TEAM C1: CLIMB
Final Presentation

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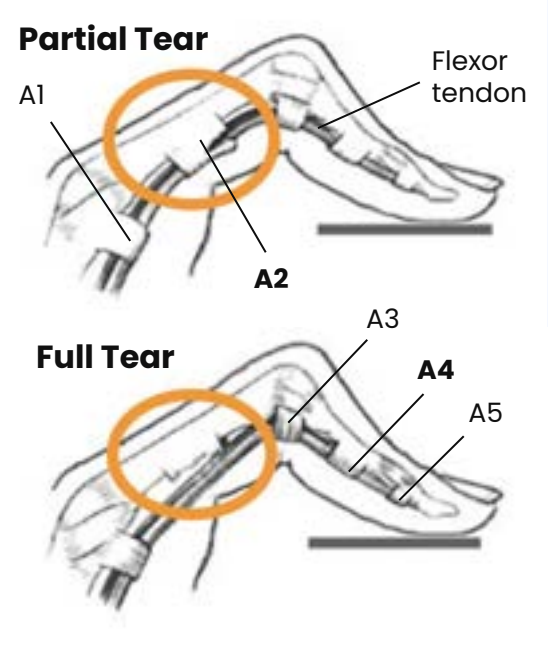
The Problem & Our Solution

Rock Climbers & Pulley Injuries

- 44.5 million climbers around the world
- Most common injury
  - Pulley rupture
- 3-12 month recovery

Our Solution

- Comfortable wearable device
- Minimal restrictive effect on climber
- Prevent injury before it happens through alarms
- Provide weight distribution data



Use Case & Design Requirements

Use Case Requirement	Technical Requirement
Comfortable & Unobtrusive	The sensors shall be placed such that **less than 30%** of per-finger surface area is covered.
Prevent Pulley Injuries	The device shall be sensitive **up to 70 lbs** of force per sensor.
→	On-device haptic alarm shall fire **within 200ms** from when user's breach the safety threshold.
Provide Useful Feedback	Analytics and suggestive feedback shall display **within 10s** of workout completion.

