Secondary Airline Mobility Device

Preliminary Report | October 7, 2018

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Course Section: BME 300&200 (Sec- 301) (Friday 1:00 p.m. - 1:30 p.m.)

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Abstract

Today, many wheelchair-bound people face difficulties with airplane travel. Most wheelchairs are not allowed on the airplane itself. Instead, passengers need to transfer to an aisle chair that is narrow enough to fit in the small airplane aisles. They then need a secondary transfer to the airplane seat. However, this has many safety risks since some flight attendants are not trained on how to correctly transfer disabled passengers from seat to seat. Specifically, our client has been dropped numerous times and wants a product that will limit the number of transfers, thereby reducing the risk of injury.

There are at least four other aisle chair products that our team's design competes with. However, these chairs are all bulky and require at least two transfers for each leg of the trip. Our proposed final design will only require one. This design can adjust its height and width to adapt to any plane size. Due to it adjustable width, it also fits over the client's electric wheelchair, allowing the client to transfer to the aisle chair in the comfort of his own home. It then slides off the electric wheelchair when he needs to board the plane, therefore eliminating a transfer at the airport. While in the air, the chair folds up and can be placed underneath the client's seat for easy storage. Once testing is complete, we will have the data to support the claim that our design is the most adjustable and compact over all the competing products.

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Introduction

Motivation

The purpose for this project is to create a device that will allow our client, who has a disability, to more easily transport onto an airplane from his electric wheelchair, since electric wheelchairs are not allowed on airplanes. In 2016 alone, there were over 32,000 disability-related complaints at airports in the United States. Most of which were wheelchair related. Creating a device in which our client can travel throughout the airport in a safe, easy manner will allow him to enjoy traveling even more.

The normal process of a person, who uses an electric wheelchair, boarding an airplane is as follows. The person is first transported from their electric wheelchair onto a manual wheelchair with the assistance of airline workers. For our client, this transfer has been dangerous in the past because he has been dropped on more than one occasion. The person is then transported via he manual wheelchair to their airplane seat, where they will once again have to be assisted by airline workers onto the airplane seat. The process is reversed when the person leaves the plane.

Competing Designs

BME 301 Spring 2018 Project

This Design is 14 in. wide and 18 in. tall. A few key features include foldable hind legs so that the device can slide over the client's electric wheelchair and omni-directional wheels. A few disadvantages to this device include it is not vertically adjustable and is very bulky.

Figure 1: BME 301 Spring 2018 Airplane Aisle Chair Design

Karman Healthcare Airplane Aisle Chair

This device has two wheels, 24 in. long, that can be detached when in the process of boarding an airplane so that four smaller wheel are used to move. This device is over 2000 dollars and would require our client to use a manual wheelchair throughout the airport which may become strenuous

Figure 2: The Karman Healthcare Airplane Aisle Chair

Columbia Medical Aislemaster Unfoldable Boarding Chair

This device costs around 2500 dollars. It has a width of 13 in and features padded seat, backrest and headrest, as well as flip-up armrests for ease of transfer. It is highly maneuverable and has a seatbelt implemented for safety of the client.

Figure 3: Columbia Medical Aislemaster Unfoldable Boarding Chair

Columbia Medical Aislemaster TransportMate Compact Wheelchair

This design is also over 2000 dollars. Although it is compact and easily maneuverable, it does not seem as sturdy as the other two competing commercial designs. It has a foldable handle bar as well as a locking brake system.

Figure 4: Columbia Medical Aislemaster TransportMate Compact Wheelchair

Problem Statement

Traveling with a disability can be a difficult process. Electric wheelchairs are not allowed on flights. A person with a disability that requires the use of an electric wheelchair must transfer to a manual wheelchair, assisted onto the airplane, and then removed again from the wheelchair and placed onto a seat on the airplane. This may cause a great deal of unnecessary distress to the individual. A secondary mobility device would theoretically attach to the client's normal wheelchair. The client would then be able to travel through the airport on their own wheelchair, along with the secondary attachment. When it comes time for boarding, the client would simply detach the secondary device from the electric wheelchair and use it to board the airplane. Once boarded on the airplane, the secondary device should be foldable so that it can either fit under the client's seat, or in the carry-on luggage section. Our goal for this project is to create a fully functional secondary motility device that will allow our client to board airplanes more safely and efficiently than the current process.

