Deliverable F

Part 1: Two Nonfunctional Design Constraints

1. DFD (design for durability)

Our team chose Design for Durability because we think that there are many ways that our device could break while the product is adhered to the wheelchair and used by the client:

- **Button durability:** The client could get angry or fidget with the device; so, he smashes or repeatedly mashes the buttons with more force than usual, causing the button and the electronics underneath to wear. The buttons we currently have are somewhat weak, and deterioration with excessive pressing was already showing. We will need to make small modifications to the design that would ensure the buttons last much longer.
- **Arm clamp durability:** Repeated adjustment overtime can wear down the turning mechanism. Force from the buttons also transfer into the arm, so we need to consider that the arm's material can withhold a stronger force both from slamming the buttons and when the device is adjusted very quickly.
- **Damage by weather conditions:** Usage of device outside and exposure to moisture, water, rain, snow, etc. can wear the materials and cause the electronics to break.

What already exists to help durability: A detailed design for a case to protect the electronics inside, an arm design.

What we do not have: wheelchair specs/access from the client, prototype testing results.

What needs to be made: Arm prototype.

- During testing, the electronics enclosure survived a ~15-foot fall with no cracking or visible damage. Tests were carried out by dropping the enclosure from several heights, in 1m increments, to simulate a caretaker dropping the case, and going further to ensure that the breaking point was far higher than the impact of the case being dropped from a realistic height.

2. **Speaker Volume & Quality (Design for Usability):** Both the volume and the legibility of the product's speaker system projects sound clearly hearable from 0-10m, such that it does not subtract from its usability. Assuming the caretakers have sufficient hearing skills they can consistently respond to the client when he uses the device. To check the current system's volume capacity, we can use a sound level meter.

Design for durability:

Currently we are using plastic, which is already lightweight and does not break so easily with drops. A bigger concern is with the electronics which are more vulnerable and prone to breaking, especially, and they may unfasten or get exposed if the case opens. We could possibly pad the electronics with rubber or foam encasing to reduce impact on the electronics. This should not add too much weight to the design, although foam is not very sustainable. This will require testing of foam cases and their ability to protect the objects within (say, try dropping a foam case with an egg on heights for a test).

Design for Usability

What already exists: speakers for each of the pet buttons we bought.

3. Proof of effectiveness

DFD (design for durability)

Tests: Dropping the buttons and enclosure from different fixed heights to ensure that the device can withstand the force of the client pushing the buttons.

Analysis: For our device to be considered durable it must be able to withstand pressure or wear so by dropping our device from different heights we were able to show that our device is durability since the enclosure and the buttons were perfectly fine after falling from various heights.

Calculations:

F=mg

Speaker Volume & Quality (Design for Usability)

Tests:

- Distance test: Play a sound in an empty hallway and test if the listener can hear them from X distance. Try this experiment in more crowded areas with people talking, and around corners.

Calculations:

- Soundwave intensity, $B = 10 \times \log\left(\frac{I}{I_o}\right)$ (Intensities in W/m^2, or dB)

Intensity of a sound, $I = \frac{P}{(4\pi R^2)} \rightarrow \frac{I}{I_o} = \frac{\frac{1}{R^2}}{\frac{I}{R_0^2}}$

Part 2: Client Feedback Summary

1) Our client did not show up for the third client meeting. (Subject to change depending on whether a substitute client meeting occurs on Nov. 12) This has not stopped us from figuring out issues with our product that we wish to change so that we may improve the final results.

- The area holding the batteries had to be changed because the slot holes for the batteries were too small, and all attempts to get the batteries to fit in the slots would fail. Additionally, the sliding case covering the batteries did not slide as smoothly as intended.
- The top cover of the case did not properly align with the case itself, resulting in instability between the two parts.
- The buttons needed to be made smaller so that they may more efficiently slide up and down without too much friction. Additionally, the first buttons we had would break very easily, and we therefore must improve the durability of the buttons.

2) We've had to make a few assumptions for our design, but we have yet to acquire further confirmation on our user's range of motion and the model of wheelchair he uses. This has the potential to affect our product in the following ways:

- If the user's mobility is less than anticipated, we will need to redefine our product specifications to align with the user's mobility, this is related to the design for

usability. Then, we will have to quickly re-create a new case and set of buttons, which will require resoldering of all the circuit boards

- If we do not know the specific model of wheelchair that our user has, we may not be able to have a secure connection between the arm and chair.
- We need to print the clamp so we would use it for the product and test that the clamp is strong to withstand the force, this relates to our design for safety.

