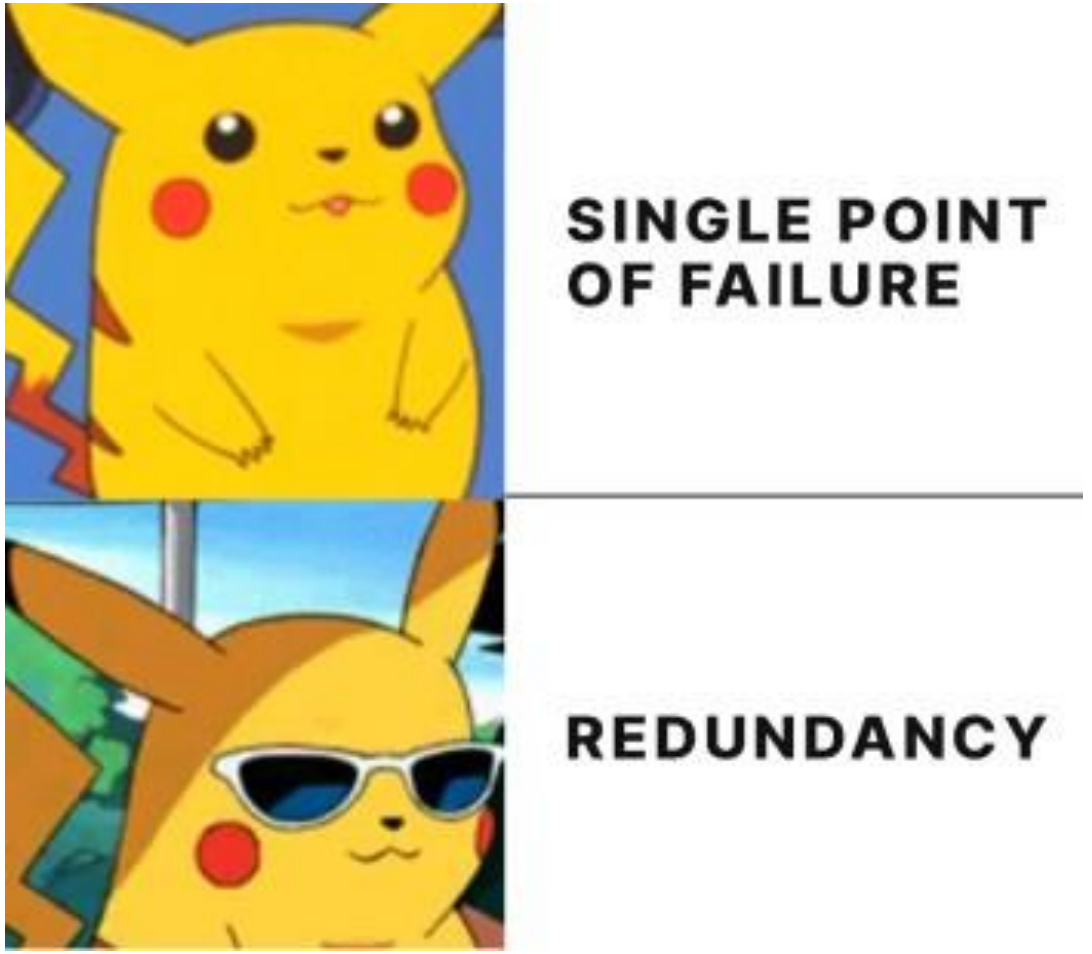
- Low Profile – Protrude less than 10cm (~4in)
- Lightweight – Less than 6lbs
- Cable Driven
- Portable – Design functions from the user's body and no stationary machines
- Comfort – Wearable constantly w/o hindering quality of life

Proof

- Design is made from mostly PLA (i.e., very lightweight)
- Design only protrudes ~7cm off the body
- Power output comes from motor
- All components are on the body
- Comfort is an issue; additional padding will be implemented in future iterations