Background

Physiology and Pathology

Our client has muscular dystrophy, which is a disease that causes the progressive loss of muscle mass, which leads to extreme muscle weakness. One of the predominant causes of muscular dystrophy is due to the lack of dystrophin in a person's muscles. This protein is responsible for keeping muscle cells healthy and functional. For many people with muscular dystrophy, including our client, a wheelchair is necessary. Knowing some of the pathophysiology of muscular dystrophy will be advantageous when designing a secondary airline motility device that will be most helpful to our client.

Background Research

The average width of an airline aisle is 20 in. Our design must have a width smaller than this in order for it to be able to be fully mobile throughout the airplane. The average pitch, distance between two seats from backrest to backrest, is approximately 30 in. This may cause problems where the client would try to fit in between seats with the secondary motility device, such as the "C-Shape" chair design. There are a couple FAA guidelines for people traveling with disabilities that should also be addressed. Items being stored in the cabinet of the airplane must conform to FAA guidelines, however assistive devices do have priority over other items being stored. This may come in the form of a carry on (9 in x 14 in x 22 in) or a personal item (9 in x 10 in x 17 in). Another requirement is that airlines must offer assistance to customers with disabilities to make boarding easier. Through our meetings with our client, a goal has been derived, in which the device being created should require minimal airline assistance for the safety of our client and people that assist him.

Client Information

Our client, Dan Dorszynski, is a frequent traveler, who travels all over to play in tennis tournaments and experience different parts of the country. Dan has muscular dystrophy, which makes it difficult to board airplanes. This is why he reached out to us to create a device that will make transfers from electric wheelchair to airplane seat a more efficient and safe process.

Product Design Specifications

There were a few parts of this design that our client emphasized more than others. One emphasis was that he prefers this device to be adjustable on the vertical axis so that he can raise or lower his seat if necessary for an easier transfer onto or off another seat. This device should support well over 250 lbs. while weighing under 30 lbs. so it can be mobilized easily. This device should require little to no assistance and must make seat transfers easy and safe for our client. A material must be used that can withstand extreme temperature, pressure, and humidity changes as well. The total cost of this device, and the process in creating it, must be no more than 500 dollars.

Preliminary Designs

Ramp Chair

The ramp chair is designed to be compact, lightweight, and introduce a new method of transferring the client to the airplane seat. The seat and seat back are made of plastic or cloth, and the back and wheels both fold in so that the device can be stowed under an airplane seat. There is a crank on the side of the chair that allows for raising and lowering the seat to match the level of the airline chair. There is a ramp that is stowed in the side of the seat and can be pulled out. Spring mechanisms within the seat allow free movement of the ramp, and the client can slide or shift into the airplane chair without the need for lifting. The wheels of the device can fit around the client's personal chair to allow for an easy on/off transfer.

