HR 2 BREAKDOWN

TEAM: 19F13 Biomechatronic Hip Exoskeleton Team (BHET)

Due Date:
Friday, March 6, 2020 at 11:59pm

Pictures of the current state of the completed system thus far:

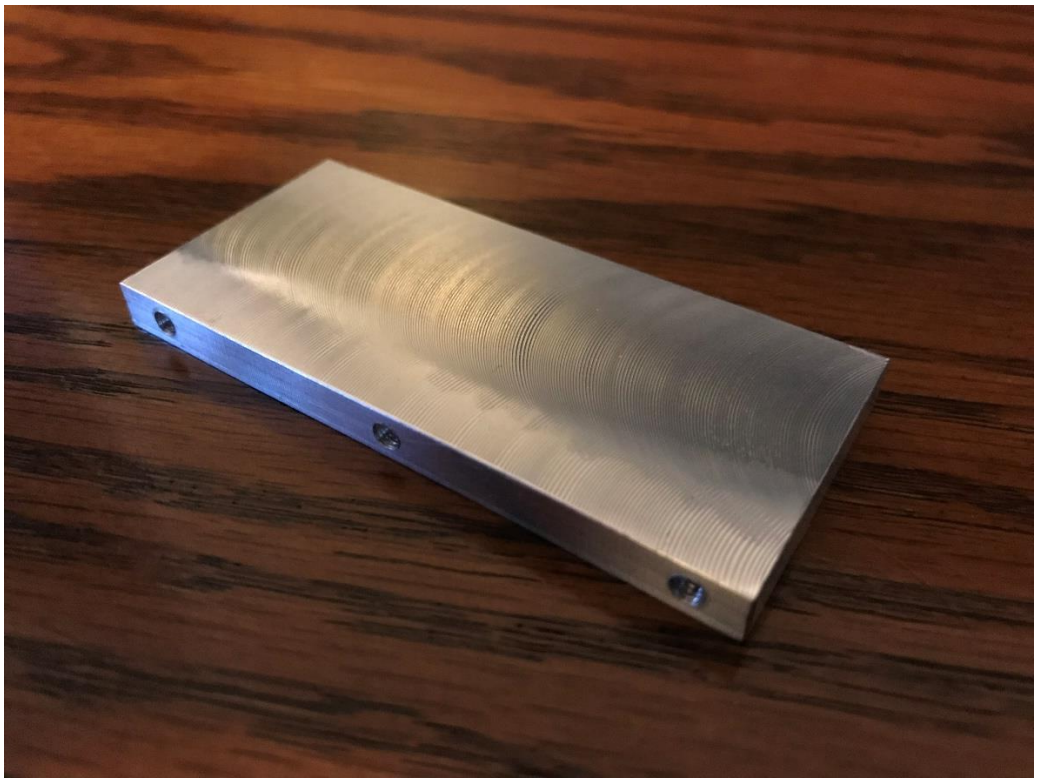


