Team Susan

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Meet Susan

- Susan is 55 and living with MS at the Boston Home
- Her right arm is largely immobile; she retains dexterity in her left arm and hand
- Susan regularly travels on her own beyond the Boston Home
- She desires a method to reliably actuate crosswalk buttons on her right & front side

High Level Goal

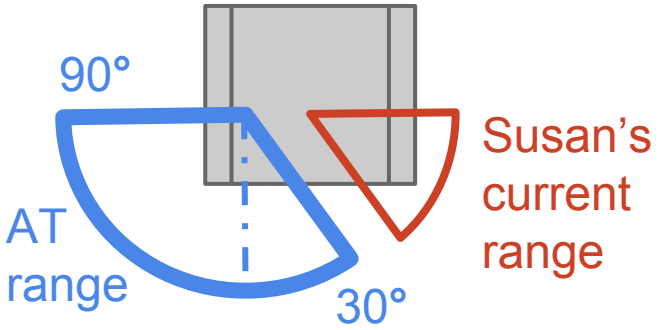
To ensure Susan retains maximum independence and safety by allowing her to reliably actuate crosswalk buttons with significantly reduced maneuvering.

Performance Metric

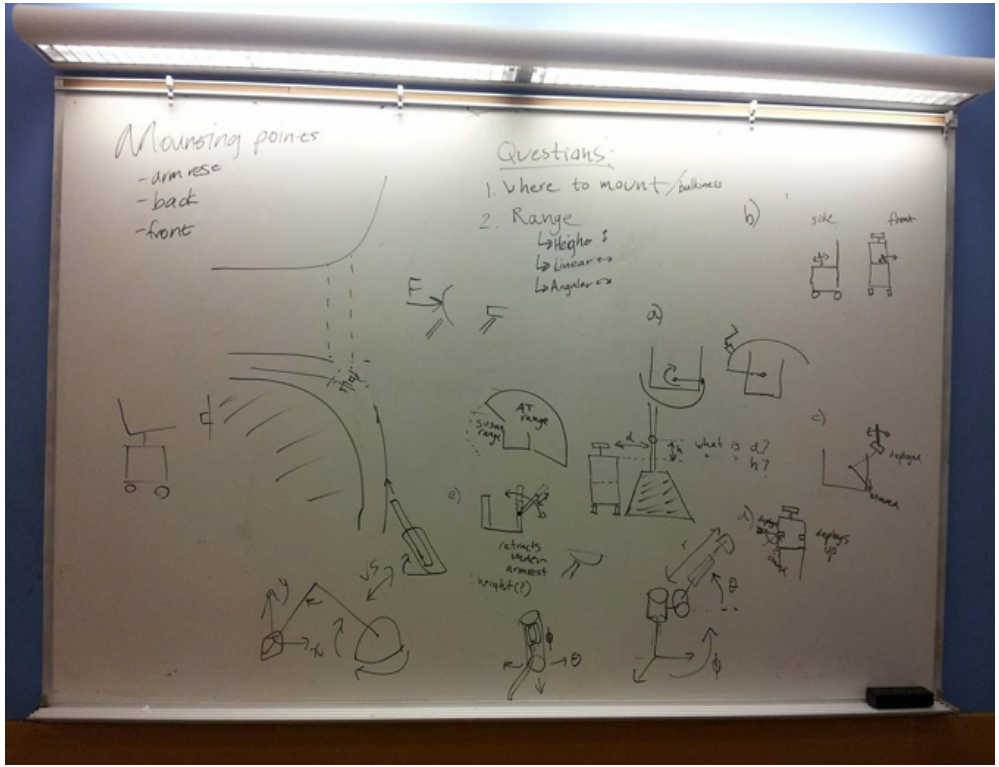
- **Reduce excessive maneuvering** on Susan’s part in **accessing crosswalk buttons** on her **front** or **right side**.
- Reduce Susan’s risk of **tipping** due to the need to **reach.**
- Strengthen Susan’s **independence.**