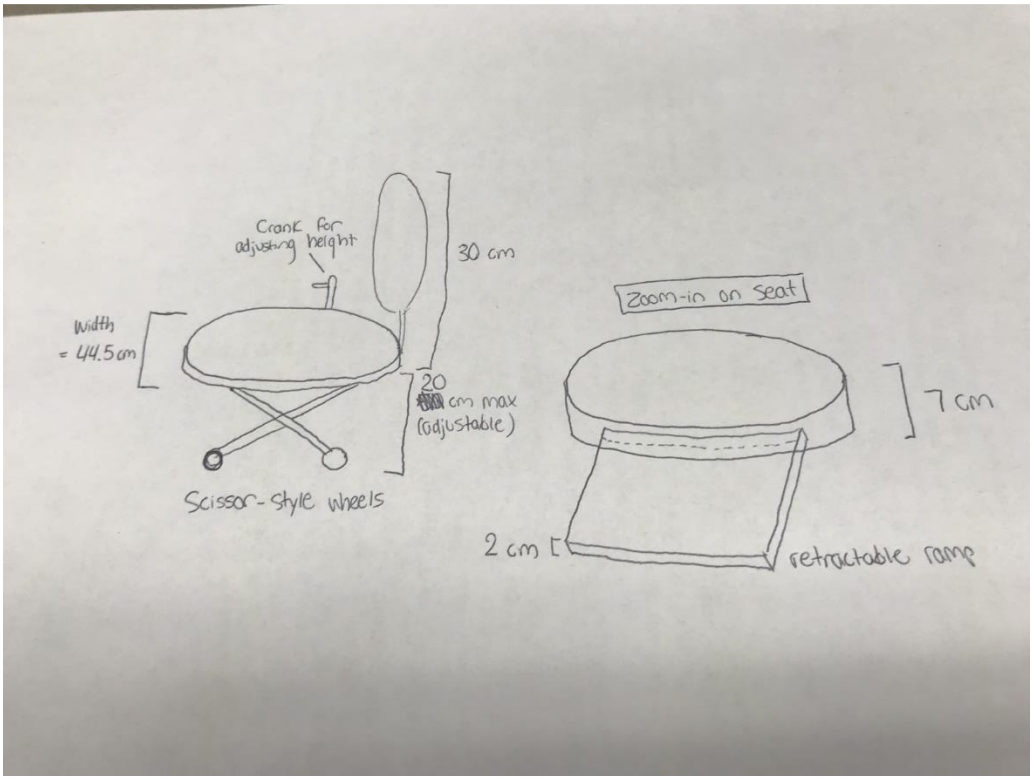

Figure 5: Ramp Chair Drawing

Fit-In Chair

The Fit-In Chair is designed to target ease of use and ease of fabrication with good durability. The back legs of the chair can be contracted when the client needs to move back onto his electric wheelchair. The front legs have the same height as the electric wheelchair, so the assistant can directly push the Fit-In Chair onto client's wheelchair. A handle is placed at the back of seat to make assistance moving the client as easy as possible. The Fit-In Chair will have omnidirectional wheels so it can go all directions. The seat of the Fit-In Chair contains two boards with a track between them in order to slide the client laterally into the airplane seat without unnecessary transitions. A seat-belt is also built on the chair so the client is secure.

