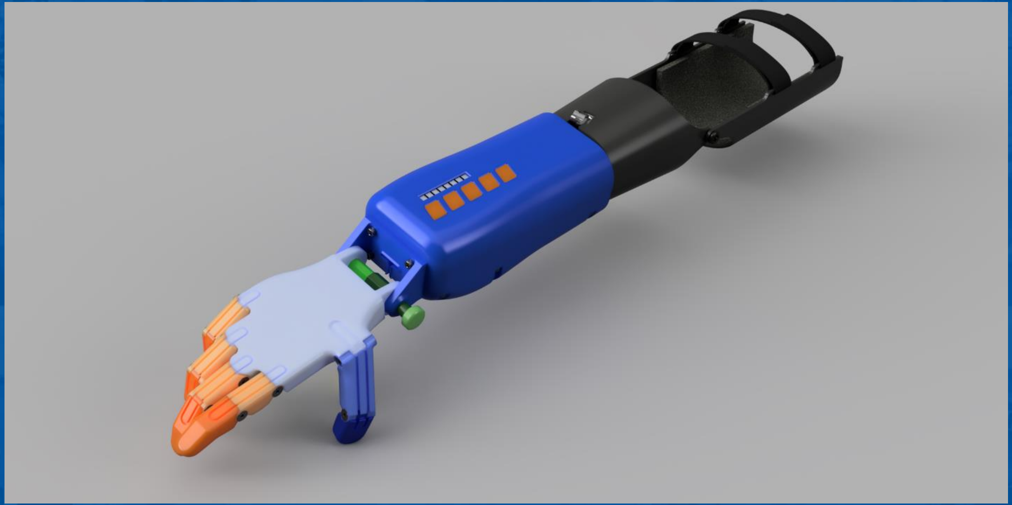
UF Herbert Wertheim College of Engineering UNIVERSITY of FLORIDA

EML4502: Mechanical Design 3,
2024 Spring



Group MT0A-3: LimbLeap Innovations™

Team Members: Brad Shack, Ayrton Howard, Alex Shaftel, Kyle Browning,
Jordi Rey, Carlos Nieves, Olivia Miller, Canyon Tennant, Gaige Bryan

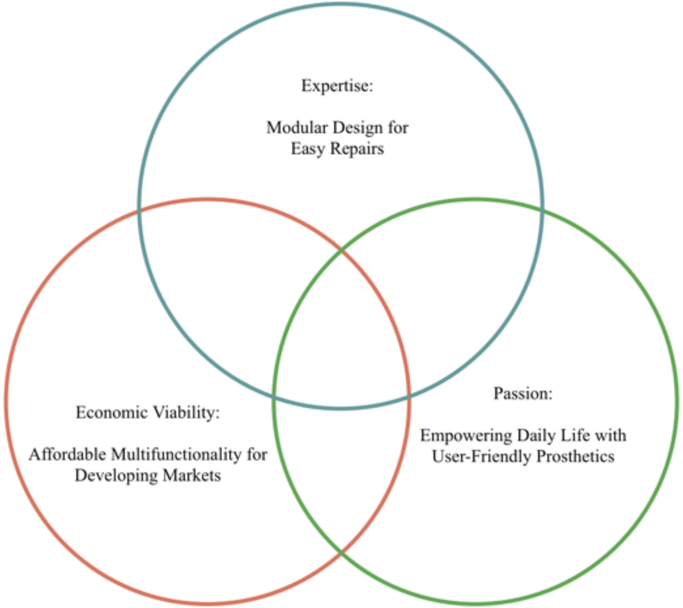
POWERING THE NEW ENGINEER TO TRANSFORM THE FUTURE

Agenda

1. Hedgehog Concept
2. Product Specs
3. Testing Results
4. Unique Features
5. Design Evolution & Detailed CAD Views
6. Cost Overview
7. Future Improvements

Hedgehog Concept:

- LimbLeap Innovations is unparalleled in creating modular prosthetics that blend user-friendly design with affordability and durability.
- LimbLeap's proposition is to restore lost limb functionality through a widely accessible and simple solution



Key Product Specs

- 70 hour operational battery life, 11 hour full charge time
- Up to 10 pounds of grip force, 2 pounds per finger
- Each finger is individually actuated
- Performs 12 of the grasps displayed on customer needs statement
- 120º wrist range of motion, full 360º wrist rotation
- Grasps are controlled manually by button combinations, with infinitely adjustable grip settings
- Compliance prevents damage to motors in everyday use
- Bluetooth and Wifi control capability
- Internal flashlight

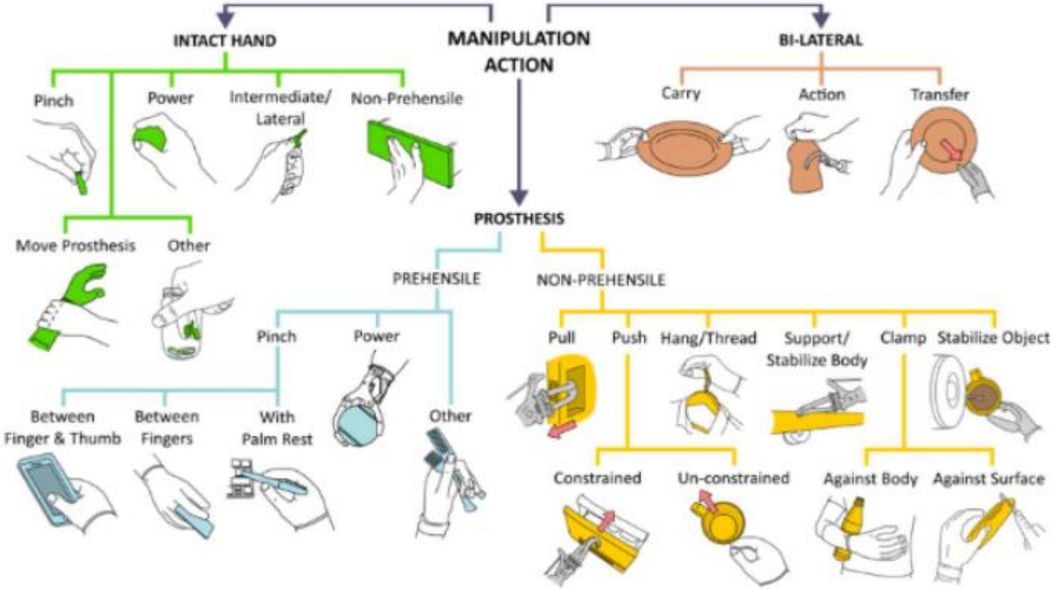
Completion of Testing Deliverables

Grip Test

Purpose: Test the hand's ability to perform various grips used in everyday activities.

Customer Need: The device should be able to perform at least ten unique grips.

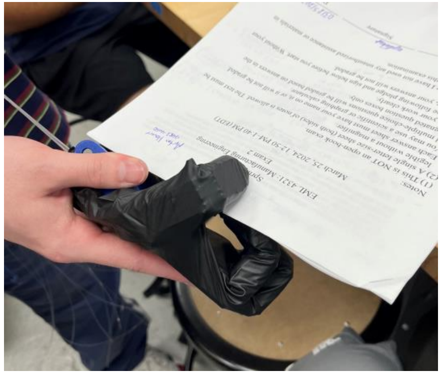
Method: The fishing line tendons were operated manually to test 15 various grasps.



Completion of Testing Deliverables

Power Grasp

Constrained Push Grasp



Carry/Transfer Grasp

Pinch with Palm Rest Grasp

Completion of Testing Deliverables

Grip Test

Results:

- 12/15 tested grips were performed successfully.
- Three grips failed due to the fingers' inability to abduct and adduct.
- Since 10 unique grips are required by the customer need, the design evaluation for this protocol was successful.

Completion of Testing Deliverables

Drop Test

Purpose: Evaluate the arm's resilience when dropped from a series of small heights.

Customer Need: Device must be resistant to reoccurring impact.