Functional Requirements

- Must maintain Susan in a **comfortable position** and **range of motion**
  - Height adjustment built in
- Should be **compatible with Susan's wheelchair** armrest & water bottle and not be too bulky
- Must be able to push **different button types at various heights**
- Secondary goals: aesthetics, feedback, state indicators



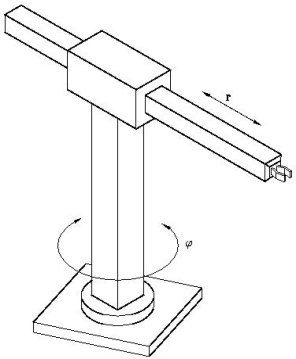
Initial Brainstorm



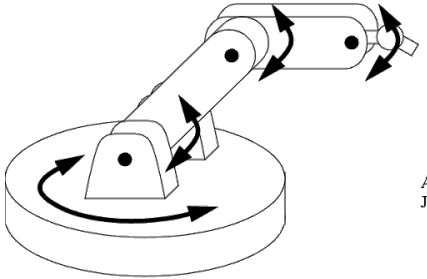
Revisit First Prototypes

1. RFID tag

2A. Simple robotic arm (2 DOF)



2B. Serial link robotic arm (3 DOF)



ARTICULATED/REVOLUTE/
JOINTED SPHERICAL

Revisit First Prototypes

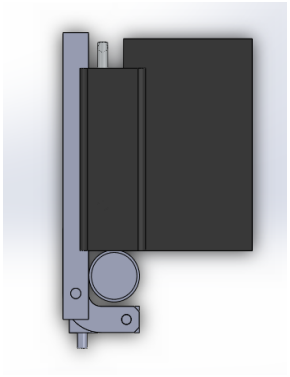
	Pros	Cons
1. RFID tag	• Automatic • Easiest	• Unfeasible • Not versatile
2A. Simple robotic arm (2 DOF)	• Easy to use • Good range • Good size, stowing	• No height adjustment (tipping risk)
2B. Serial link robotic arm (3 DOF)	• Built-in height adjustment	• Harder to control • Potentially bulky

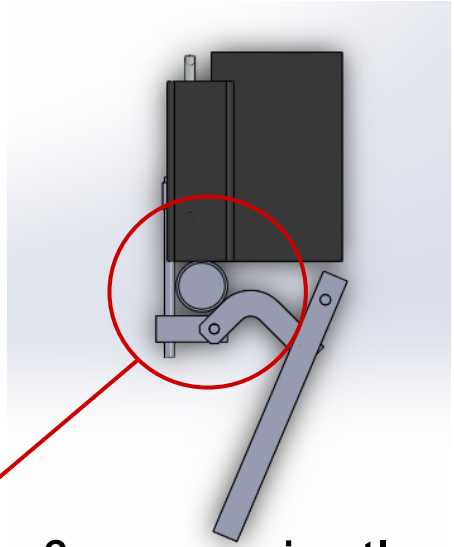
Feedback from PPAT

- Too ambitious for the time we have?
- Look for ways to make AT less mechatronic, more manual
- Consider manual aiming, since Susan has good dexterity in her left hand and arm
- Determine extent of Susan’s left hand/arm dexterity, grip strength, and reach

