Untethered Hydraulic Artificial Muscle Elbow Exoskeleton

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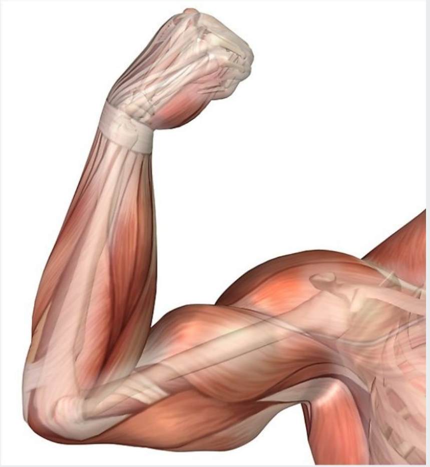
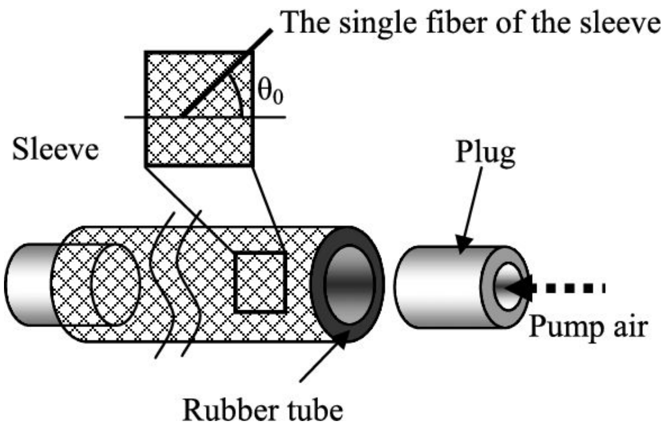
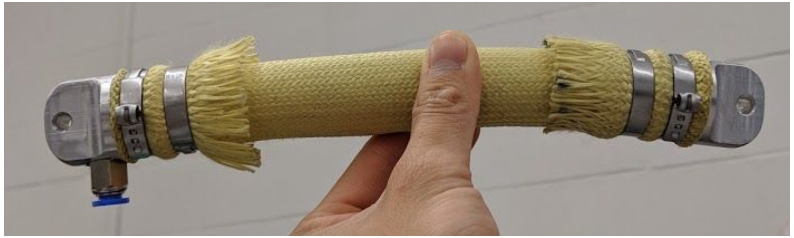


Introduction

- Elbow exoskeleton for hydraulic artificial muscle (HAM)
- Inspired by the McKibben artificial muscle, developed by H.F. Schulte
- Goal is to design exoskeleton that is compatible with the HAM's specifics





Introduction (cont.)

- Exoskeleton can eliminate limitations in human performance
- New technologies allow for advancements
- Development of "soft robotics"
    - Better alternative to traditional rigid body prosthetics

Objectives

- To help workers in the construction field carry or lift heavy objects
- Prevents muscle fatigue from repetitive lifting
- To rehabilitate patients in hospitals or nursing homes that have suffered damage to muscles in their arms, and require physical therapy to regain mobility

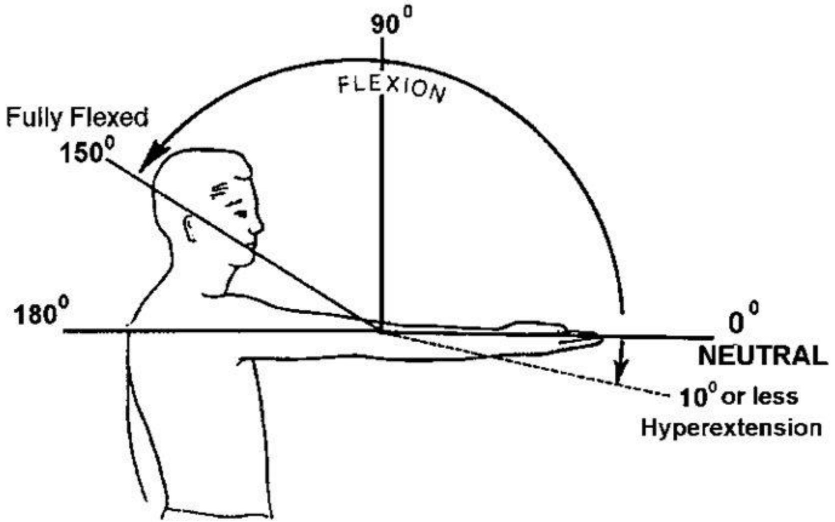
Product Design Specifications

Categories Considered:

- Special Features
- Design Problem
- Customer Requirements
- Geometric Limitations
- Functional performance
- Operating Environment
- Economics
- Reliability and Robustness
- Safety
- Ease of Use
- Appearance
- Human Factors
- Maintenance, Repair, and Retirement

Design Problems & Customer Requirements

- Problems include selecting a material that is elastic, durable, and lightweight.
- Mass of the exoskeleton can not exceed 2.5 kg.
- Design must be suitable for various arm sizes without compromising secure fit.
- Exoskeleton must have a range of motion from 0° to 150°



Geometric Limitation, Functional Performance, Operating Environment

- Elbow contraction frequency of 0.5 Hz (about 2 seconds from start to end)
- Mimic natural human elbow flexion
- Produces a contraction force of 300N ≅ 67.4 lbs
- Adjustability is key in ensuring a secure fit on varying arm sizes while optimizing performance.
- Suitable for medical, vigorous along with everyday use.

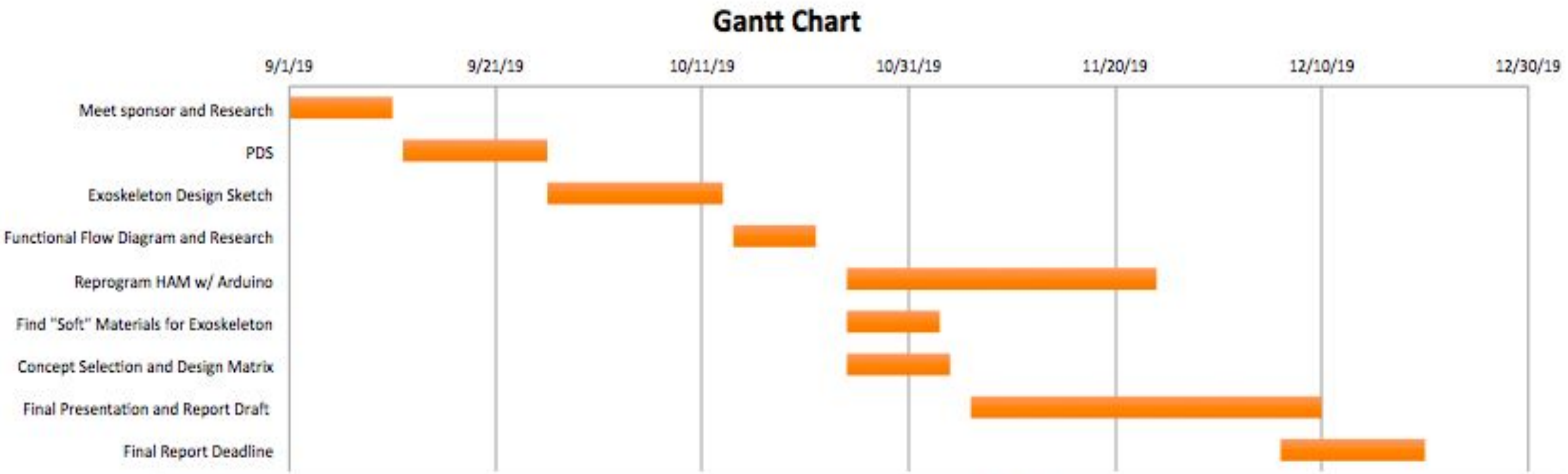
Economics, Maintenance and Repair,Reliability and Robustness

- The product should have an economic life of five to ten years.
- Minor maintenance: cleaning, checking for wear and tear
- Major maintenance: Tubing, straps, pressure valves, instrumentation
- Retirement should be done every 5 to 10 years, some parts could be recycled
- Product must withstand high amount of cycles within 5-10 year lifespan (average 224,000 cycles/week)