Figure 1: Bearing Block Prior to Cutting for Bearing Press-Fit

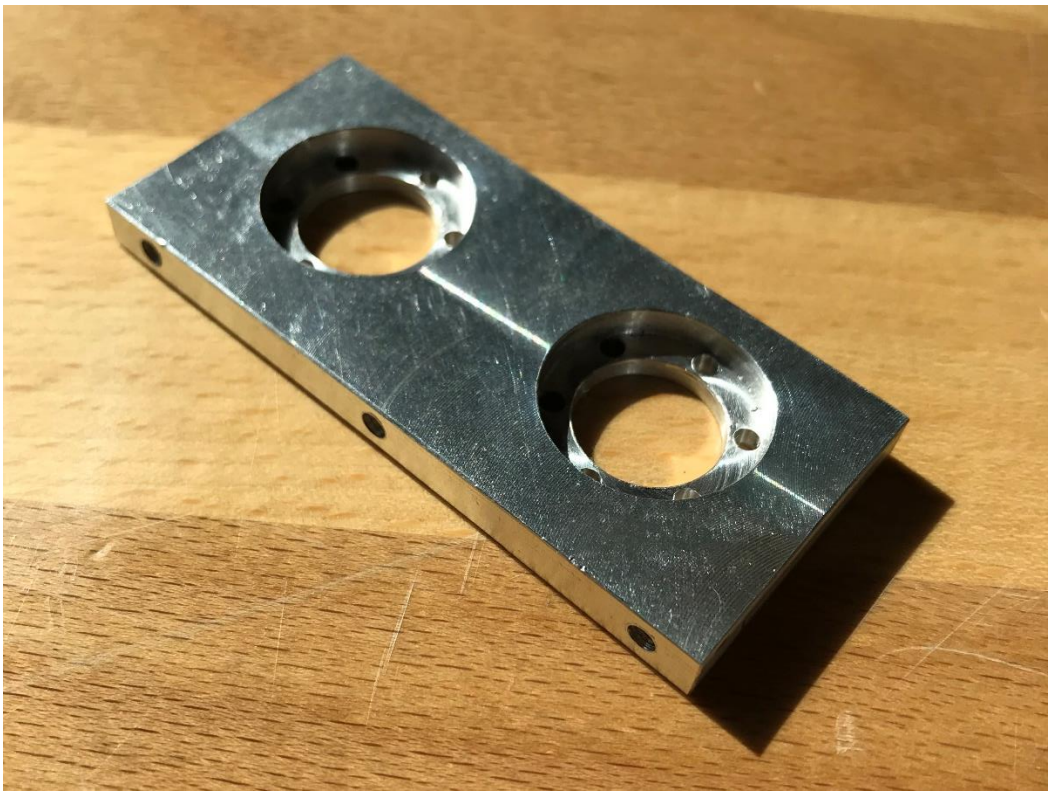


Figure 2: Completed Motor Mount Block

Figure 3: Mounting Plate Drilled for Component Mounting

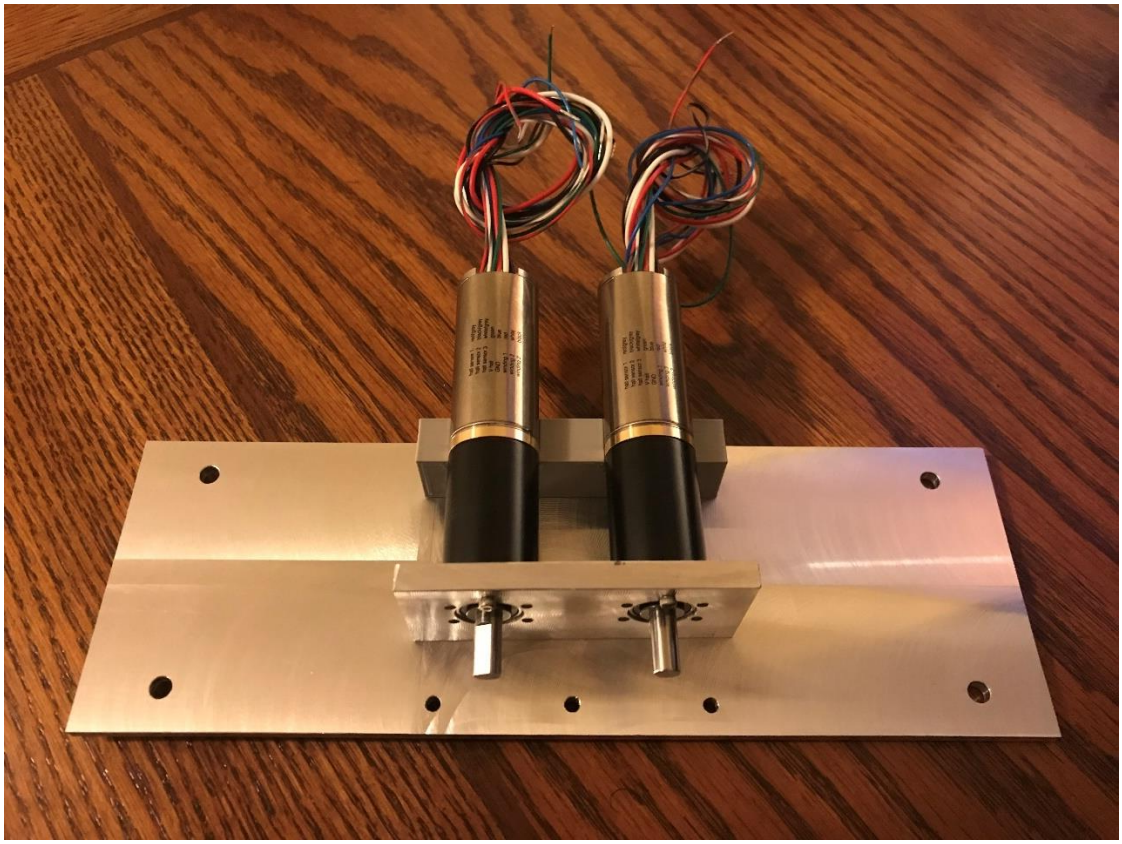