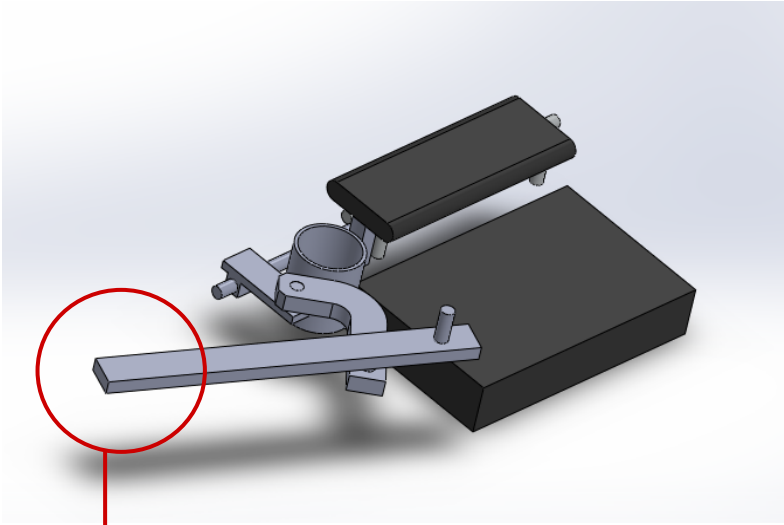
Revised Design: Manual

Stowed





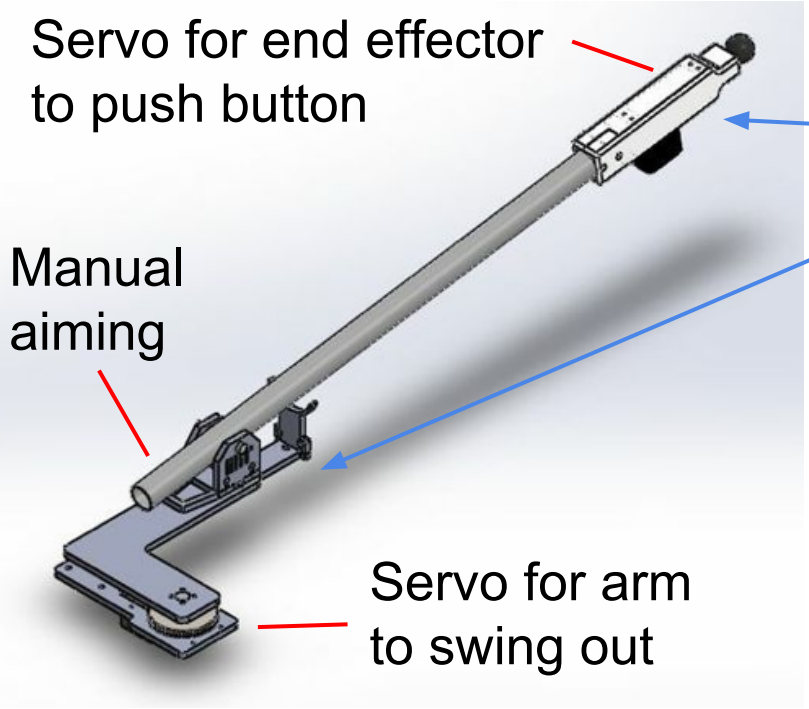
Deployed



Susan cannot safely & conveniently reach over to deploy arm

How to actuate button?

Final Design: Hybrid



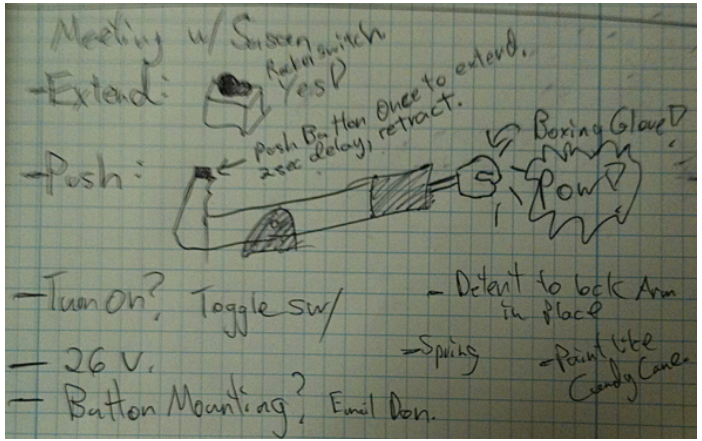
- Modeled in SolidWorks
- 3D printing
- Water jetting

