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COLLEGE OF ENGINEERING
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Smart Walker

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Overview

- Client Description
- Problem Statement
- Background Research
- Competing Designs
- Product Design Specifications
- Current Design: Electronics & App
- Design Matrix: Software & Materials
- Future Work and Acknowledgements

Client

Mr. Daniel Kutschera

- Physical therapist in neurorehabilitation
- Acute Stroke Clinic - ThedaCare, Fitchburg, WI



Figure 1: Mr. Daniel Kutschera [1]

Background

Tracking Traumatic Brain Injury (TBI) Recovery Patient Walking Progress

- Current Methods
 - Timer and tape measure for speed and distance
 - No commercially available way to track weight put on walker
- Past BME Design Iterations
 - Compromised structural integrity of walker
 - Not easily replicable

Figure 2:
2025 Final
Design



Figure 3:
2024
Final
Design



Problem Statement: The Project

Current TBI monitoring methods **only measure speed and distance** after trials, **ignoring weight data**.

Real-time metric collection can **reduce documentation time**, provide instant feedback on discharge readiness, **streamline insurance** processes, and help **patients track their progress**.

Competing Designs

- Camino Smart Walker
 - Enhances stability
 - Provides automated physical support
 - Expensive - \$2,999 [2]
- Research prototype
 - Not commercially available or patented
 - Utilised LIDAR sensor and load cells [3]
 - Permanent fixation of sensor and load cells



Figure 4: Camino Smart Walker [2]

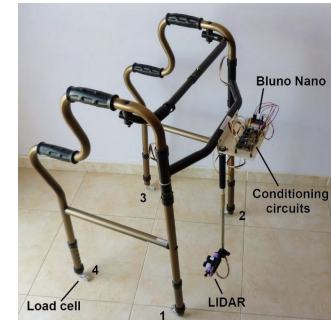


Figure 5: Instrumented Research Prototype Walker [3]

Product Design Specifications

Client Requirements

- Easily installed and removed
- Will track
 - Distance traveled
 - Walking speed
 - Weight applied to the walker
- Independent weight and speed measurements
- Display metrics from a mobile device

Accuracy

- Measure within $\pm 10\%$
 - Distances up to 50m
 - Speeds 0-9.65km/h
 - Weights of 0-100kg

Budget

- ~\$500

Current Design: Hardware

- How it works
 - Load cells track weight
 - mmWave radar track distance and speed
- Changes
 - 3D print material for electrical enclosures
 - Load cell holder design
 - Fixture to attach mobile phone on walker