Figure 4: Current State of Motor Mount Assembly

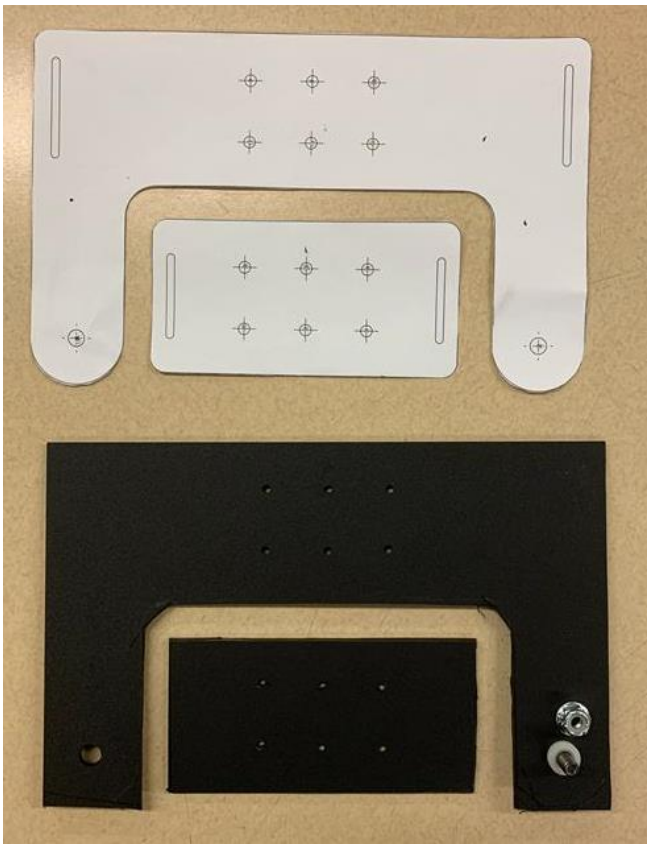


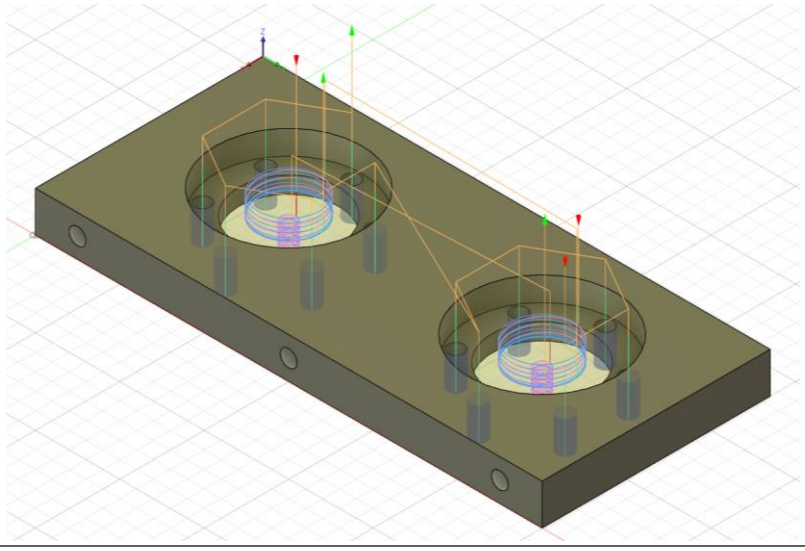
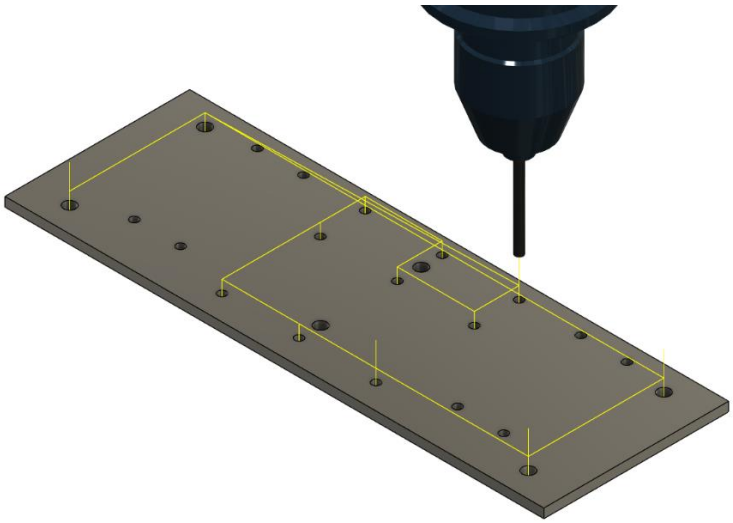
Figure 5: Kydex Knee Brace Cut for Molding