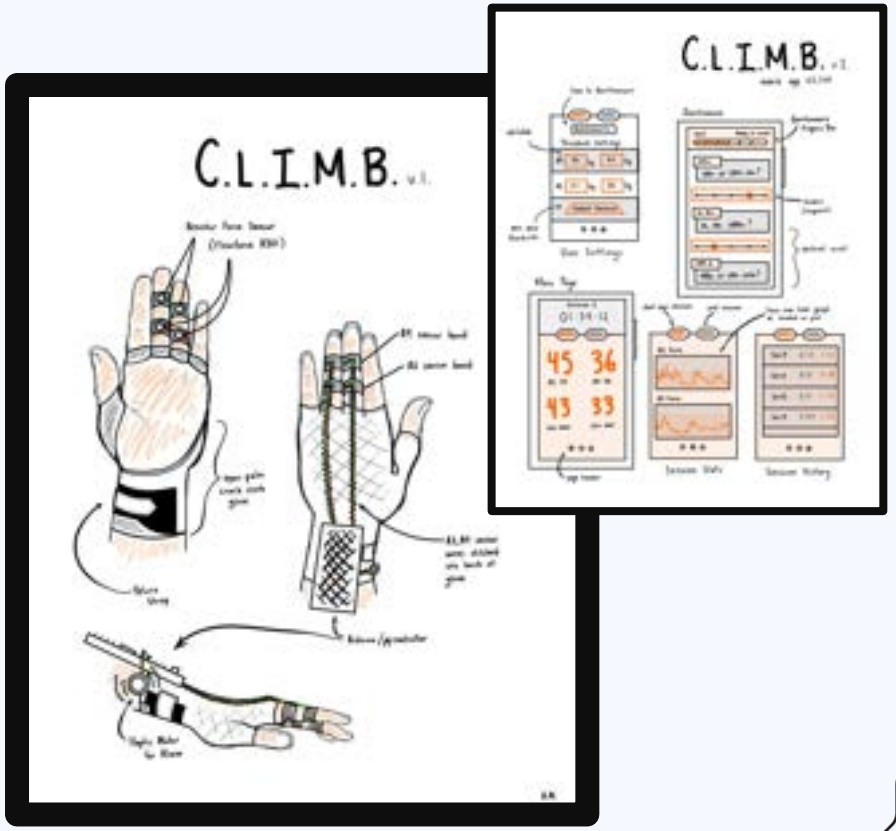
Solution Approach

Wearable Glove

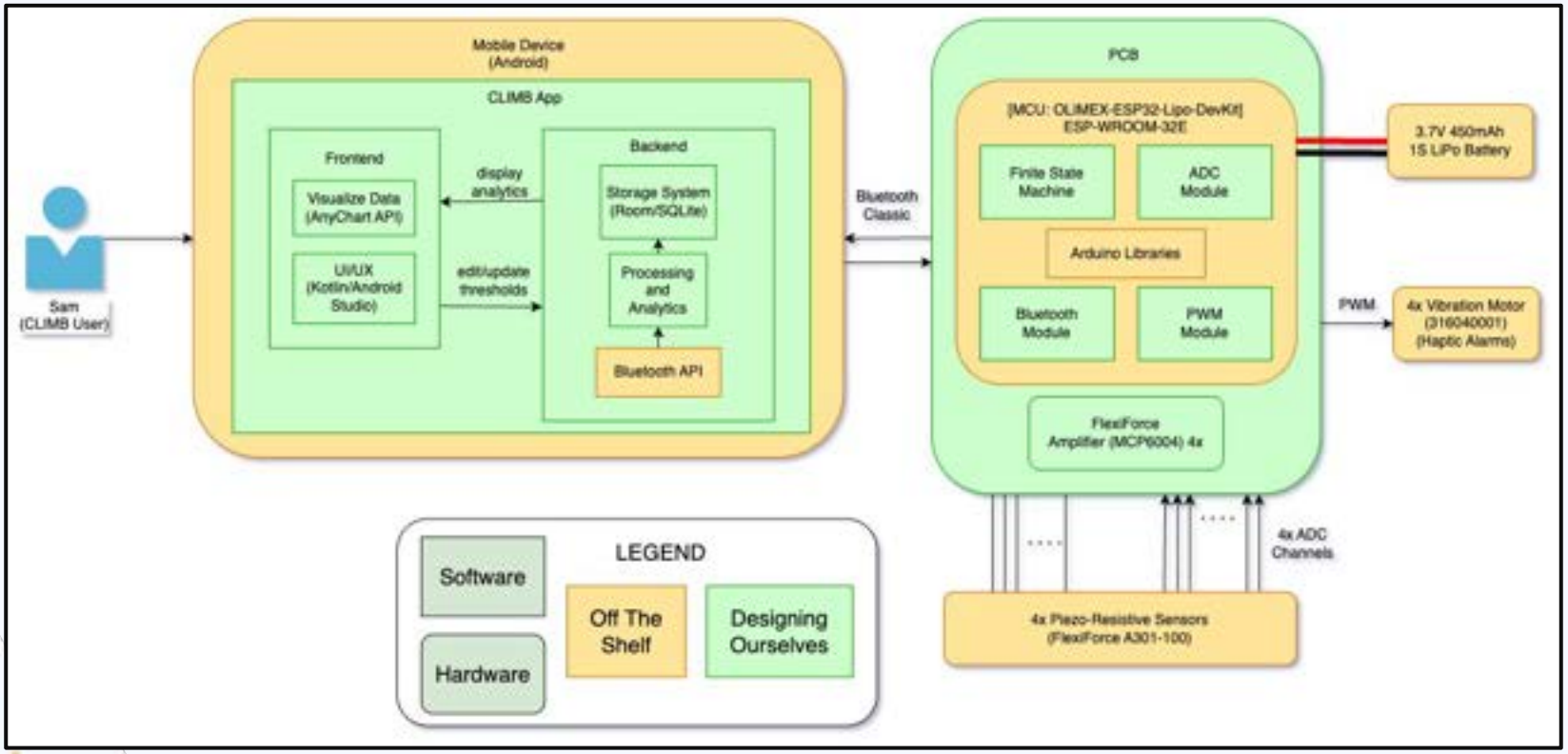
- Track force distribution data
  - Piezoresistive sensors
- Pulley Alarms
  - Haptic Motors