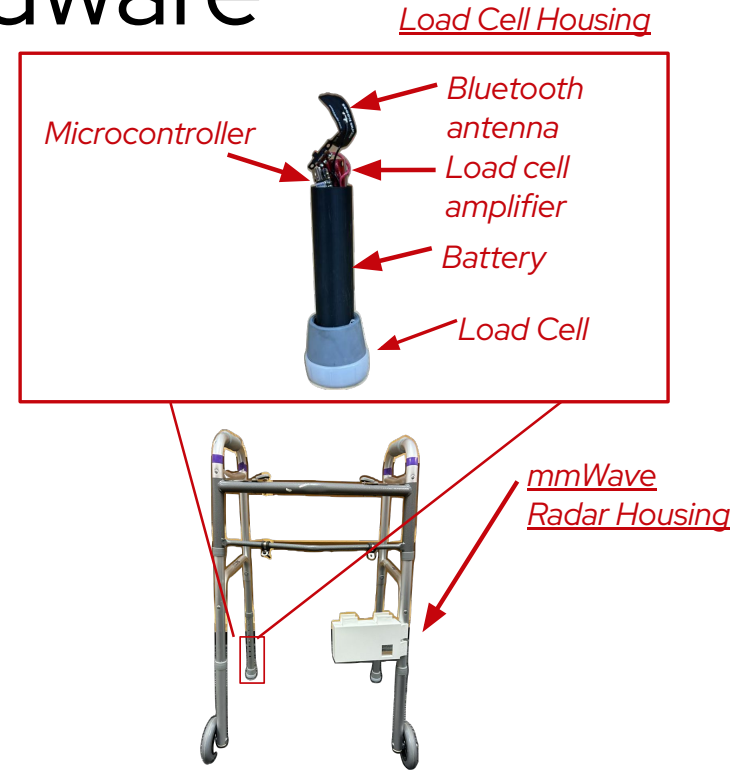


Figure 6: Spring 2026 Smart Walker

Current Design: Circuit Flow

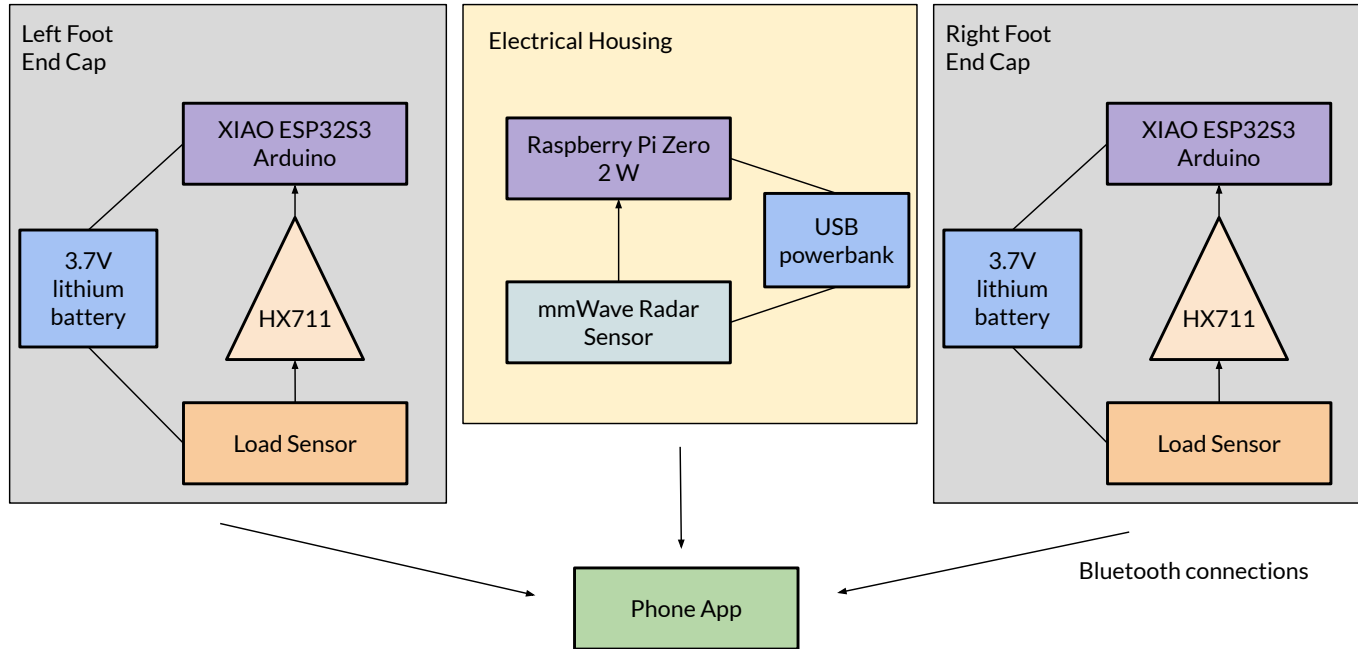


Figure 7: Circuit Design Flow

Current Design: Testing

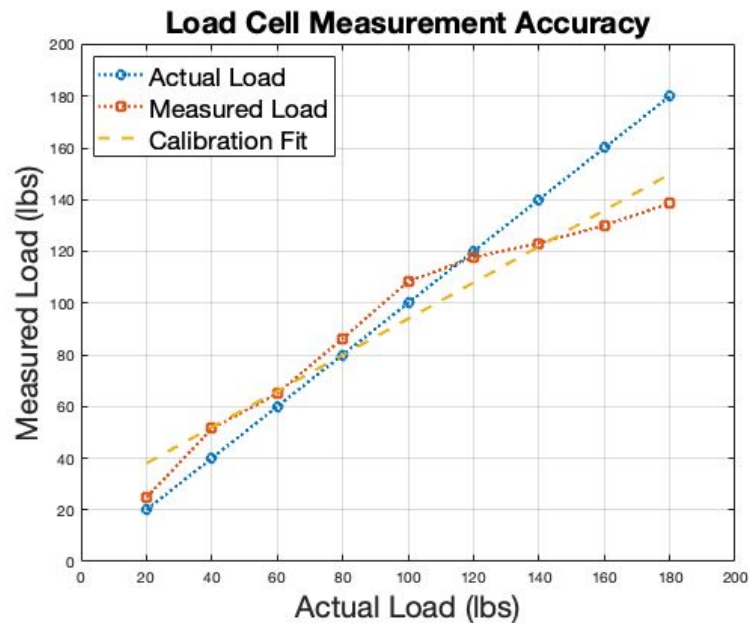


Figure 8: Load-cell measured vs actual load across the 20–180lb showing linear response.