- Motor actuation
  - Arduino
  - Simple switches
  - Connect to wheelchair battery for power

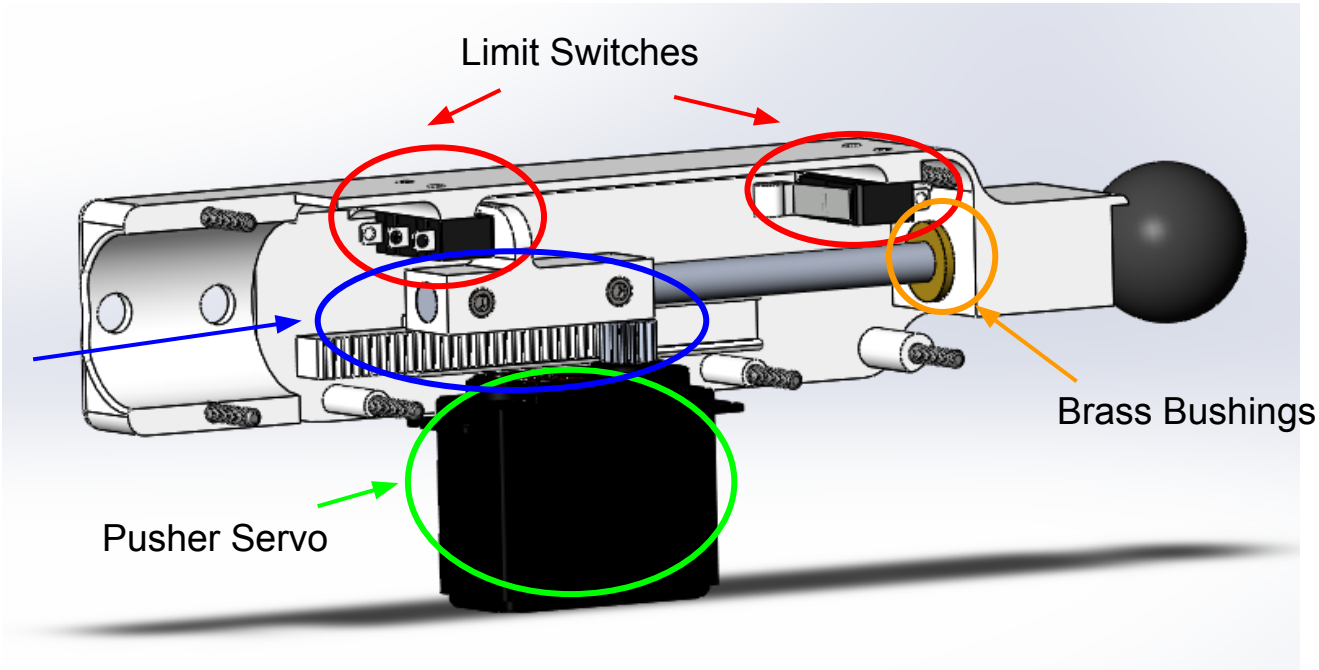