Design Validation

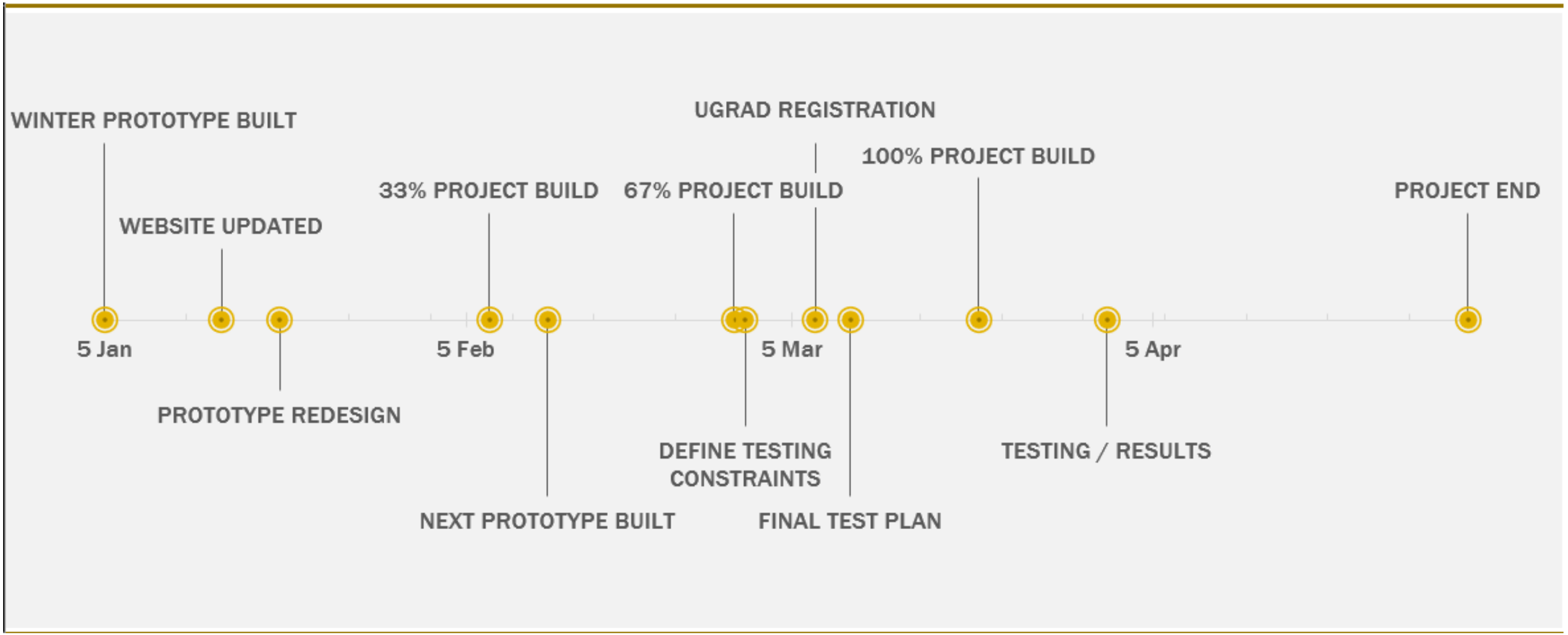
- Potential Failure Points:
  - Large Pulley Bridge – Prototype is JB welded; final design will need to be hard mounted.
  - Cable Through Holes – Current design allows for a lot of friction between the cables and shoulder mount while operating. (PLA may melt depending on the amount of heat generated from friction. PLA melts between 60-65°C, Oynx melts at 145°C).
  - Hinge Points - The prototype may not allow for enough or too much movement along the hinge points because of the connection.



Design Validation Continued

- Testing Procedures:
  (1) Operate suit without a user – Ensure it runs properly
  (2) Test suit on a volunteer without a pull-up bar.
    - Ensures a smooth and comfortable operation.
  (3) Obtain subjects base pull-up amount as a control.
  (4) Test and measure any increases in the number of pull-ups.
  (5) Reevaluate based on results and repeat
    - Only equipment required is the design with all its components and a pull-up bar.

Anticipated Schedule - Spring 2023



Budget

- None of the project's budget has been utilized so far
  - The prototype was made with already owned materials (i.e., PLA, old backpack, etc.).
- The total budget is $3,750. The team anticipates about $1,000 in expenses within the following weeks.
  - 2 Motors ~ $600
  - Carbon Fiber Filament ~$150
  - Onyx Filament ~$150
  - Other Materials ~ $100

Bill of Materials:	Quantity:		Total Cost:
Shoulder Plate	1	Manufactured	$1.00
Hinge Plate	1	Manufactured	$1.00
Large Pulley	1	Manufactured	$0.50
Large Pulley Bridge	1	Manufactured	$0.10
Pulley Flat Anchor	1	Manufactured	$0.25
Lever Arm	1	Manufactured	$0.10
Tube Spacer	1	Manufactured	$0.50
Shoulder Tube	1	Manufactured	$0.25
Bicep Cuff	1	Manufactured	$1.00
Bicep Mount Upper	1	Manufactured	$0.10
Bicep Mount Lower	1	Manufactured	$0.10
6-32 x1in Bolts	8	Buy-Out	$1.38
6-32 Nut	8	Buy-Out	$1.38
#6 Washers	12	Buy-Out	$1.38
6-32 Nylock Nuts	4	Buy-Out	$1.38
4-1 1/2 Sheet Metal Screws	4	Buy-Out	$1.38
8-32 x 1 1/2 Bolts	8	Buy-Out	$1.38
8-32 x 1 Bolts	8	Buy-Out	$1.38
8-32 Nuts	4	Buy-Out	$1.38
8-32 Nylock	4	Buy-Out	$1.38
#8 Washers	12	Buy-Out	$1.38
		Total Cost of Prototype:	$18.70