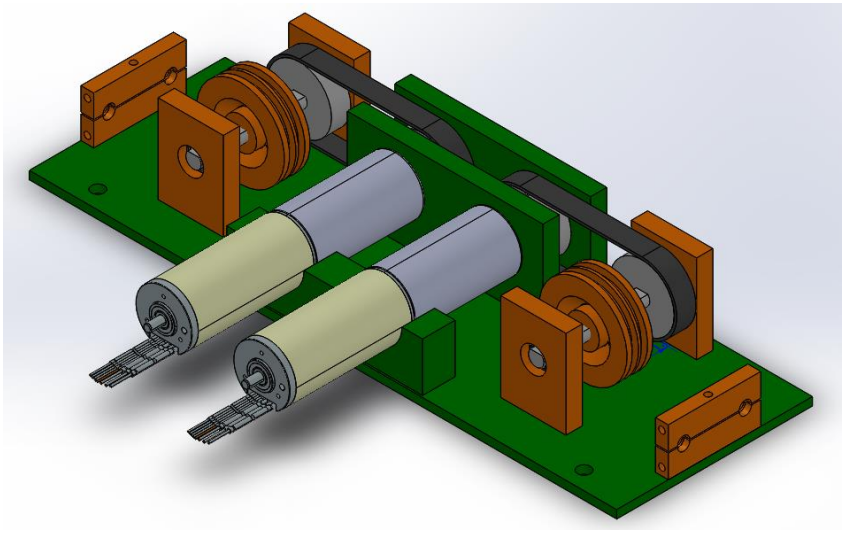
The following are the Action Items each person completed between Hardware Review 1 and Hardware Review 2:

Team Member: Inna Quiambao

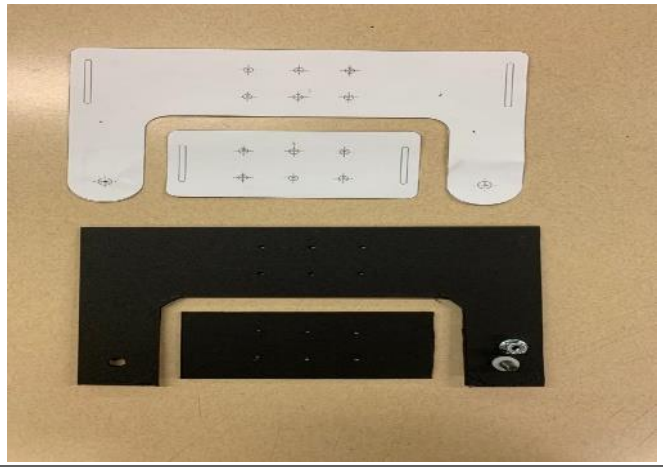
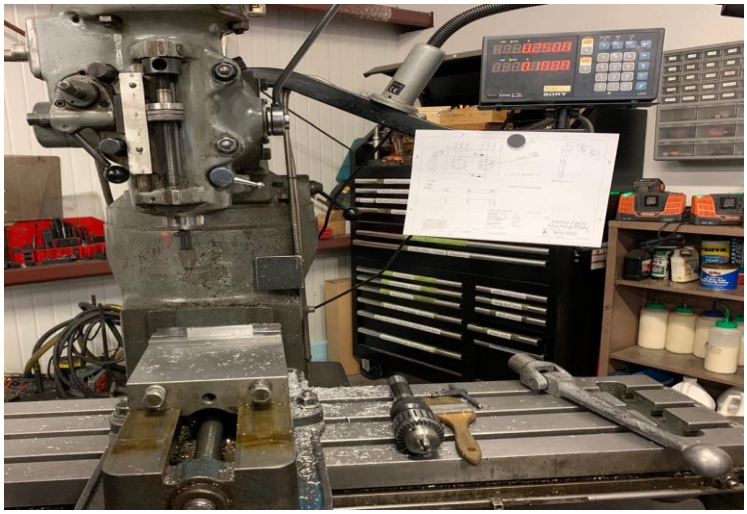
Action Item	Date Completed	Result/Proof of Completion
Cut and faced the motor mounts on manual mill	2/26/20	Motor mounts prepped for CNC mill
Used CNC to mill the bolt pattern into one of the motor mounts	2/27/20	
Implementation Report	2/27/20	Wrote down what the team did for the heat forming process and also overviewed the Gantt chart schedule