Final Design In Progress

Final Design In Progress

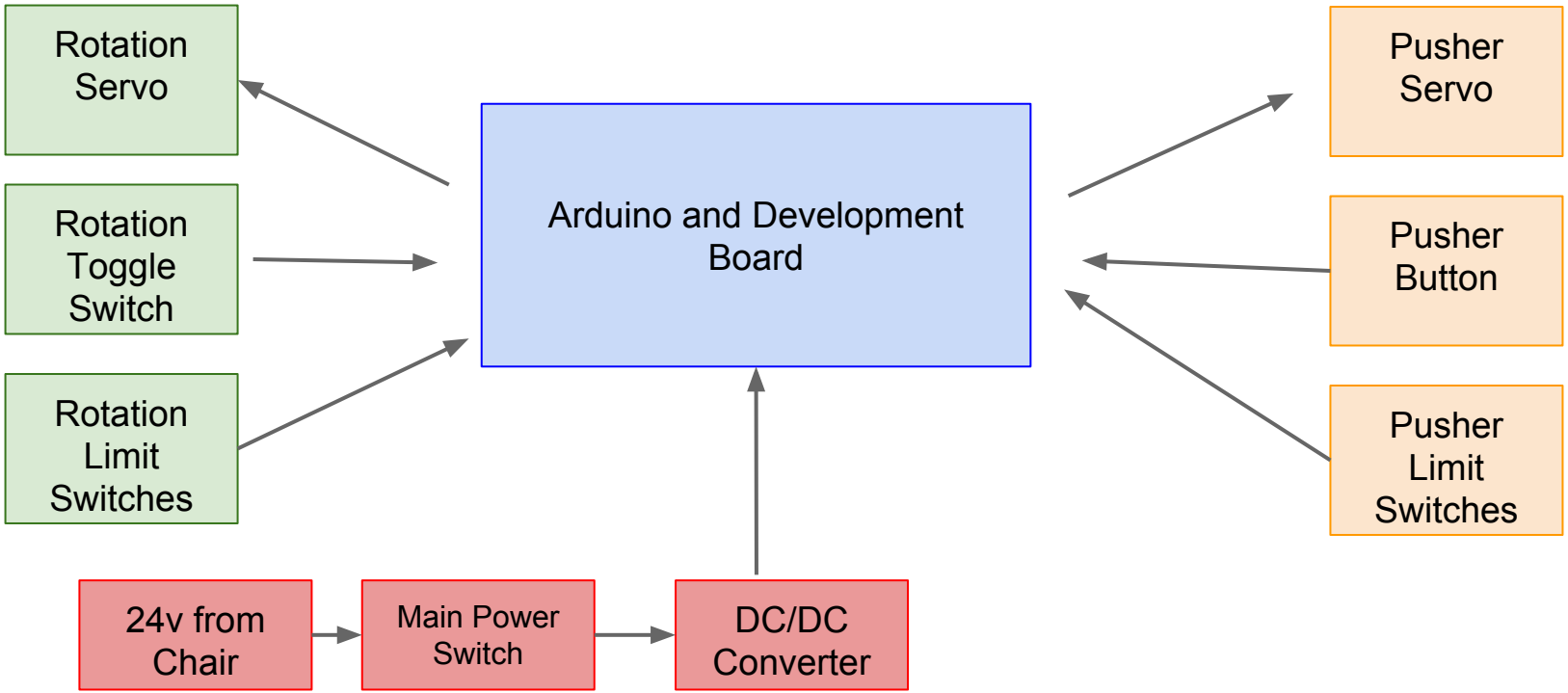
Additional considerations...