References

1. "The myoshirt - daily life assistance for the Upper Limb," – *Sensory-Motor Systems Lab | ETH Zurich*. [Online]. Available: https://sms.hest.ethz.ch/research/current-research-projects/wearable-robots-for-assistance-and-rehabilitation/The%20Myoshirt.html.
2. M. Dežman, T. Asfour, A. Ude, and A. Gams, "Mechanical design and friction modelling of a cable-driven upper-limb exoskeleton," *Mechanism and Machine Theory*, 08-Feb-2022. [Online]. Available: https://www.sciencedirect.com/science/article/pii/S0094114X22000234.
3. M. A. Gull, S. Bai, and T. Bak, "A review on design of upper limb exoskeletons," *Robotics*, vol. 9, no. 1, p. 16, 2020.
4. "Design of a cable-driven arm exoskeleton (Carex) for neural rehabilitation," *IEEE Xplore*. [Online]. Available: https://ieeexplore.ieee.org/abstract/document/6174477.
5. Y. Mao, X. Jin, G. Gera Dutta, J. P. Scholz and S. K. Agrawal, "Human Movement Training With a Cable Driven ARm EXoskeleton (CAREX)," in IEEE Transactions on Neural Systems and Rehabilitation Engineering, vol. 23, no. 1, pp. 84-92, Jan. 2015, doi: 10.1109/TNSRE.2014.2329018.
6. S. J. Ball, I. E. Brown and S. H. Scott, "MEDARM: a rehabilitation robot with 5DOF at the shoulder complex," 2007 IEEE/ASME international conference on advanced intelligent mechatronics, 2007, pp. 1-6, doi: 10.1109/AIM.2007.4412446. https://ieeexplore.ieee.org/abstract/document/4412446?casa_token=e0lWWl4IxXQAAAAA:u5Rq0V6dipjlwatvKnxla13brHBQScWb49DvS
7. H. Ki et al., "Kinematic Data Analysis for Post-Stroke Patients Following Bilateral Versus Unilateral Rehabilitation With an Upper Limb Wearable Robotic System," in IEEE Transactions on Neural Systems and Rehabilitation Engineering, vol. 21, no. 2, pp. 153-164, March 2013, doi: 10.1109/TNSRE.2012.2207462. https://ieeexplore.ieee.org/document/6252060
8. *AK60-6 V1.1_AK series dynamical modular_robot dynamics_t-motor store-official store for T-Motor Drone Motor,ESC,Propeller*. [Online]. Available: https://store.tmotor.com/goods.php?id=1201.
9. T. Petrič, L. Peternel, J. Morimoto, and J. Babič, "Assistive arm-exoskeleton control based on human muscular manipulability," *Frontiers*, 01-Jan-1AD. [Online]. Available: https://www.frontiersin.org/articles/10.3389/fnbot.2019.00030/full.
10. X. Li, W. Li, and Q. Li, "Method, design, and evaluation of an exoskeleton for lifting a load in situ," *Applied Bionics and Biomechanics*, 25-May-2021. [Online]. Available: https://www.hindawi.com/journals/abb/2021/5513013/.
11. "Design, fabrication, and control of an upper arm exoskeleton ... - WVU." [Online]. Available: https://researchrepository.wvu.edu/cgi/viewcontent.cgi?article=7677&context=etd.
12. "Ssl.umd.edu," *ssl.umd.edu*. [Online]. Available: https://ssl.umd.edu/.
13. "An Exoneuromusculoskeleton for self-help upper limb rehabilitation ..." [Online]. Available: https://www.liebertpub.com/doi/10.1089/soro.2020.0090.
14. C. Vavra, "Exoskeleton helps arm-based physical therapy," *Control Engineering*, 07-Feb-2022. [Online]. Available: https://www.controleng.com/articles/exoskeleton-helps-arm-based-physical-therapy/.
15. "The rise of the exoskeletons | machine design." [Online]. Available: https://www.machinedesign.com/mechanical-motion-systems/article/21831817/the-rise-of-the-exoskeletons.
16. D. Chakarov, I. Veneva, M. Tsveov, and T. Tiankov, "New exoskeleton arm concept design and actuation for haptic interaction with virtual objects," *CyberLeninka*, 01-Jan-1970. [Online]. Available: https://cyberleninka.org/article/n/223018.
17. "DataSpace: Atlasarm: An exoskeleton arm for muscular rehabilitation patients and beyond," *Princeton University*. [Online]. Available: https://dataspace.princeton.edu/handle/88435/dsp0176537397p.

Thank you!

Any Questions?