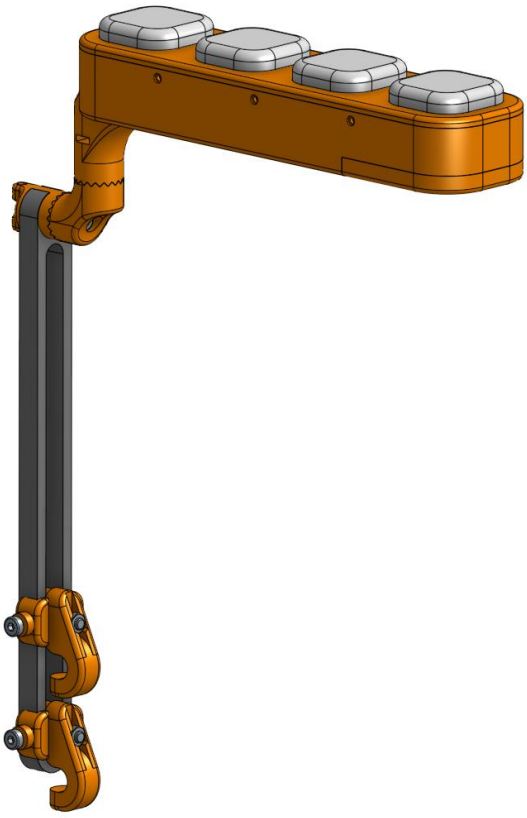
To account for this, we've implemented the following design changes:

- The clamps will not be round, but V-shaped, adapted from the use of "V-blocks" in a vice's jaws when a piece of material is being machined in a mill. This design allows for several diameters of round stock to be clamped with a single set of clamps.
- The current button size does conform to what was determined as a usable size in the first client meeting, therefore we are within the correct size range already.

3) Our next prototypes have already been designed and many parts have been constructed:

- The new case has been designed, completed, and tested. The batteries fit perfectly in the battery slots, the sliding cover for the battery slot section slides perfectly, and the case itself is very resistant to external forces.
- The case cover has also been completed. The case fits perfectly with the case and does not detach itself on its own.
- The microphone functions correctly and is audible within target spec range.
- The print orientation when 3D printing for the buttons needs to be changed so that the buttons can work efficiently and not deteriorate quickly. The design for the buttons is complete and only printing and testing is left to be completed for these.

4) Our current prototype begins the integration phase of our product, where we ensure that all of the separate systems can be integrated seamlessly, and adjustments will be made wherever needed. At the time of writing, we have all the fasteners we require and only need to print the remaining parts, as well as order and machine the stainless-steel arm.



5)

Testing Results / Analysis as compared to PDC target specifications

Test	Units	Result	Desired	Outcome
Drop Test (Durability)	feet	Survived 15ft foot fall	Survive a 5ft fall	Pass
Button Size	inch	2x2	3x3	Fail (In order to save space)
Ease of cleaning	yes/no	3d printed plastic	Wipeable plastic	Pass
Number of buttons	integer	4	4-5	Pass

Price	Canadian Dollars	~$50 (not completed yet)	<$100	Pass
Adjustability	easy/medium/hard	---------- (mounting arm not made yet)	easy	_____
Durability	material	Resistant plastic	Resistant plastic	Pass