Team Member: Keegan Ragan

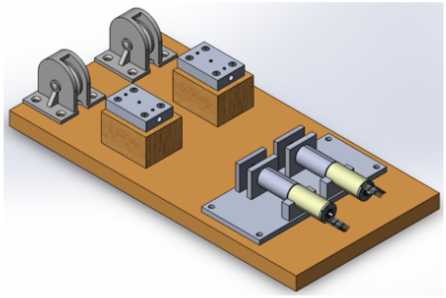
Action Item	Date Completed	Result/Proof of Completion
Generate CAM in Fusion 360 for Motor Mount	2/25/20	
Cut aluminum stock to size for mounting bracket on the manual mill	2/28/20	Aluminum Stock Prepped for manufacturing on CNC mill
Generate CAM in Fusion 360 for holes in mounting bracket / mill holes in mounting bracket on CNC mill	2/2/20	

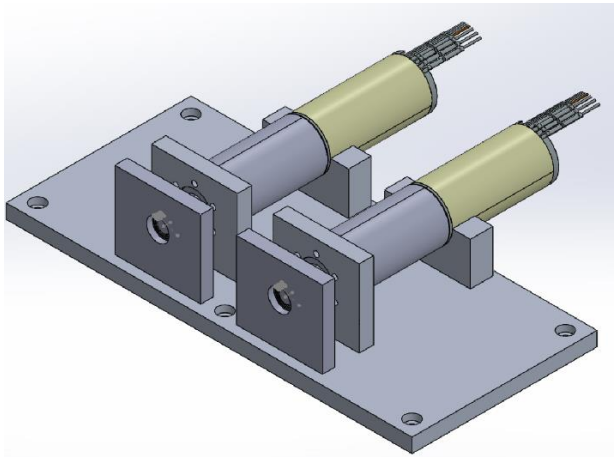
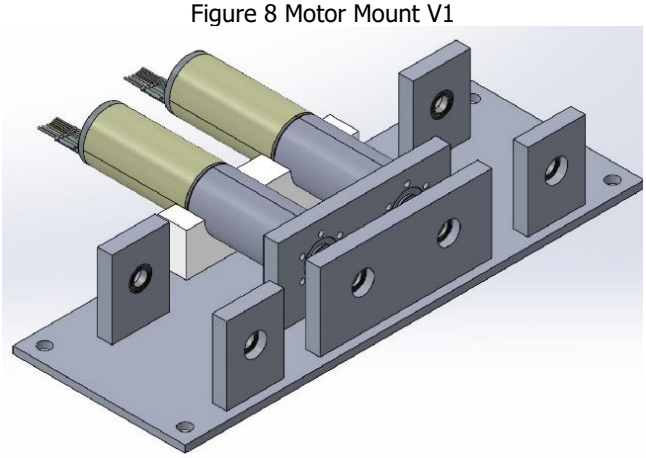
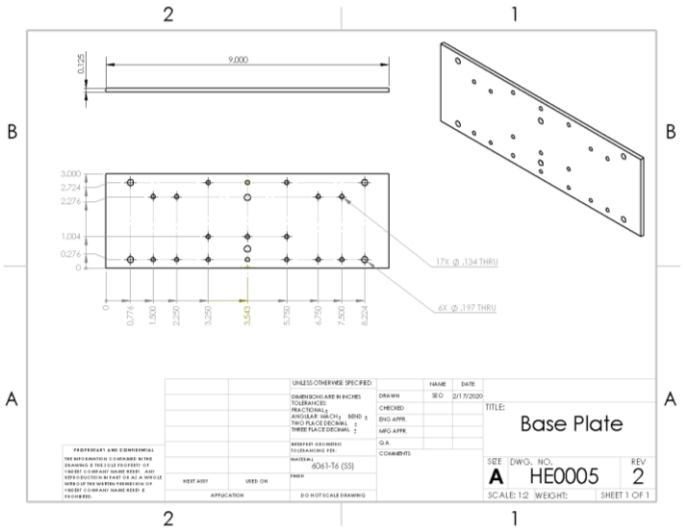
Update motor mount assembly CAD for midpoint presentation / manufacturing. Identified which components still need to be manufactured (highlighted orange).	2/4/20	