Method: The arm was dropped from a range of heights, after which it was inspected visually and by ear to check for defects. A functionality test was performed after each drop to test if a 10 lb weight could be lifted.

Completion of Testing Deliverables

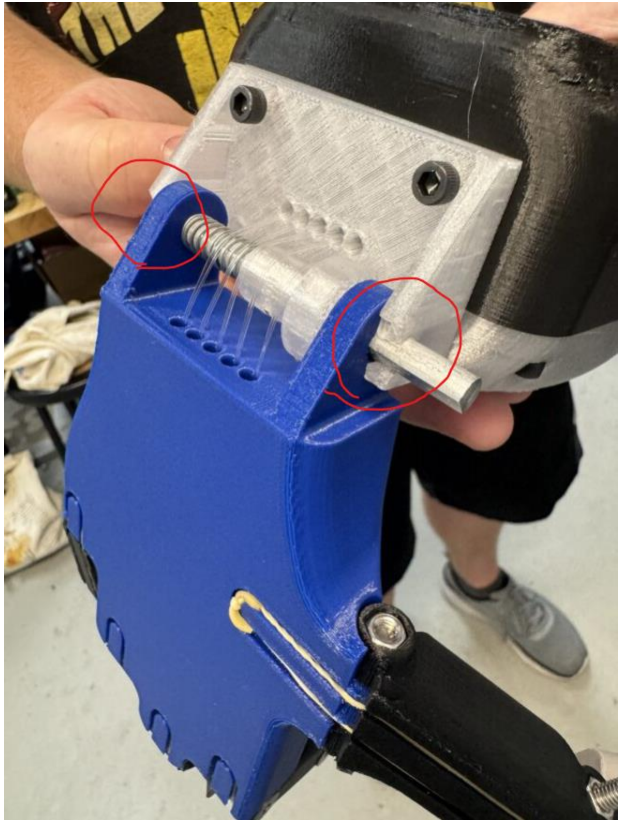
Broken hand holding weight

Loosened fastener after 12" test

Completion of Testing Deliverables

Drop Test

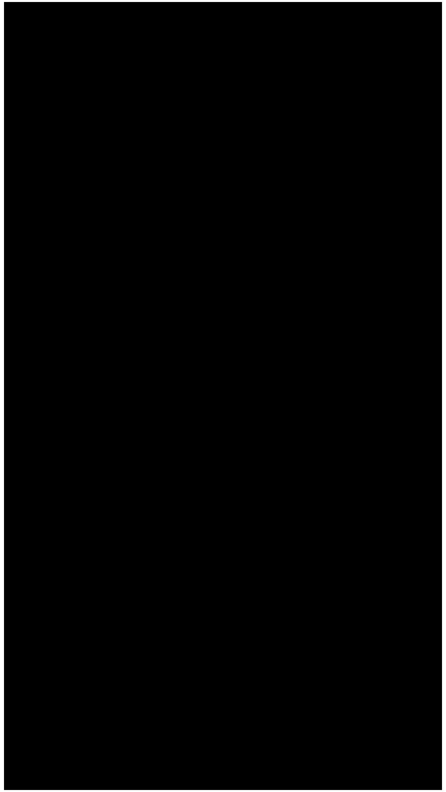
Results: The d-shaft constraining motion in the wrist stripped its hole during the 6" drops, which allowed the hand to rotate freely. Then there were no noticeable problems until the 3rd 12" drop, where the wrist hinges snapped and a fastener fully loosened from a finger. The hand was considered to have failed the test.

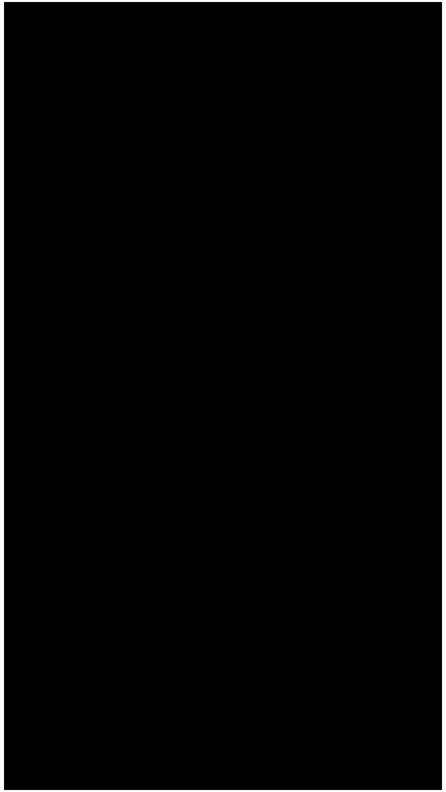


Broken wrist hinge after 12" drop

Demonstration Videos

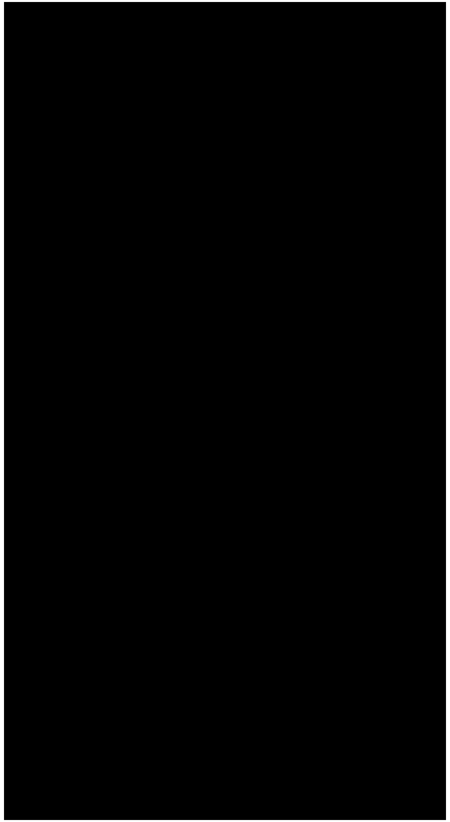
- Grasping of cylinder & box shapes
  - Aerosol spray can
  - Box of fasteners