Ease of Use, Safety, Human Factors

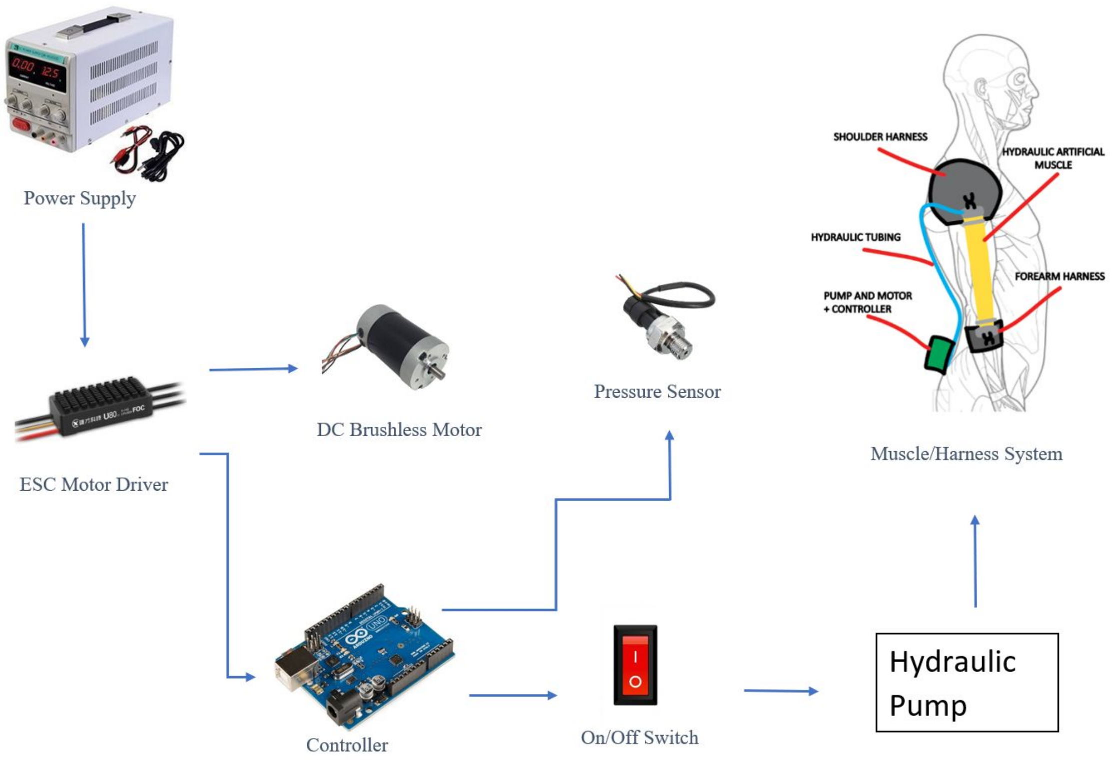
- While in use and on standby, the product should not cause any abrasions and/or bruises to the user
- Hydraulic muscle must curl arm without cramping the user's limbs
- The user should be able to wear, use and take off the exoskeleton with ease
- Device should not interfere with any natural arm movements