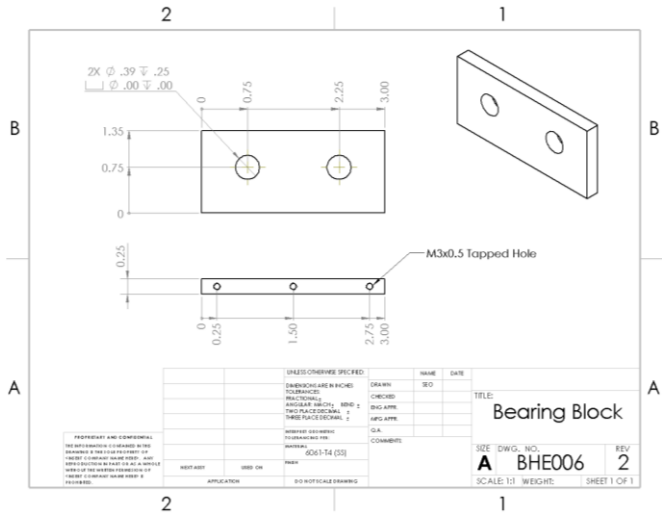
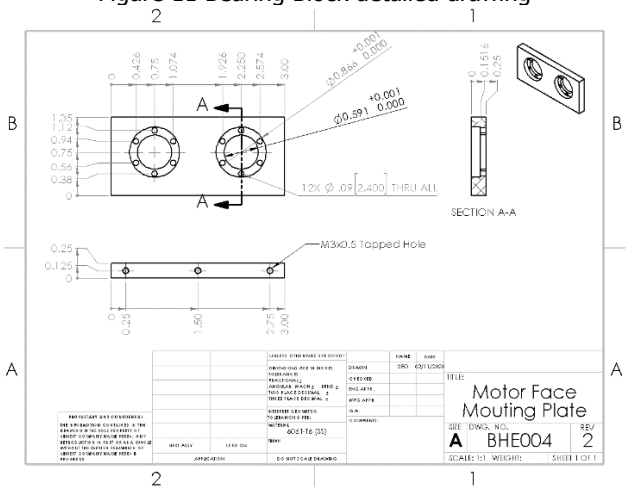
Team Member: Mohanad Fakkeh

Action Item	Date Completed	Result/Proof of Completion
Outline the Testing Procedure for the User Comfort test	02/14/2020	The primary objective of this test is to get feedback about the new hip exoskeleton design from variety of people and check if there are any minor changes that need to be done to help get a more universal fit. The questions that will be asked to the user are based on customer requirements.
Website for the first check	02/21/2020	Edited the website with fully Content up to date (Check1) and here is the link for it: BHET Project Site
Manufacturing the Knee brace with the team	02/23/2020	
Completed shop safety training and helped the team with Machined aluminum parts	2/25/2020	