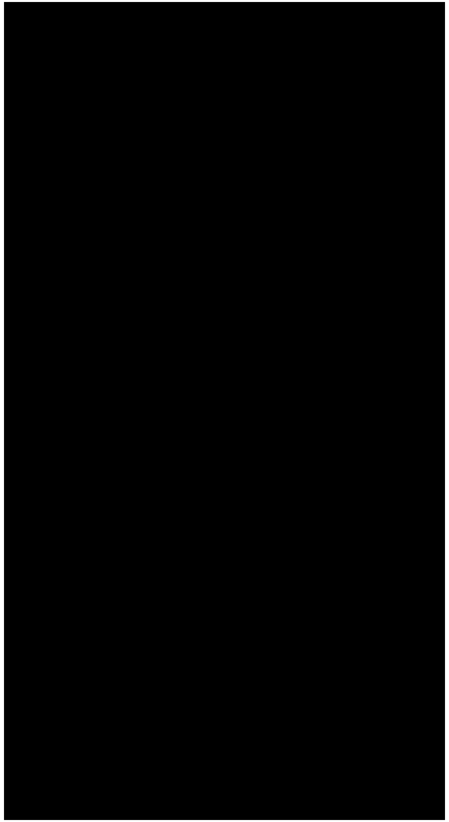




Demonstration Videos

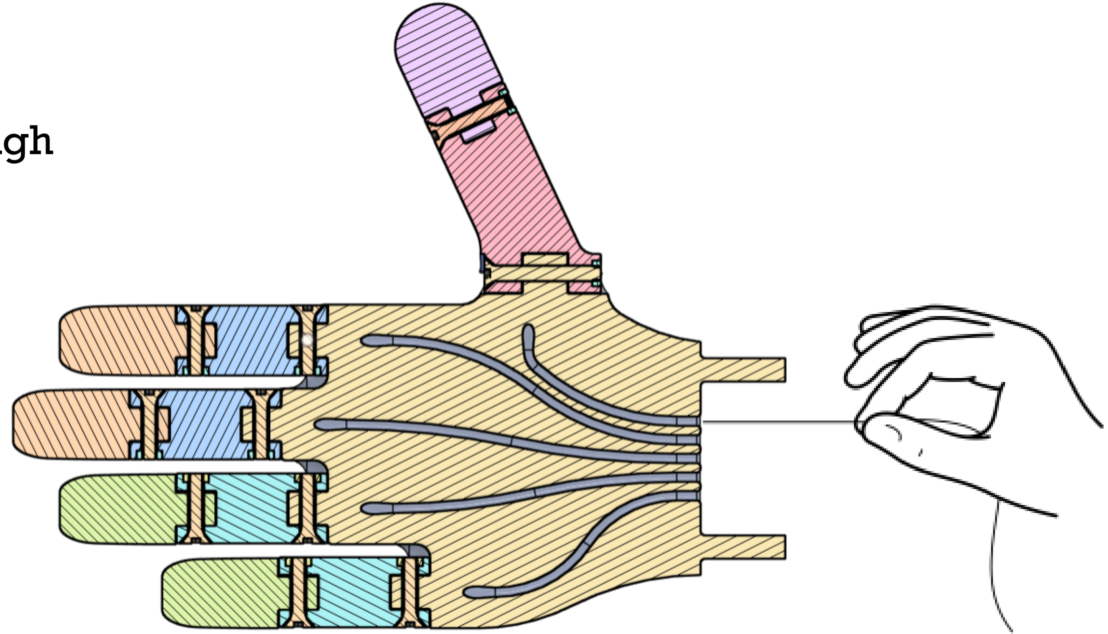
- Grasping of objects with unique shapes and features
  - Piece of paper off the table
  - Milk carafe with handle





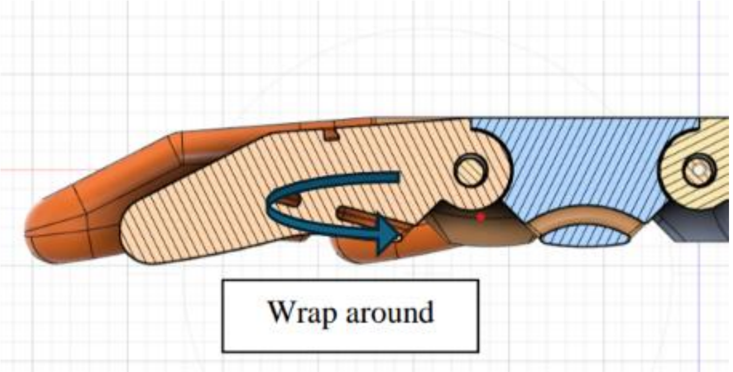
Tendon Channels

- Easy to install fishing line tendons, line is guided through entire path
- Decreases installation and maintenance time
- Ensures no tangling of the fishing line



Tendon Channels

- Fishing line wraps around fingertip
- Two strands of fishing line on pathways
- Reduced tensile tress



Force in each tendon:

$$\sum M = 0 = (8.5\ N)(0.045\ m) - 2F_T(0.010\ m)$$

$$F_T = 19.125\ N = 4.3\ lbs$$

Retraction length to cause a 90-degree bend in both the MCP and PIP joints:

$$\theta_{MCP} = \theta_{PIP} = 90^{\circ}$$

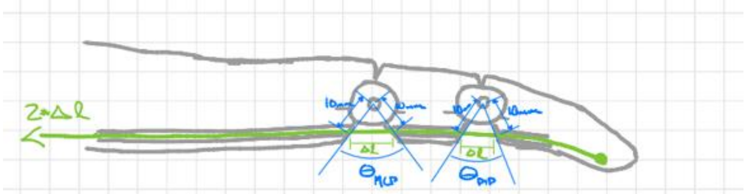
$$\Delta l = \sqrt{2(10\ mm)^2} = 14.1\ mm$$

$$2\Delta l = 28.2\ mm$$

Maximum servo motor force:

$$R = \frac{2.82\ cm}{170^{\circ}} = 0.95\ cm$$

$$F_{servo} = \frac{98\ N \cdot cm}{0.95\ cm} = 103\ N = 23 lbs$$



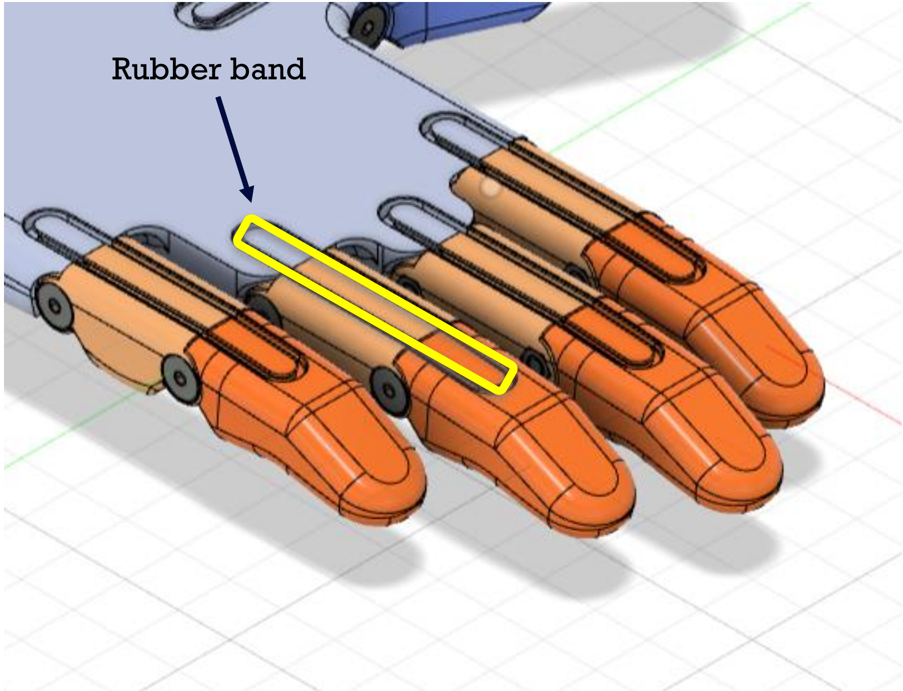
Finger Grooves

- Allow fingers to remain extended
- Internal part of the finger
- Easy and cheap to replace and maintain

Force provided by rubber band:

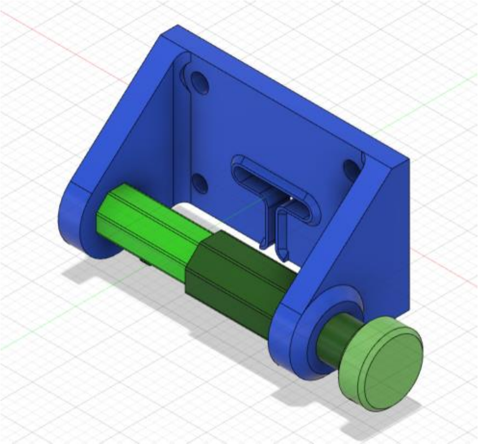
$$F = K \cdot \Delta x$$

$$30 \frac{N}{m} \cdot 0.072\, m = 2.16\, N$$

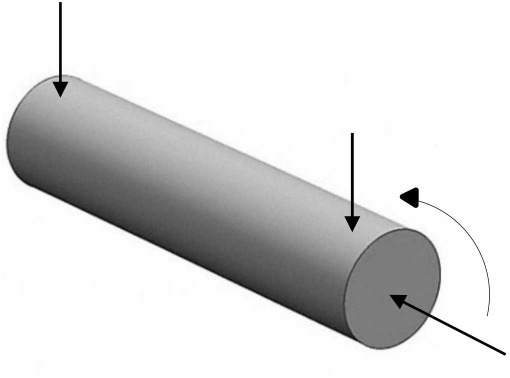


Lower wrist mechanism

- Hexagonal locking mechanism
- Spring-loaded shaft
- Pathway for tendons at centerline