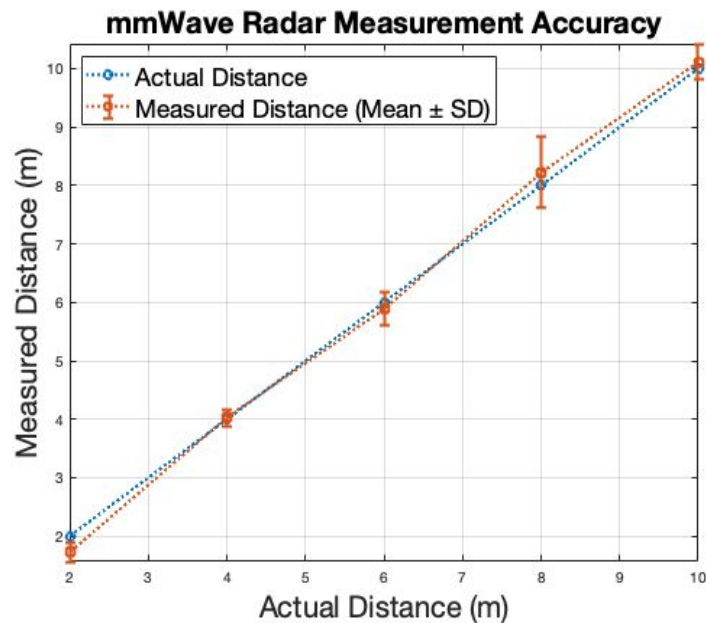


Figure 9: mmWave radar measured vs actual distance (mean $\pm$ SD) across the 2–10m.

PETG (Polyethylene Terephthalate Glycol)

- + High strength & layer adhesion
- + Resists impact, UV, water
- + Easy to print and lowest cost (\$2/100g)
- Creep under sustained clamping
- Limited elastic range



Figure 10: PETG [4]

TPU (Thermoplastic Polyurethane)

- + Largest elastic range
- + Shock absorbing
- + Used in Past Smart Walker
- Too flexible for a secure long-term grip on the walker post
- Highest cost (\$4/100 g)



Figure 11: TPU [5]

ABS (Acrylonitrile Butadiene Styrene)

- + High stiffness and impact resistance
- + Electrical Insulator
- + Better creep resistance than PETG
- Weak layer adhesion
- Warps

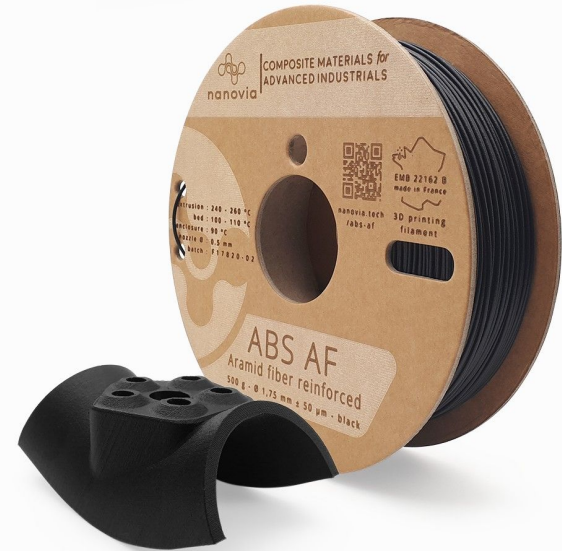


Figure 12: ABS [6]

Design Matrix: Enclosure Material

Criteria (weight)	Concept A: PETG	Concept B: TPU	Concept C: ABS
<i>Strength (35)</i>	31.5	24.5	21
<i>Limit of Elastic Deformation (30)</i>	21	30	21
<i>Longevity (20)</i>	18	16	14
<i>Ease of Fabrication (10)</i>	8	7	4
<i>Cost (5)</i>	5	3	3.5
<i>Total (100)</i>	83.5	80.5	63.5