Gantt Chart

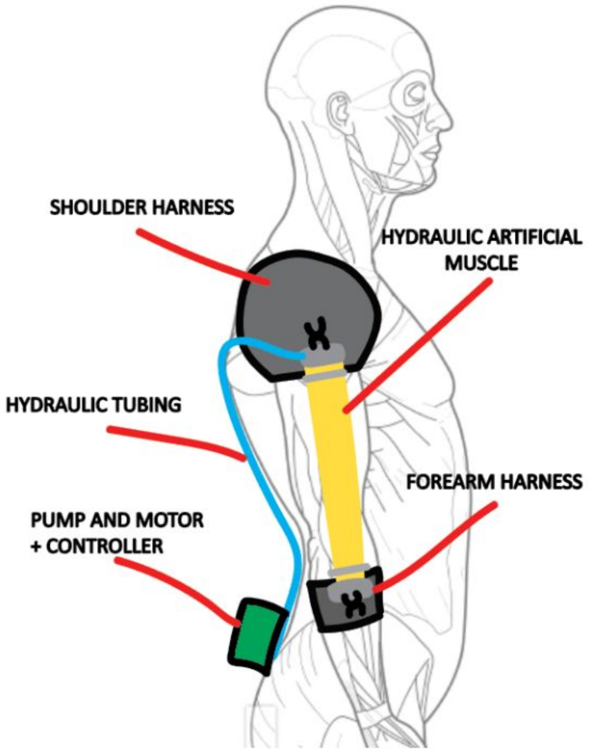


	Final Report Deadline	Final Presentation and Report Draft	Concept Selection and Design Matrix	Find "Soft" Materials for Exoskeleton	Reprogram HAM w/ Arduino	Functional Flow Diagram and Research	Exoskeleton Design Sketch	PDS	Meet sponsor and Research
START DATE	12/6/19	11/6/19	10/25/19	10/25/19	10/25/19	10/14/19	9/26/19	9/12/19	9/1/19
DURATION (days)	14	34	10	9	30	8	17	14	10

Functional Schematic

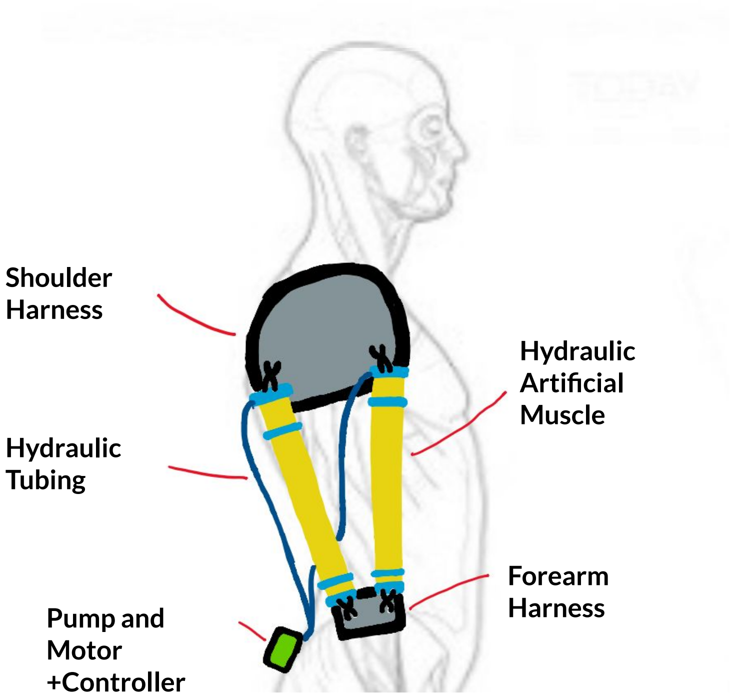


Wearable Structure Design Concept #1



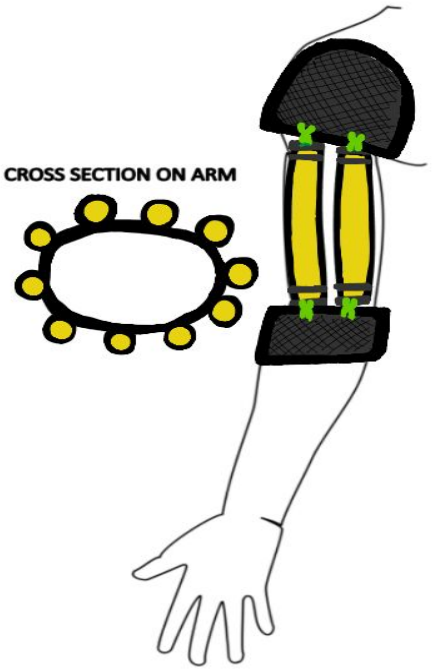
- Shoulder harness
- Forearm strap
- 1 muscle
  - Bicep