Free-body diagram:



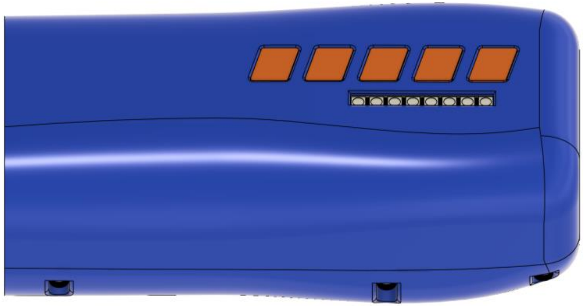
Calculations

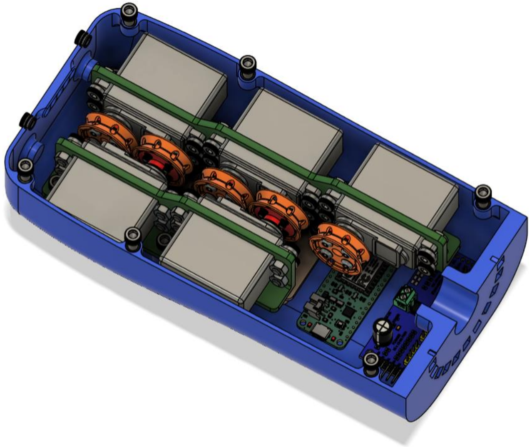
$$\tau = \frac{3 \cdot (\,100N)}{2 \cdot (1.54 \cdot 10^{-5}\ m^2)} + \frac{(250\ N \cdot m)(0.0022\ m)}{5.74 \cdot 10^{-8}\ m^4} = 19.32\ MPa$$

$$\sigma = \frac{(5.2\ N \cdot m) \cdot (0.0022m)}{5.69 \cdot 10^{-10}\ m^4} + \frac{70N}{1.54 \cdot 10^{-5}\ m^2} = 24.7\ MPa$$

Grips

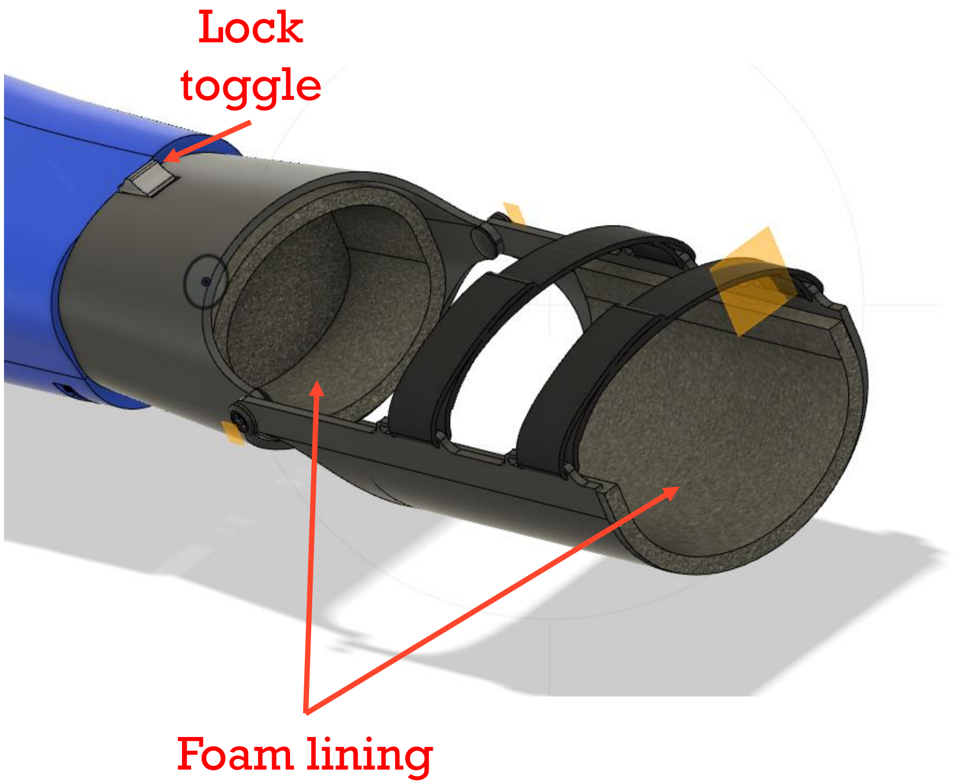
- Holding button slowly closes to specified grip
- Any intermediate grip is possible
- Each finger has its own servo motor





Lower Arm Mount

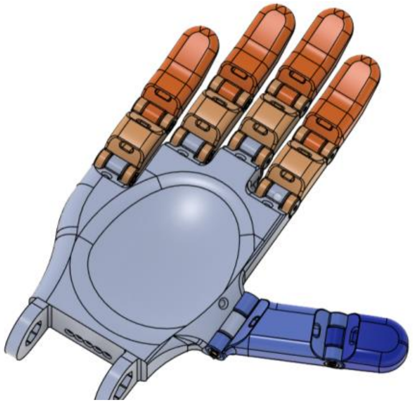
- Velcro straps for adjustability
- Foam for comfort
- Lock toggle to adjust wrist orientation

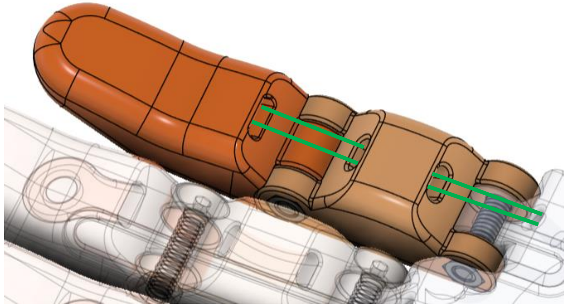


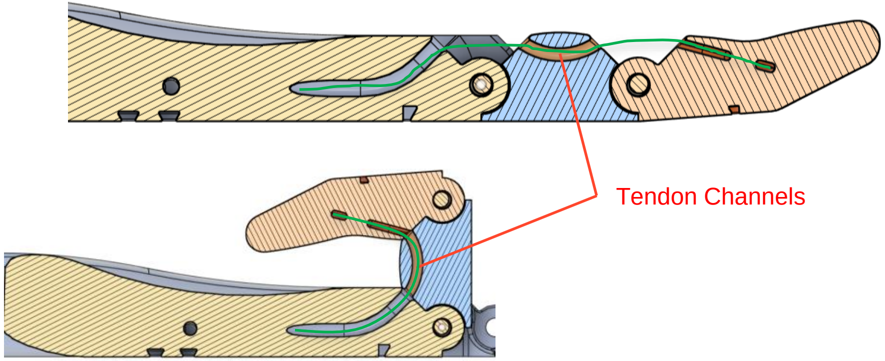
CAD Design Views

Finger Design

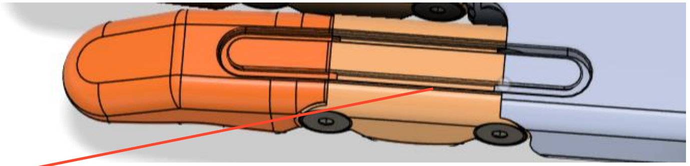
- Two-part tendon-driven design
- Extended by rubber bands
- Modular and replacable