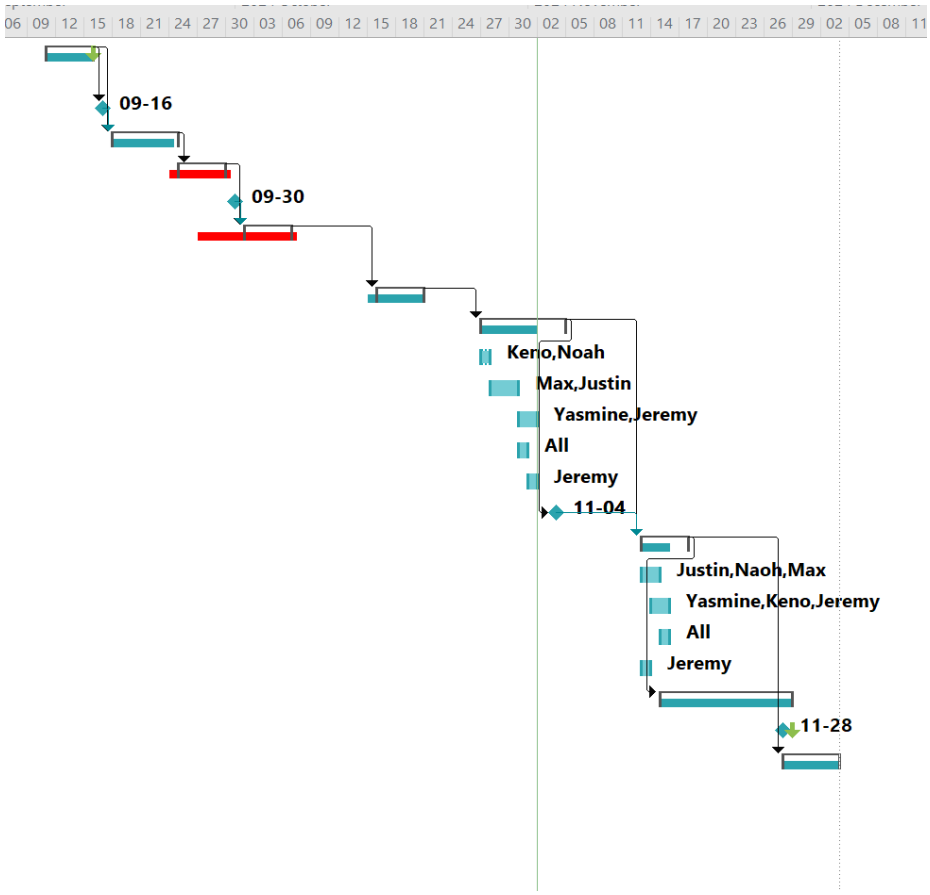
6) Since our client meeting was rescheduled, we have yet to go through with our third client meeting. We therefore wish to show the client the newer improved model, which will have the new case with improved battery slots, the new case cover, and the improved buttons.

For our next client meeting, scheduled for the 28th of November, we want to pitch and present to the client our fully assembled product, featuring the arm-clamp function with the rest of the device.

Key information to look for during this meet from the client (and any of the accompanying clients staff /peers) are: any oversights and first-impression reviews from the client in terms of their ability to efficiently communicate, quality of the buttons, ease of adjustability/removability/installation of the clamping arm/batteries/voice lines, and the device durability (bumping, moving in the wheelchair, dropping, accidental applied force, mashing the buttons).

Part 3: Project Plan Update

Task Name	Duration	Start	Finish	Predecessors	assigned task
PD A: Contract, client meeting preparation and project skeleton	**4 days**	**Wed 24-09-11**	**Sun 24-09-15**		
Client meet 1	1 day	Mon 24-09-16	Mon 24-09-16	1	
PD B: Sustainability and DFX	**5 days**	**Wed 24-09-18**	**Tue 24-09-24**	**7,1**	
PD C: Problem, concepts and plan	**4 days**	**Wed 24-09-25**	**Sun 24-09-29**	**8**	
Client meet 2	0 days	Mon 24-09-30	Mon 24-09-30		All
PD D: Detailed design	**4 days**	**Wed 24-10-02**	**Sun 24-10-06**	**16,23**	
In class design review					
PD E: Project progress presentation	**4 days**	**Wed 24-10-16**	**Sun 24-10-20**	**24**	
PD F: Design constraints	**7 days**	**Sun 24-10-27**	**Mon 24-11-04**	**31**	
PD F.1: Design constraints	1 day	Sun 24-10-27	Sun 24-10-27		Keno,Noah
PD F.2: Prototype 2	3 days	Mon 24-10-28	Wed 24-10-30		Max,Justin
PD F.2: Testing	2 days	Thu 24-10-31	Fri 24-11-01		Yasmine,Jeremy
PD F quality check	1 day	Thu 24-10-31	Thu 24-10-31		All
PD F projet plan update	1 day	Fri 24-11-01	Fri 24-11-01		Jeremy
Client meet 3	0 days	Mon 24-11-04	Mon 24-11-04	38	
PD G: Economic and IP considerations	**4 days**	**Wed 24-11-13**	**Sun 24-11-17**	**38,44**	
PD G.1: Economics report	2 days	Wed 24-11-13	Thu 24-11-14		Justin,Naoh,Max
PD G.2: IP report	2 days	Thu 24-11-14	Fri 24-11-15		Yasmine,Keno,Jeremy
PD G quality check	1 day	Fri 24-11-15	Fri 24-11-15		All
PD G projet plan update	1 day	Wed 24-11-13	Wed 24-11-13		Jeremy
PD H: Design day	**10 days**	**Fri 24-11-15**	**Thu 24-11-28**	**45**	
Design day	0 days	Thu 24-11-28	Thu 24-11-28		
PD I: User manual	**4 days**	**Thu 24-11-28**	**Tue 24-12-03**	**45**	
PD J: Final presentation					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