Mobile App

- Determine and set safety thresholds
- Start and end climbing sessions
- Display and analyze session data



Complete Solution

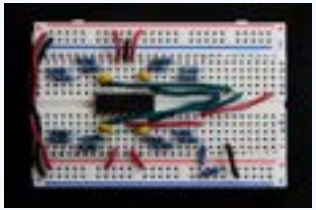


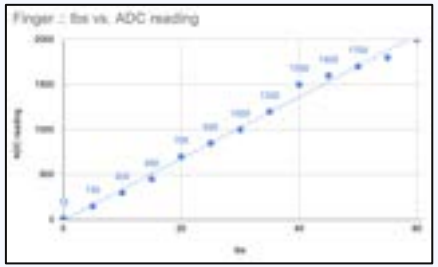
Glove (Hardware Solution)

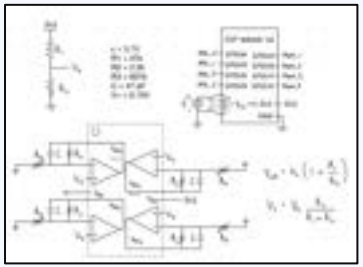
Continuous Force Reading
- Sampling rate
  T = 0.1s (**100ms**)

Maintain Distinct Thresholds
- Four sensors & pulleys per hand
- Target A2, A4, pulleys:
  middle and ring fingers

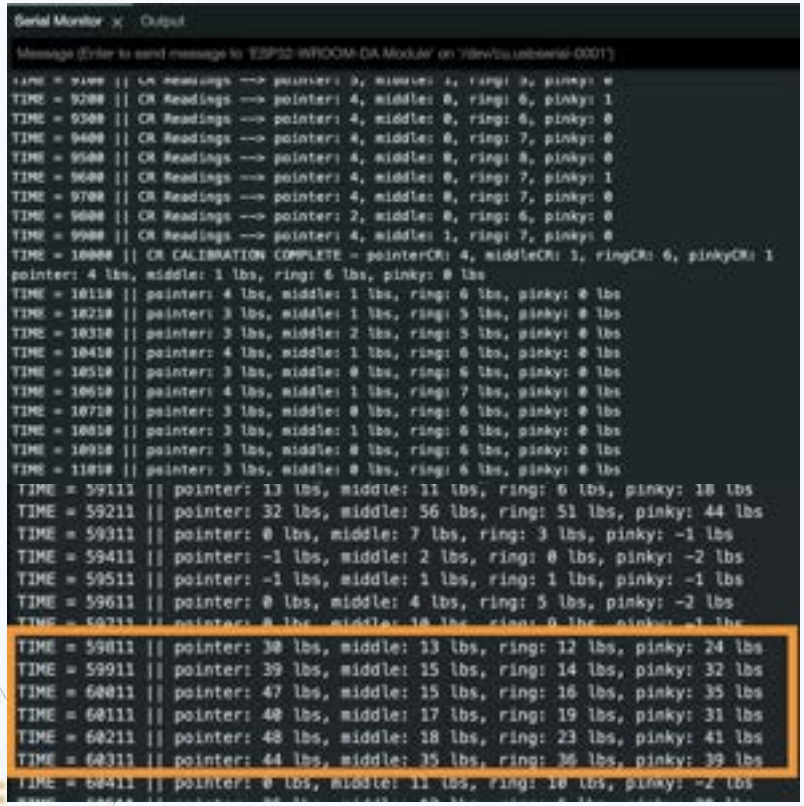
Fire Haptic Motor Alarms
- Increased risk → stronger alarms