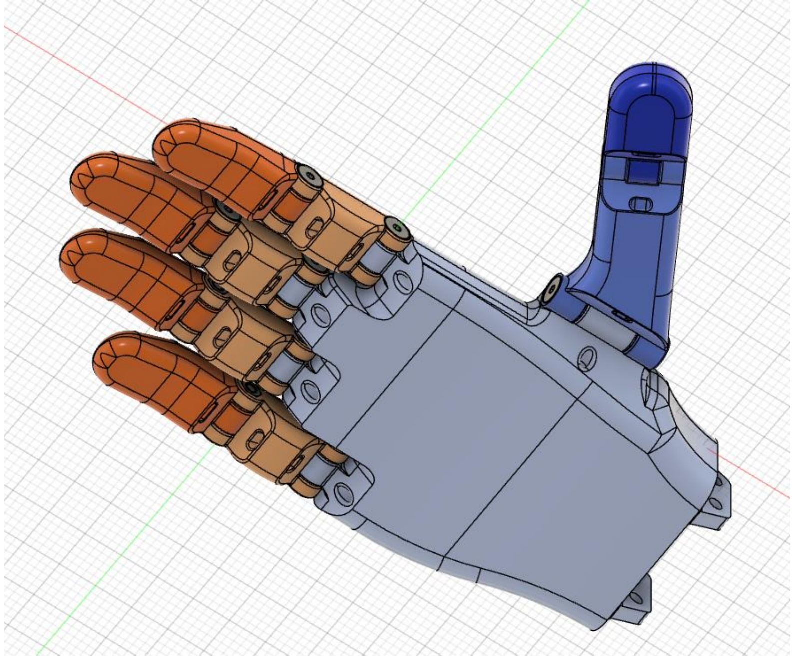
SIDE SECTION VIEW

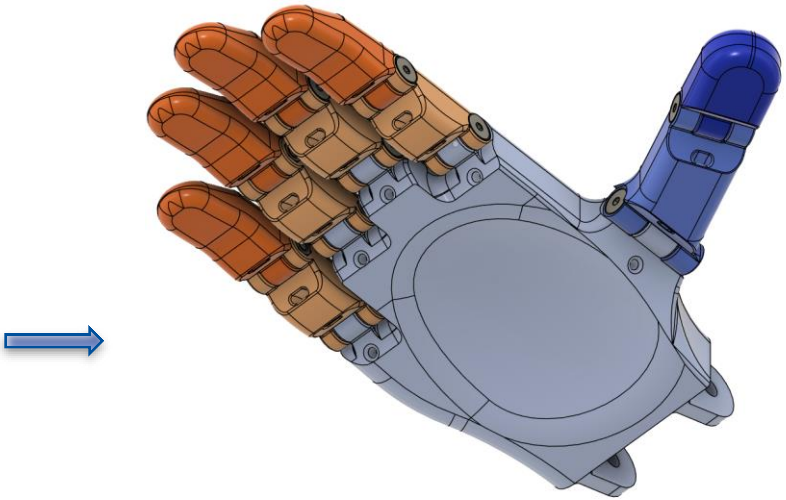


Design Evolution

Palm Shape

- Ergonomic Shaping, Thinner, Shorter

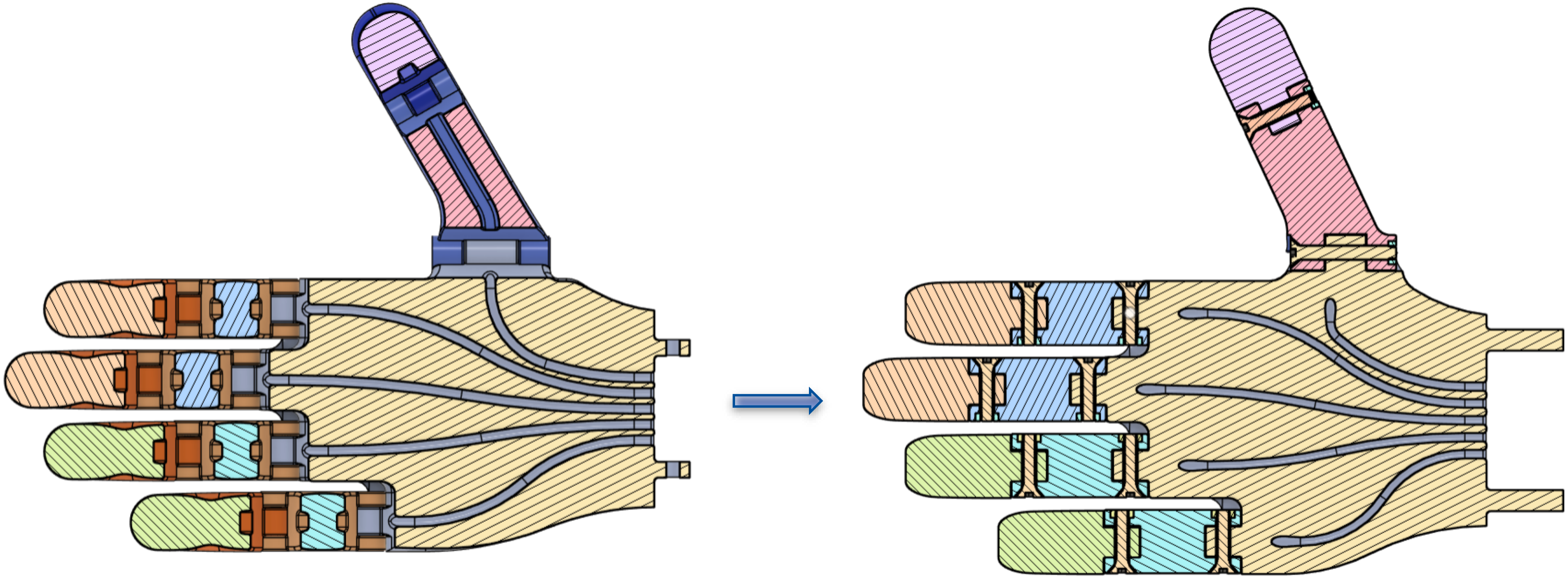




Design Evolution

Tendon Routing

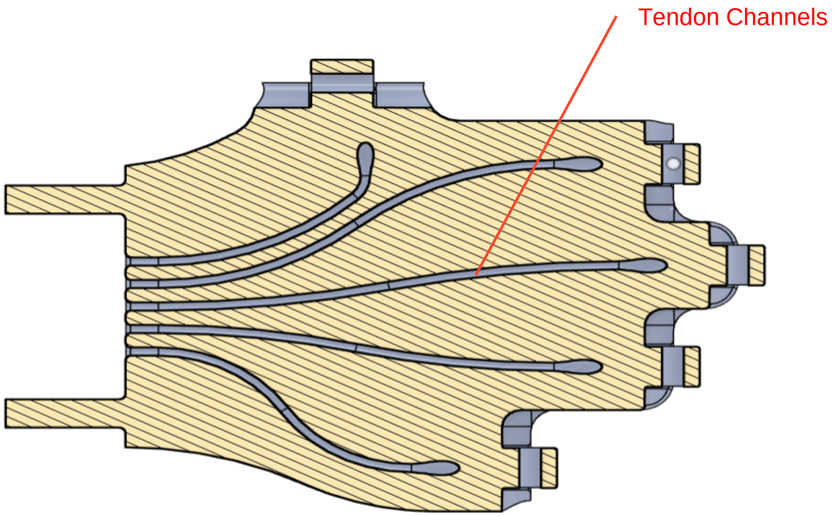
- 3D tendon paths



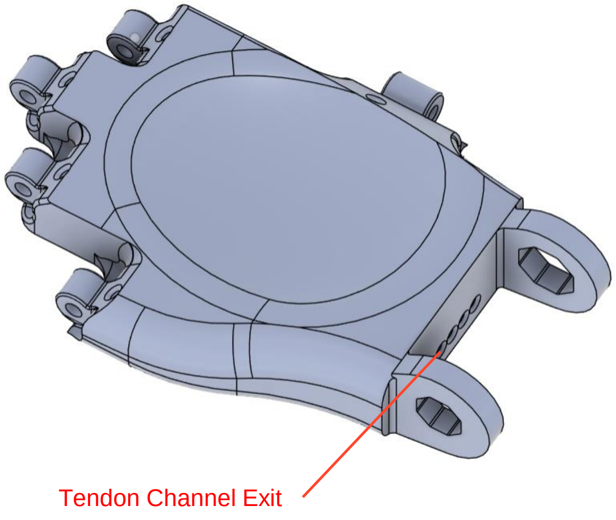
CAD Design Views

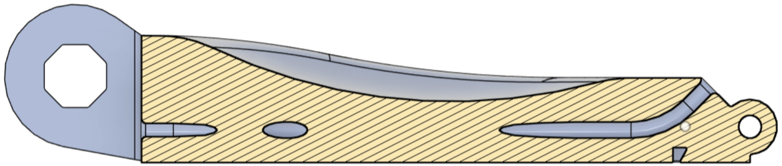
Palm Design

- Single-piece design for simplicity
- 3D tendon routing paths



TOP SECTION VIEW





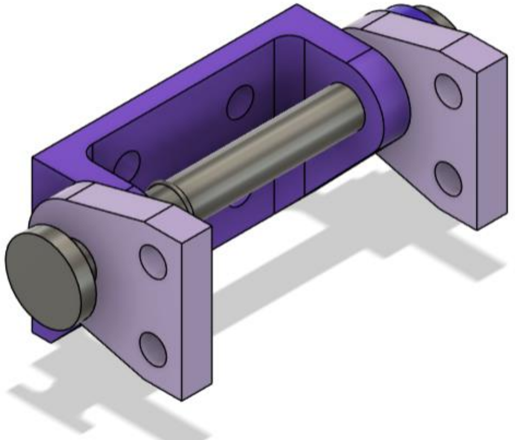
SIDE SECTION VIEW