Final Design- Pusher

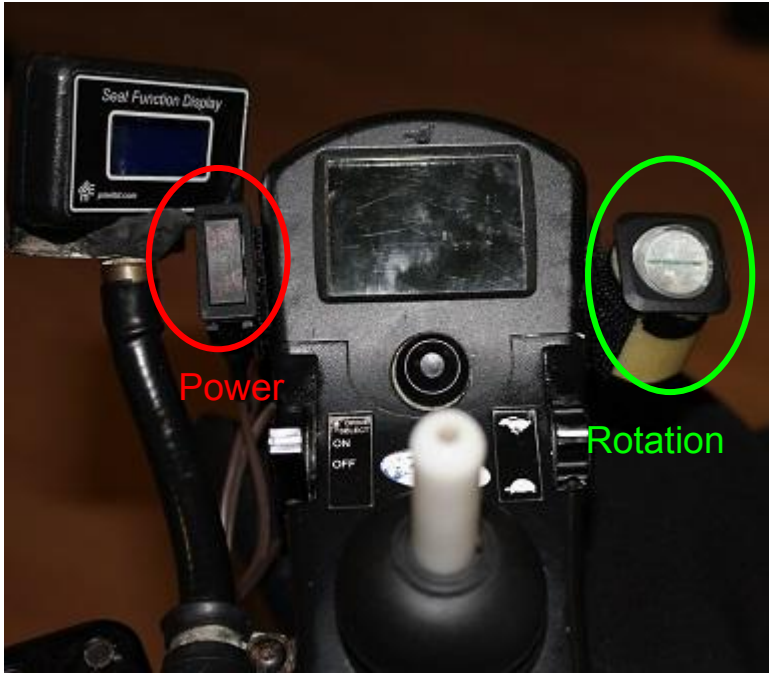


Final Design- Wiring Layout

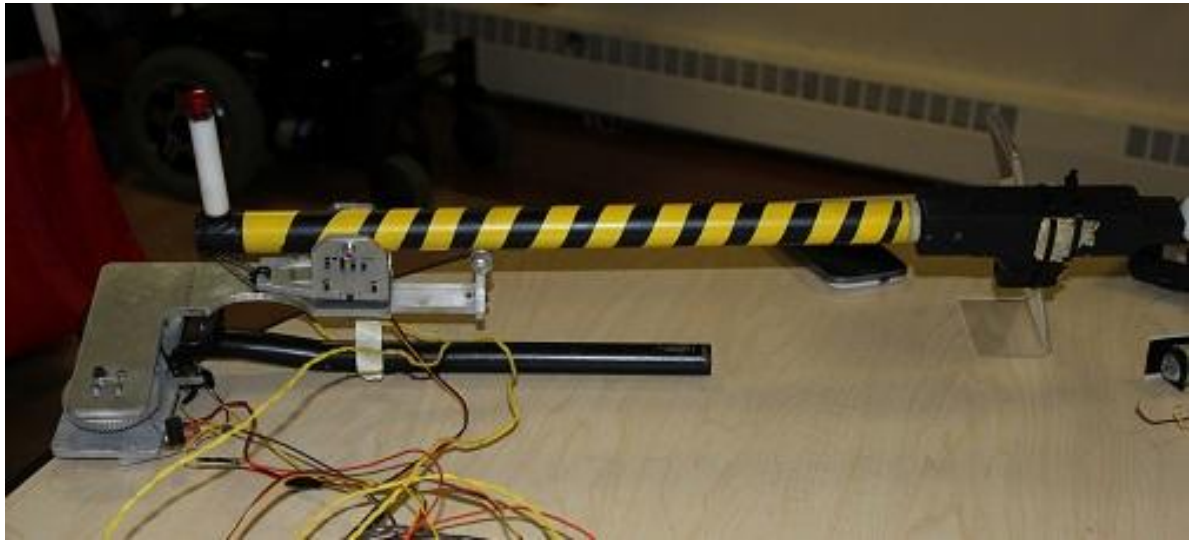


Steps for Operation

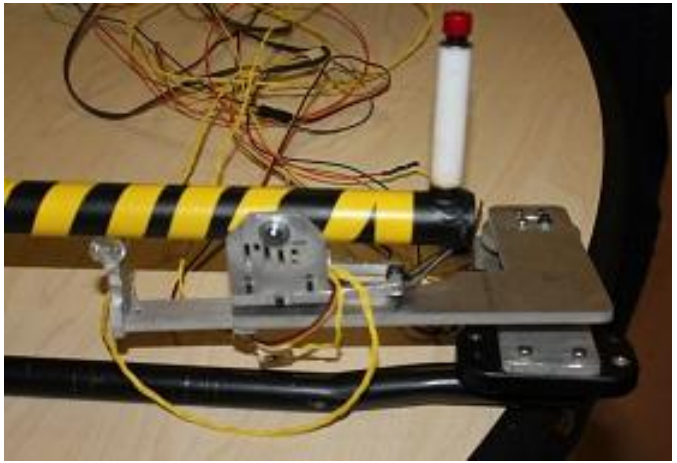
1. Power up system using main power switch
2. Rotate arm into operational position using toggle switch
3. Manually aim arm at button using handle
4. Push button by activating red button on top of handle
    a. Pusher direction may be reserved through second actuation if button pushed or missed
5. Replace arm in holster
6. Rotate arm to travel position using toggle switch