Wearable Structure Design Concept #2



- Shoulder harness
- Forearm strap
- 2 Muscles
  - Bicep
  - Tricep

Wearable Structure Design Concept #3



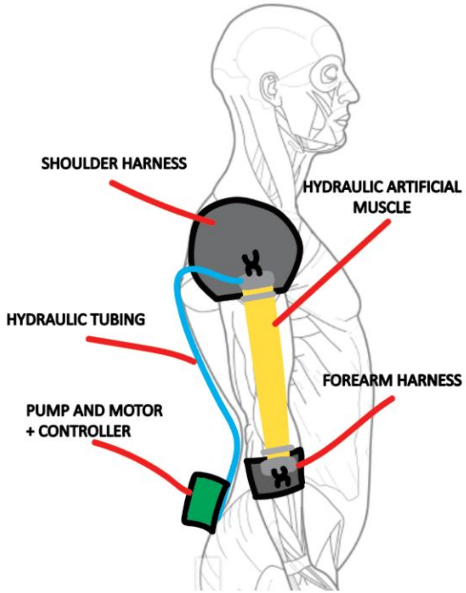
- Shoulder harness
- Forearm strap
- Multiple smaller muscles going around the arm
    - Bicep

Design Matrix

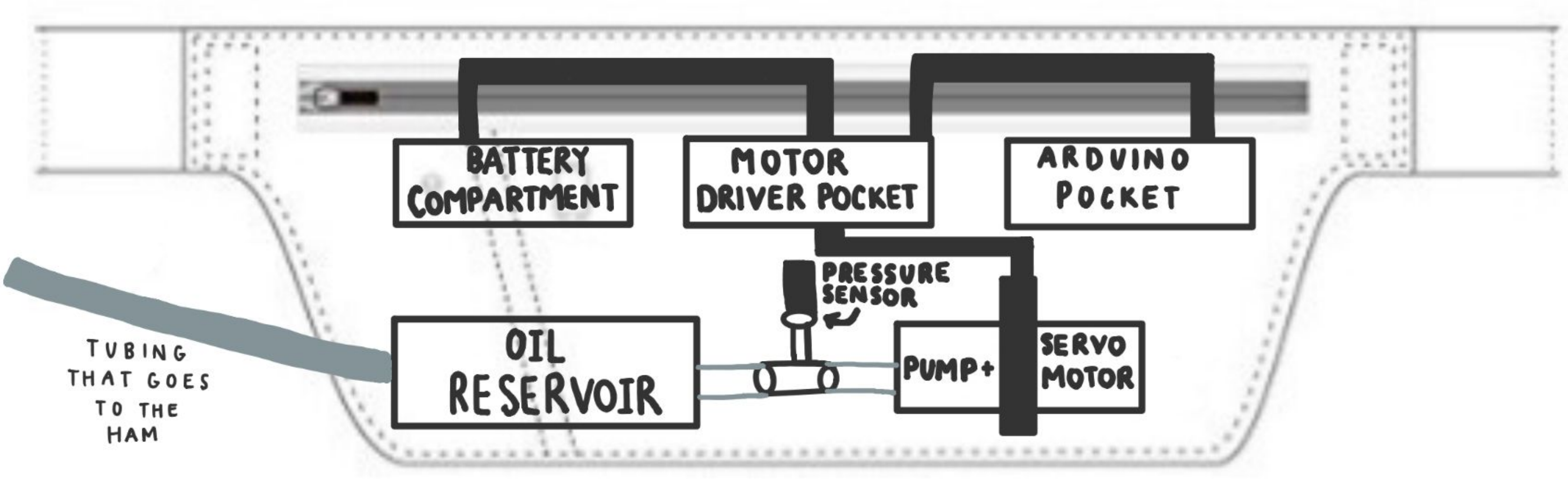
Concepts		One Muscle	Two Muscles	Multiple Muscles
Criteria	Weight			
Cost	1	+	-	-
Technical Difficulty	2	+	-	0
Range of Motion (0-150)	3	+	+	+
Weight (< 2.5 kg)	2	+	-	+
Flexion Ability	3	+	+	+
Extension Ability	1	-	+	-
Universal	2	+	+	+
Ease of Use	2	+	+	+
Appearance	1	0	-	-
Portable	3	+	0	-
Overall Total		***7***	***1***	***1***
Weighted (+)		18	11	12
Weighted (-)		1	6	6
Weighted Total		***17***	***5***	***6***