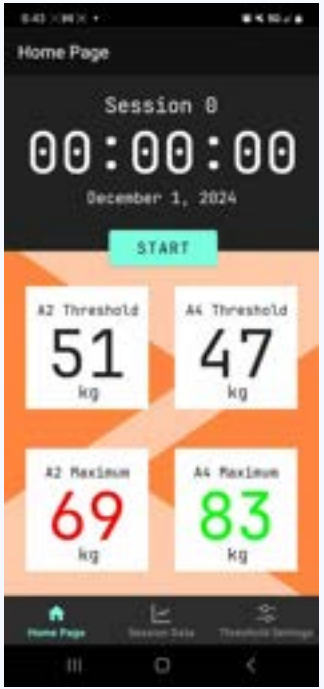






Mobile App (Software Solution)





Testing Requirements

Testing (Goal)	Specification
Ergonomic Validation	Survey 20 random climbers to determine usability (yes/no), WTP ($), and obtrusiveness (%)
Durability Verification & Validation	Sensitivity drift and wear/tear is measured after each of 20 static & dynamic uses (2 minutes /) with 80kg applied (drift to be within 2.5%)
Safety Verification	(1) Verify that a constant 0 – 60 lbs is consistent (within 5%) at each 5lb increment reading over 20 trials (2) Verify that at least one alarm is triggered within 100ms when force reading is within 20% of threshold at a 99% success rate (3) Verify that second alarm fires within 200ms of threshold excession with a 99% success rate
Feedback Verification	Verify that 20 (~96kb) batches (batch/use) ship to the mobile device within 10s at a 95% success rate

Hardware Testing Results

Specification	Requirement	Result
Sensitivity drift	< 2.5%	~ 2%
Reading Consistency	< 5%	~ 3%
Alarm Fire	> 99%	100%
Battery Life	> 3 Hours	Ongoing
CLIMB Survey	20 Climbers	Ongoing (5)

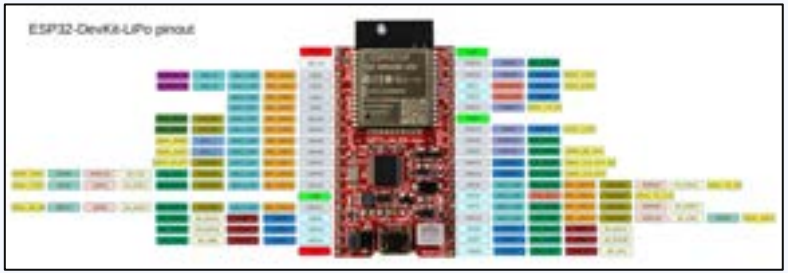
"Yeah I'd use that as long as my fingertips and palm are free, it'd definitely save people from getting pulleys." ~ fellow climber at ICB

Software Testing Results

Specification	Requirement	Result
Bluetooth Pairing Time	< 5s	~ 1s
Bluetooth Distance	> 10ft	30ft
Bluetooth Shipment Time	< 5s	~ 3s
Time to load 3kB from database	< 3s	~ 2s
Data visualization Time (Charts)	< 2s	Ongoing

Design Tradeoffs

- MCU
  - ESP32 → ~(25 x 18 x 3)mm, clk: 240MHz, built-in BT Classic/LE support, ~0.6W, 15 ADCs
    - Olimex → **~15$, smaller**, has **on-board power jack**, reduces the need to design/purchase LDO and add complexity to PCB
    - Adafruit → **~8$**, **larger size**, **no LDO (& power-jack)**
  - STM32FRE → (68 x 53 x 13)mm, clk: 160MHz, ~ 0.3W, no built-in BT support, 9 ADCs
- Sensor attachment
  - Tape → more grip flexibility, modularity, greater placement accuracy
  - Nylon Rings → greater placement consistency, less grip



Looking Ahead & Proj Management

Next Steps

- Add second glove
- PCB & Capsule
- Display data retrieved from database
  - Analytics
  - Session history

Schedule