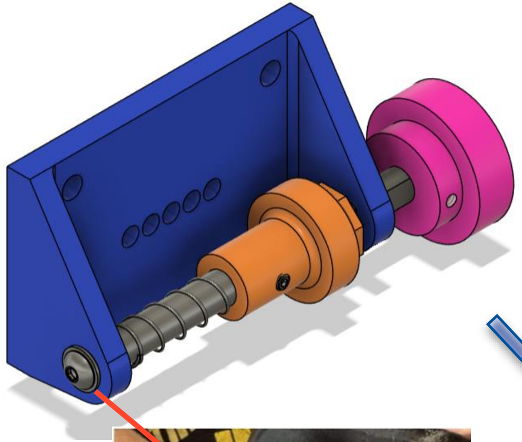
Design Evolution

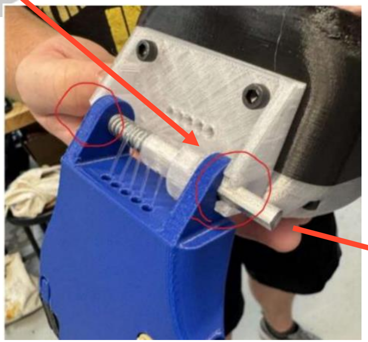
Lower Wrist Design

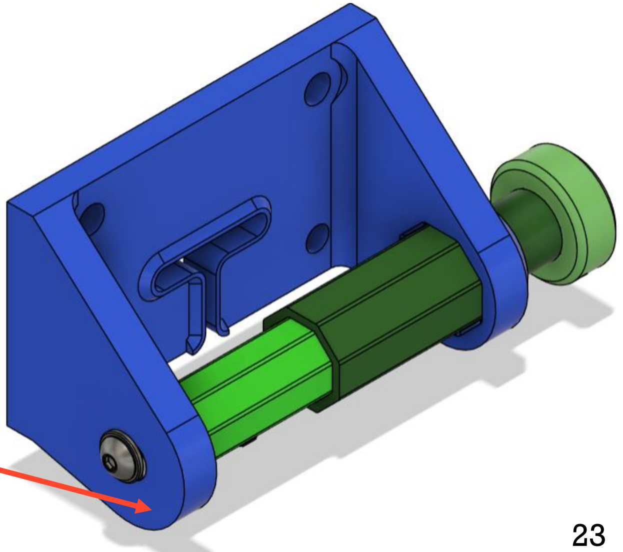
- Improved rigidity
- Resistance to unlocking
- Removable without cutting tendons

•Drop test showed weakness in hinge point plastic





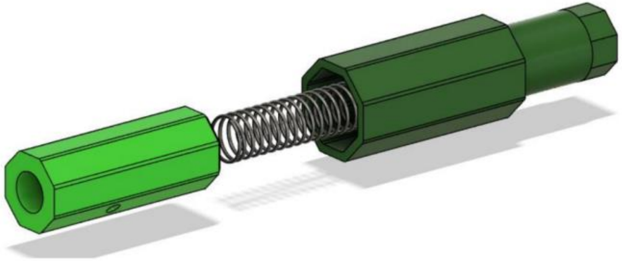


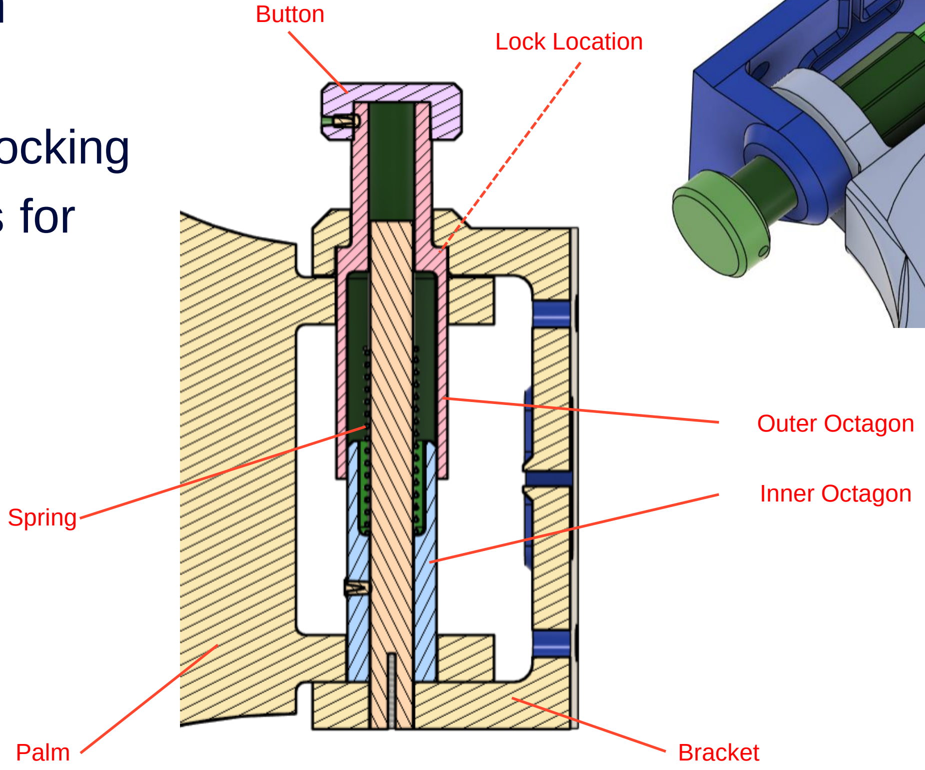


CAD Design Views

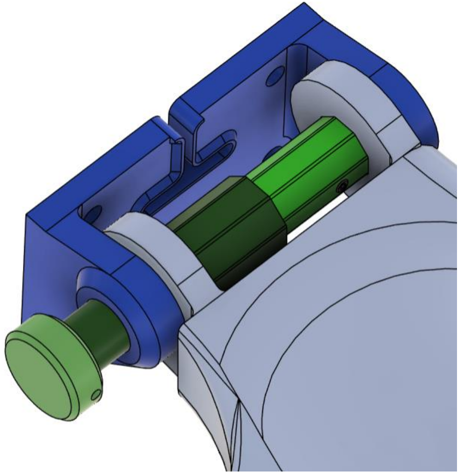
Lower Wrist Mechanism (Wrist Supination)

- Internal spring for auto-locking
- Octagonal design allows for multiple angle options