Concept Selected

- Design concept 1 had the best evaluation score



Portable Pumping System Design



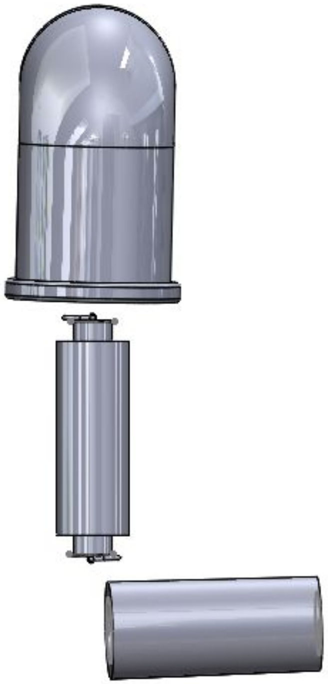
Proof of Concept

Shoulder Harness

HAM

Forearm Strap

Front View



Side View

Proof of Concept

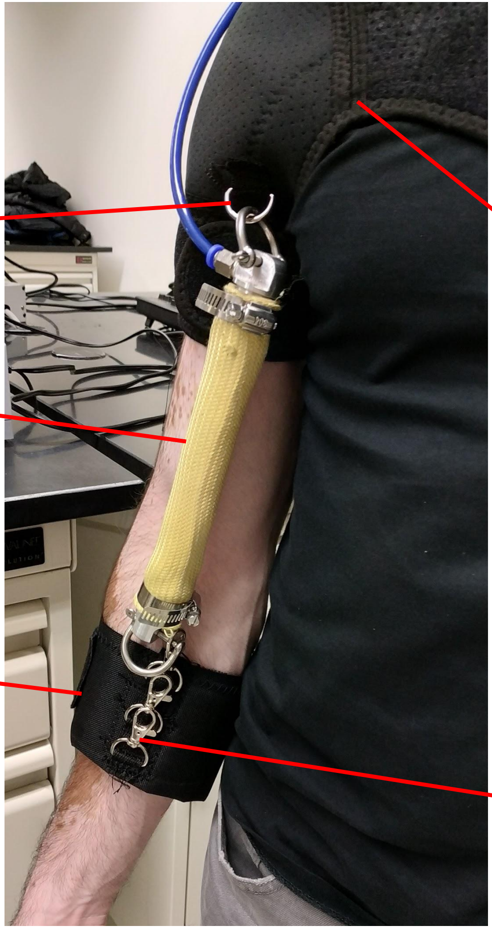
D-Rings

H.A.M.

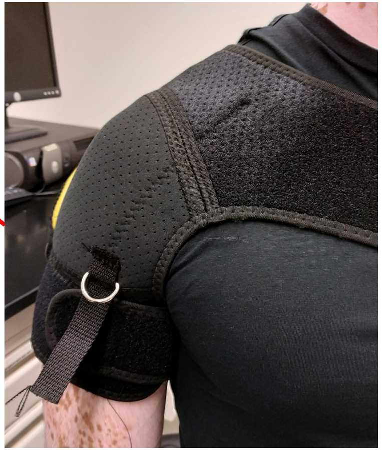
- ➟ Rubber tubing inside
- ➟ Kevlar sleeve outside

Forearm Strap

- ➟ Soft nylon mesh for bottom
- ➟ Nylon fabric for top
- ➟ Neoprene padding inside
- ➟ Velcro strapping



Shoulder Harness



- ➟ 4.0 mm Neoprene with lining

Metal Clasps

Results

- Finalized design is simplified model
    - Improvements to be made after initial prototype is completed
- Design is determined by sponsor's requirements
- Limited options due to:
    - Weight
    - Usability
    - Budget
- Assembly process and testing will influence final product

Conclusions & Future Work

- Dealing with challenges
  - Sponsor’s requirements
  - Making the muscle work
  - Writing the code
- Future Work
  - Practicality
  - Pressure control

Thank You!