Team Member: Sean Oviedo

Action Item	Date Completed	Result/Proof of Completion
Create procedure for Torque/Power delivery test	2/7/2020	**3.1.1 Testing Procedure 1: Objective** The test will be performed using the motor mount assembly, attached to a test fixture. the motor mount will include the final speed reduction pulley and actuation cables, which will be secured to statically mounted load cells. An Arduino microcontroller will be programed to record the output of the load cells and instruct the motor speed controllers. The motors will be powered on for two second intervals, tensioning the cables. Different power levels will be tested to run the motors, to develop an expected range of torque the hip exo is capable of. Each level will be run three times and the results will be averaged. Power delivery will be evaluated utilizing the motor mount and test fixture, with the load cells replaced by pulleys. Weights will be attached to the cable ends. The test assembly will be placed at the edge of a table, with the cables routed through the pulleys. The motors will be programed to run, lifting the weights. Recording the time taken to move the weight allows the power delivered to be calculated. Figure 6 Test procedure overview, excerpt from ER/TP revamp memo
Create list of required resources for Torque/Power delivery test	2/12/2020	**3.1.2 Testing Procedure 1: Resources Required** The equipment and resources needed for this test are listed below with a brief description of their use and sources. *Test fixture* – simple frame designed to constrain the motor mount and load cells such that they are aligned, and displacement of the load cell occurs colinear with the cord. The test fixture will also be used for fatigue testing. The fixture is currently being designed by the team and will be manufactured by 2/28/2020 using off the shelf materials and tools, already owned by one of the team members. Figure 1 shows the test fixture assembly. 6 NAU NORTHERN ARIZONA UNIVERSITY Mechanical Engineering 19F13 Biomechatronic Hip Exoskeleton Team  *Figure 1 Test fixture CAD rendering, shown in pulley configuration for power test* *Motor mount assembly* – Including motors, cables, hardware and power source. The individual components will be manufactured by the team in the NAU Machine Shop, building 98C, using raw materials purchased from OnlineMetals. *Load cells (2)* – Wheatstone bridge affixed to an aluminum member, sold with a 24-bit analog-to-digital converter. These were purchased by a team member for a previous project. *Arduino microcontroller* – Open-source programable microcontroller to interpret and record load cell output. Already owned by a team member. Code will need to be written for the Arduino, which will be done in MATLAB. *Computer* – Communicates with Arduino to store the measured data and will be used to process the test results. Figure 7 Resource requirements, excerpt from ER/TP revamp memo

Revise motor mount design • Simplify design by reducing part count • Verify accurate tolerances • Begin designing final speed reduction components	2/12/2020	 Figure 8 Motor Mount V1  Figure 9 Motor Mount V2
Prepare Motor Mount components drawings for manufacturing. • Ensure inch standard dimensions • Add ordinate dimensions	2/17/2020	 Figure 10 Base Plate detailed drawing

		 Figure 11 Bearing Block detailed drawing  Figure 12 Face Plate detailed drawing
Research stock part options for belt drive and order components	3/4/2020	There are a variety of standardized timing belt tooth profiles availiable though suppliers. The most common profile for this application (small shaft diameter) is GT2 (2mm pitch for the tooth profile), which gives the team numerous options for stock parts to choose from. Despite the availiable stock pulleys, the team is limited by the length of the gearbox shaft (~11.5mm). Another limiting factor is the gearbox shaft profile, which is a 'D' shaft. Most stock components are mated to the shaft via set screws, which can be unreliable in long-term applications. The client expressed the preference to not use set screws, but the pulley should also not be permanently affixed for serviceablity. The limitations listed above were considered and the team has decided to manufacture a pulley from stock material (available as an extrusion with the tooth profile manufactured. The pulley stock can be cut to a desired width and bored to the desired specifications. Stock pulley parts were ordered on 3/4/2020

The following are the Action Items for each team member between HR 2 and the Final Product presentation:

Team Member	Action Items	Date Due
Inna Quiambao	1. Prep aluminum stock for machining on CNC mill 2. Finish machining parts for motor mount assembly 3. De-bur and check all parts for fitment and tolerances 4. Assemble finished motor assembly	1. 3/11/2020 2. 3/23/2020 3. 3/25/2020 4. 3/27/2020
Keegan Ragan	1. Finalize motor mount assembly for manufacturing and generate CAM for remaining parts 2. Determine way to machine d-shaft press fit into timing belt pulleys, generate CAM 3. Finish machining parts for motor mount assembly 4. Assemble finished motor assembly	1. 3/10/2020 2. 3/11/2020 3. 3/23/2020 4. 3/27/2020
Mohanad Fakkeh	1. Motor assembly – Machining and Complete Assembly 2. User Comfort Rating Survey Test will be conducted 3. Individual Analytical Analysis II - Option 1 revisit 4. Assemble finished motor assembly	1. 03/13/2020 2. 03/23/2020 3. 03/13/2020 4. 3/27/2020
Sean Oviedo	1. Finish edges and corners for knee brace cutouts 2. Finalize design of belt drive components, including belt tension mechanism 3. Complete shaft design analysis for belt drive (individual analysis 2 topic) 4. Finish Arduino code for torque test 5. Build test bench for torque test	1. 3/8/2020 2. 3/13/2020 3. 3/13/2020 4. 4/1/2020 5. 4/3/2020