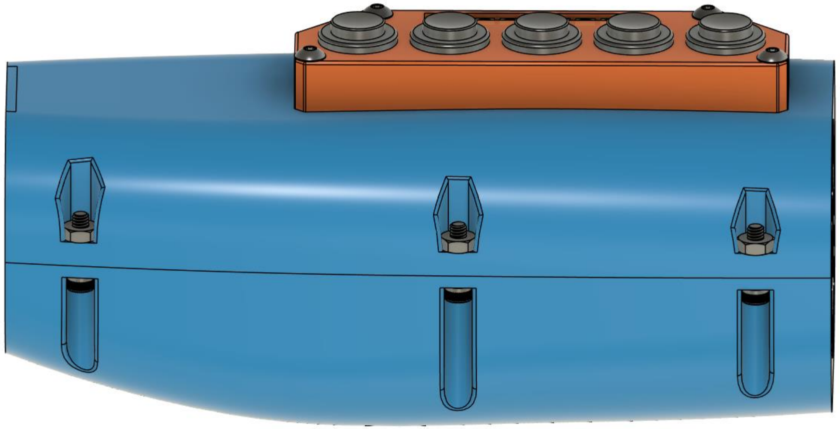
TOP SECTION VIEW

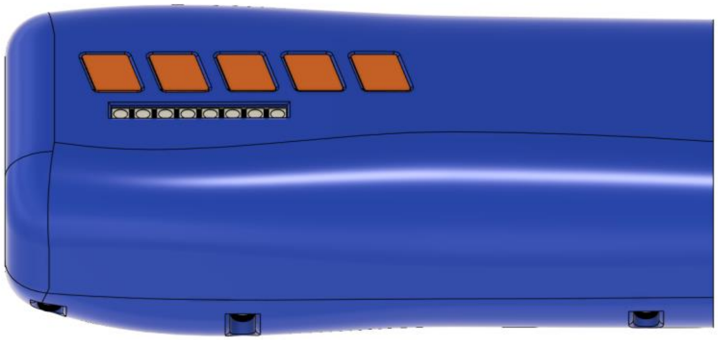


Design Evolution

Motor housing Design

- Smaller, button panel embedded, fewer fasteners

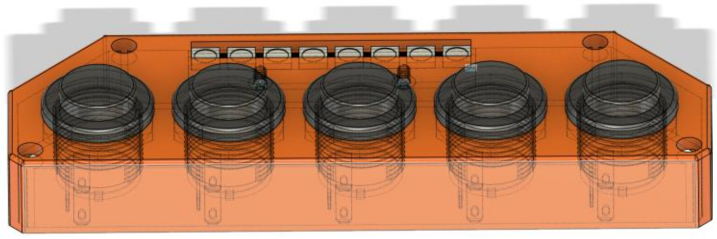


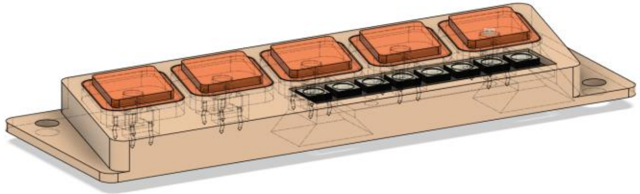


Design Evolution

Button Panel Design

- Thinner, internal mounting

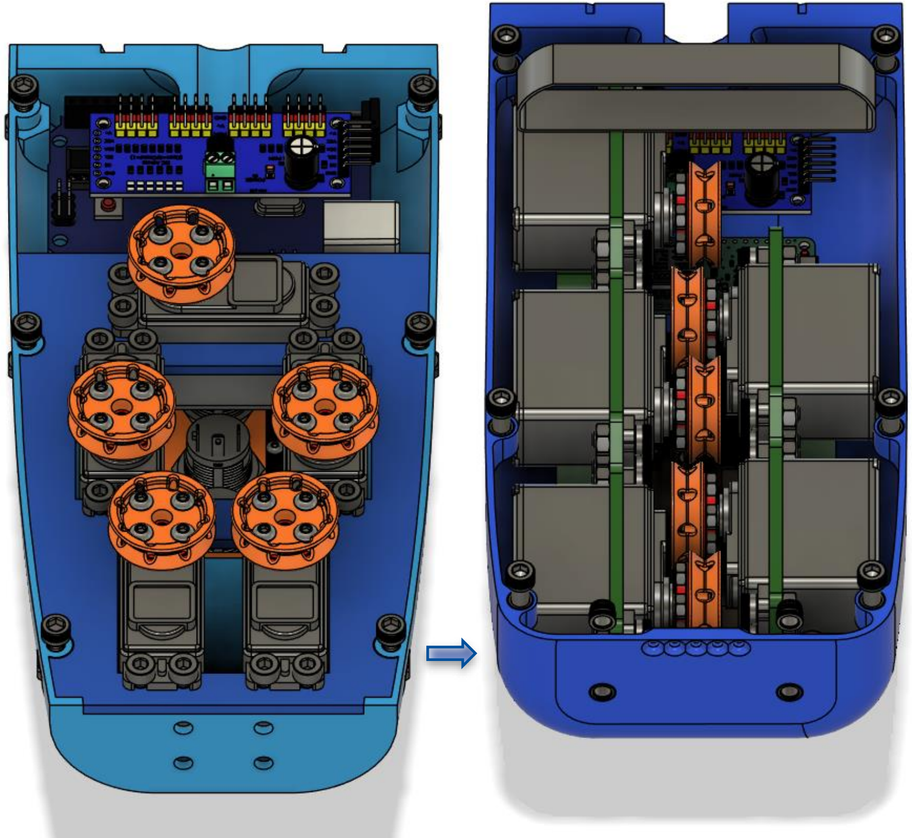




Design Evolution

Motor Mount Layout

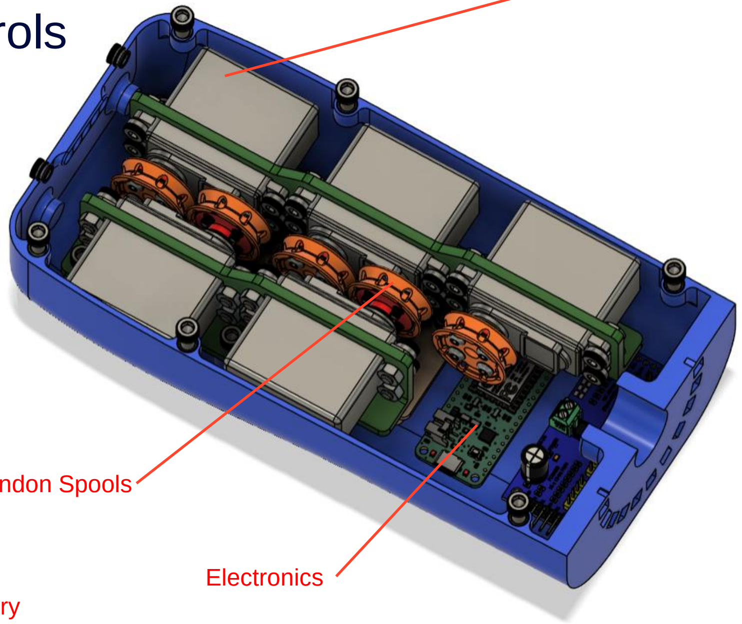
- Motors mounted horizontally
- Staggered for tendon clearance
- Allows for button panel to fit

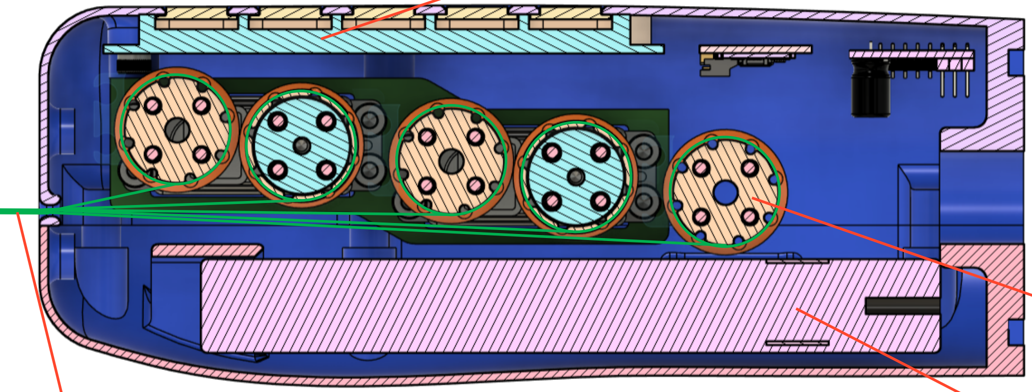


CAD Design Views

Motor Housing and Electronics

- Motors aligned for space-saving design
- Staggered for tendon clearance
- Fits battery, electronics, and button controls