Final* Prototype



Hybrid robotic arm at the Boston Home prior to mounting to Susan's chair



Handle and push button detail

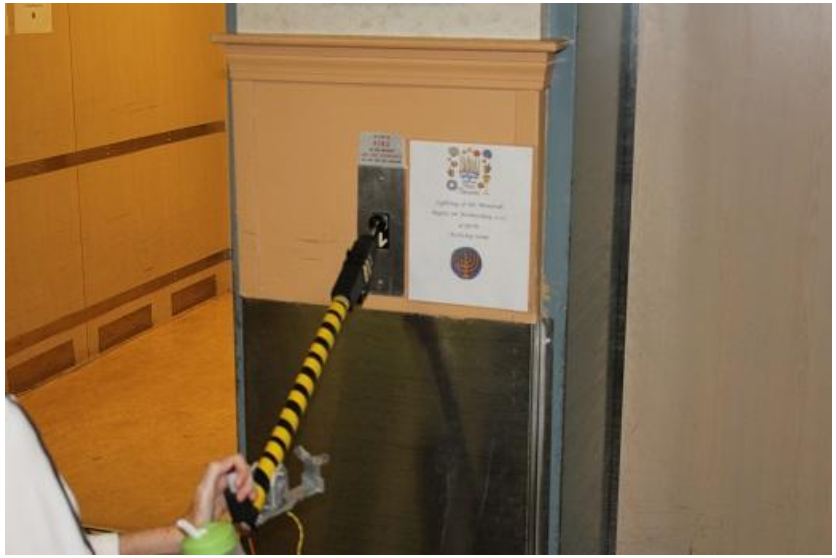
Final* Prototype

Hybrid robotic arm was found to easily mount to Susan's chair, and rotation put handle within easy reach of her left hand

The use of springs to counterbalance the weight of the pusher assembly reduces fatigue

Final* Prototype

Due to cold and dark, an elevator button was used as an analog for a crosswalk button



Susan was able to successfully actuate elevator button with minimal training

Performance metric

- **Reduce excessive maneuvering** on Susan's part in **accessing crosswalk buttons** on her **front** or **right side**.
  - Arm allowed Susan to push an elevator button in front and slightly right of her chair
- Reduce Susan's risk of **tipping** due to the need to **reach.**
  - Arm handle is positioned in the middle of Susan's lap, and rotation is automated to eliminate need to reach
- Strengthen Susan's **independence.**
  - More testing during real use is needed

Future steps

Near Term:

- Use of ball bearing for the manual arm pivot is too smooth. Susan would prefer some friction in the system to dampen motions slightly
- Wiring needs to be cleaned up and mounted in a way that is both secure and allows full range of motion
- Mounting position for the rotation limit switches is not optimal
- Rotation switch position and mounting needs improvement

Long Term:

- Arm requires too much space to rotate from travel to operational position. This limits use in confined/crowded spaces
- Force feedback on pusher servo is needed to sense when a button is bottomed out
- Pusher assembly could be more robust and allow for longer throw

Team Member Roles

Jeff: Arm pivot design, machining, epoxying, painting, wiring

Daniel: Pusher design, waterjet/printing, code development

Cole: Rotation design, machining, wiring

Sneha: Primary contact with Susan/Don, machining, documentation

Acknowledgements

- Tremendous thanks to Susan for being and outstanding client and providing exceptional feedback
- Don Fredette for providing advice, equipment, and parts
- The PPAT staff for guidance
- The Stata and Edgerton shop staffs
- MITERS for 3D printing
- Tow Tank labmates for putting up with us!