Figure 13: Design Matrix for Electronic Enclosure 3D Print Material

Current Design: Software

- How it works
 - SwiftUI for iOS
 - Real-time monitoring
 - Data recording
 - Post-trial analysis
 - Connect wirelessly via bluetooth
- Changes
 - Multiplatform support

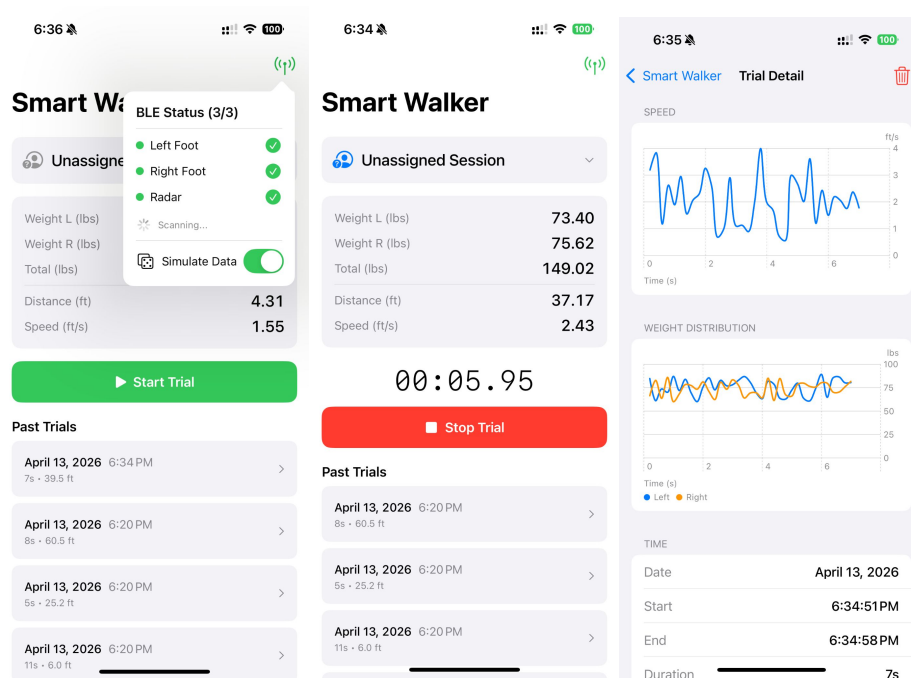


Figure 14: Photo of App UI

Software Design 1: 2 Natives

- + Best native BLE access
- + Existing iOS app can stay
- + Full control on both platforms
- + Proven in past Smart Walker end cap prints
- Two separate codebases
- Every feature/fix may need to be done 2x
- High maintenance effort
- No desktop support



Figure 15 and 16 (Top to Bottom): Swift [7] and Kotlin [8] Logos

Software Design 2: Skip

- + Maximum reuse of current Swift code
- + Supports iOS + Android from Swift
- + Can access native Android APIs
- Newer, smaller ecosystem
- Less proven for backend support
- No desktop support



Figure 17: Skip Logo [9]

Software Design 3: Kotlin Multiplatform

- + One shared codebase
- + Desktop support
- Significant rewrite
- Less proven on iOS



Figure 18: Kotlin Multi Platform Logo [10]

Software Design 4: Flutter

- + One shared codebase
- + Proven performance across platforms
- + Large ecosystem and strong support
- + Desktop support
- Significant rewrite



Figure 19: Flutter Logo [11]

Design Matrix: Software

Criteria (weight)	Concept A: 2 Natives	Concept B: Skip	Concept C: Kotlin Multiplatform	Concept D: Flutter
<i>Swift reuse (20)</i>	10	20	0	6
<i>Multi Platform compatibility (40)</i>	40	32	32	40
<i>Maintenance (40)</i>	0	20	32	32
<i>Total (100)</i>	50	72	64	78

Figure 20: Design Matrix for Software

Future Work

Further Improvements:

- Add cable management: Load Cell Housing
- Outer housing clamp improvements
- Reprint both housings for better durability
- Angle the base of the load cell housing to match the angle the walker legs meet the ground

Testing:

- Load testing of the angled load cell housing. 100 kg (N, % error)
- Attach and remove cycle testing (cycles, time per install in s)
- Durability and drop testing of the PETG housings (drop height in m, pass/fail)



Figure 21: Walker Image and load cell housing slant zoom

Acknowledgements

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Questions?