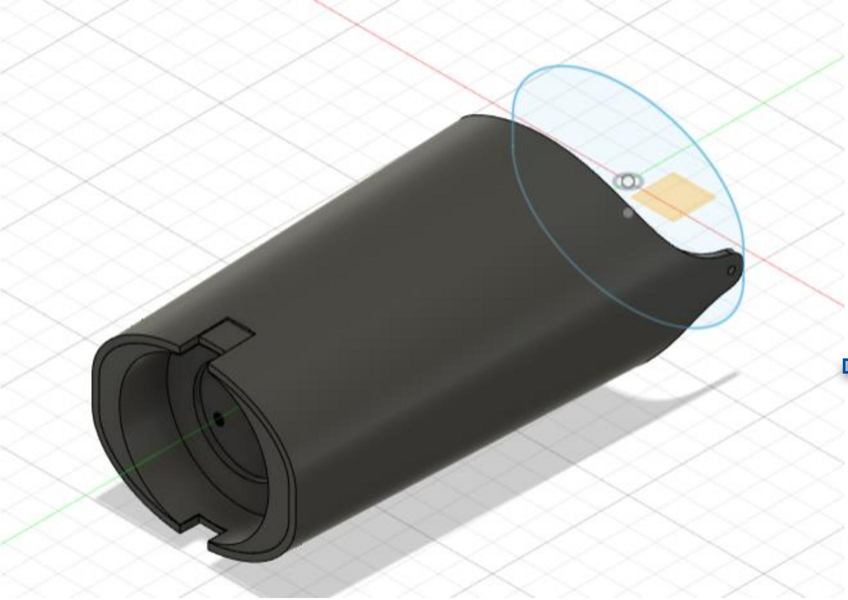


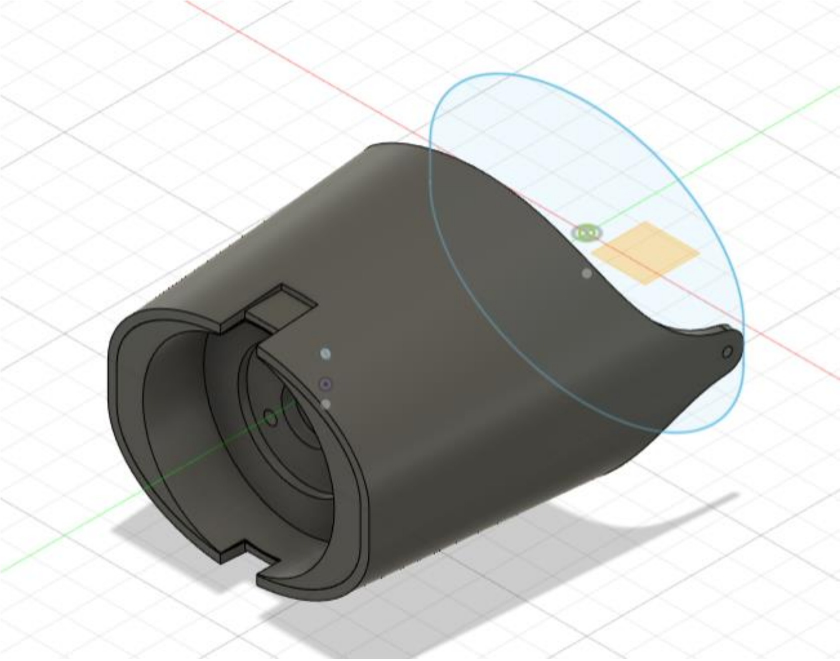
SIDE SECTION VIEW

Design Evolution

Lower Arm Mount

- Shortened for arm length
- Hinges thickened for durability

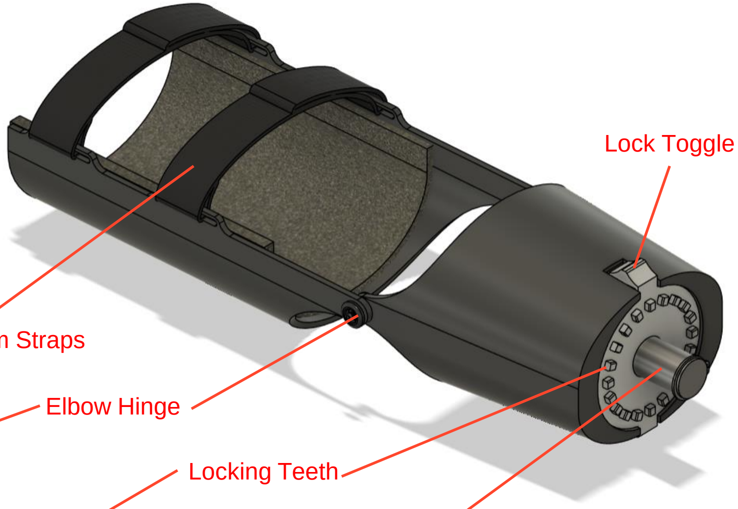


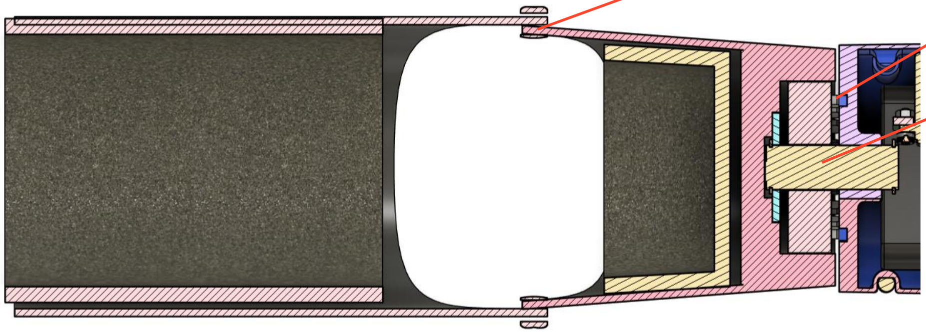


CAD Design Views

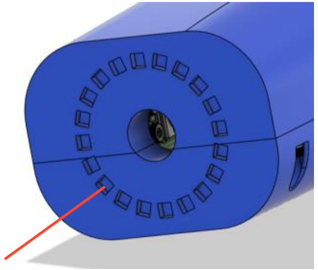
Upper "Wrist" and Arm Mount

- Easy to use locking mechanism allows for many angle options
- Strap around upper arm to secure prosthetic





TOP SECTION VIEW



Cost Table

	One Prototype	Batch of 60 Units
OTS Components Cost	$414.38	$10,770.41
PETG Filament Cost	$23.71	$1,422.84
Manufacturing/Assembly Cost	$99.79	$457.33
Total	$537.88	$12,193.25 ($203.22 per unit)

Future Improvements

- Rubber covering/glove implementation for improved grip
- Smaller battery for weight and price reduction
- Increased strength to wrist hinge
- Larger teeth for upper arm rotation mechanism
- Bluetooth/WIFI integration for phone control (only requires a software update)

Summary

- Ease of Use
- Affordability
- Accessibility

Herbert Wertheim College of Engineering
UNIVERSITY of FLORIDA

LimbLeap INNOVATIONS

Group MT0A-3: LimbLeap Innovations

Team Members: Brad Shack, Ayrton Howard, Alex Shaftel, Kyle Browning, Jordi Rey, Carlos Nieves, Olivia Miller, Canyon Tennant, Gaige Bryan

EML4502: Mechanical Design 3,
2024 Spring

POWERING THE NEW ENGINEER TO TRANSFORM THE FUTURE