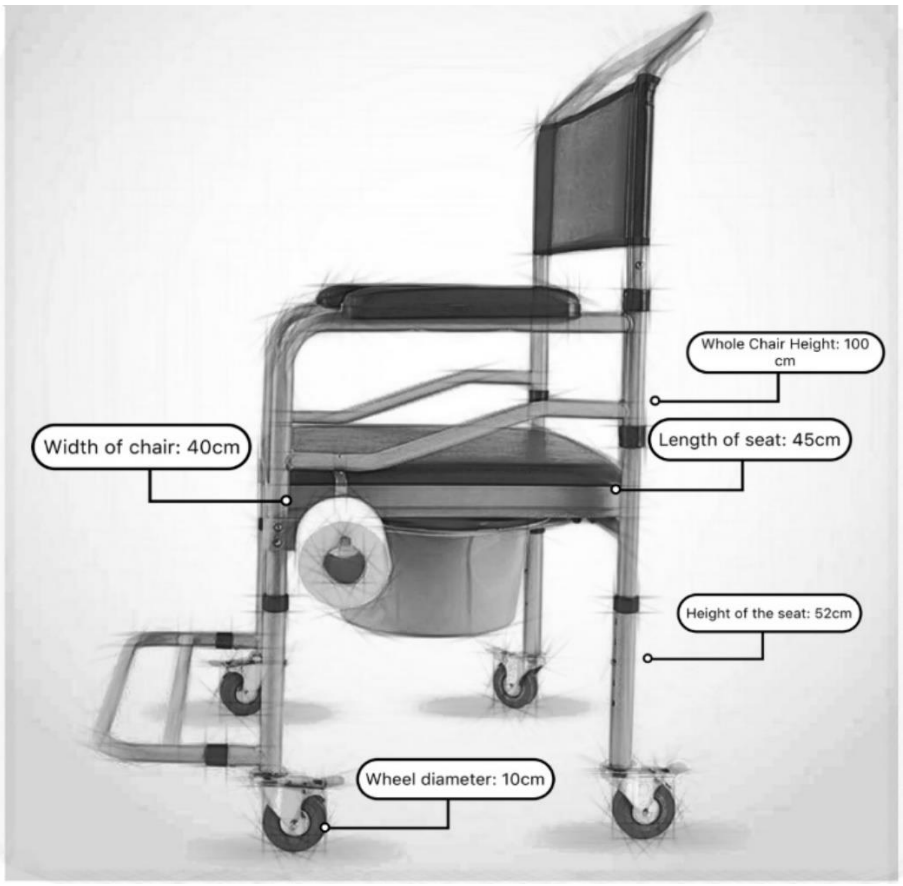

Figure 6: Fit-In Chair

C-Shaped Chair

The C-Shaped Chair is designed to limit the amount of transitions for the client. The client will sit on this chair for the duration of the flight while the C-Shaped chair rests on the airplane seat. The C-Shaped Chair can be attached and detached from client's electric wheelchair via a roller/slider mechanism. It has foldable handles to allow for easy assistance from flight attendants. Its omnidirectional wheels on the bottom of the design allows for lateral movement of the chair. Its adjustable leg allows the chair to adapt to any size plane seat and electric wheelchair.

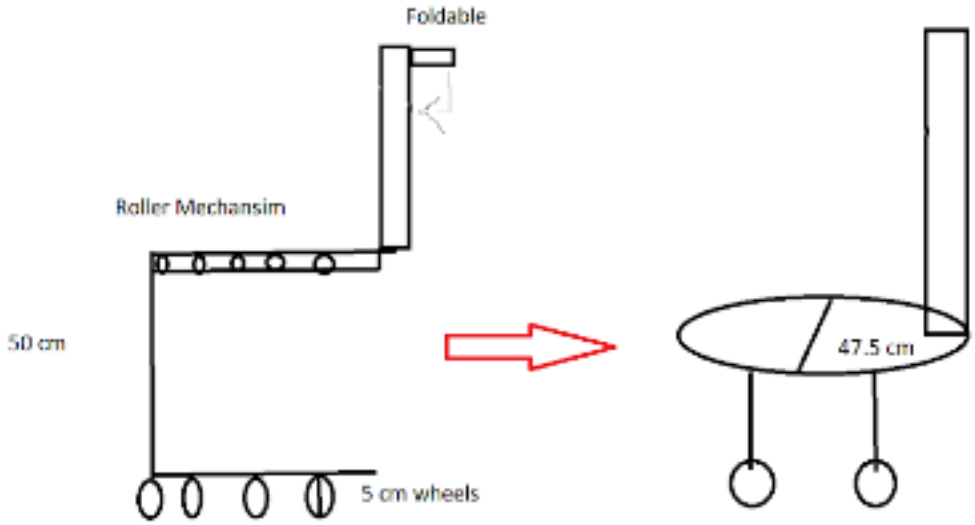

Figure 7: C-Shaped Chair Drawing

Foldable Chair

The Foldable Chair is designed to adapt to any airline. The legs are adjustable to any height needed, and the seat can fold or to accommodate for small airplane aisles. The seat will be made of a sturdy, mesh fabric. It will have four, metal rods that provide support. The two inner rods will come together to create a smaller width that will allow the Foldable Chair to fit in the aisle of the airplane. The back of the chair is foldable for compact storage. The deployment mechanism pushes the Foldable Chair off the wheelchair. It also grabs the Foldable Chair and pulls it to the wheelchair and secures it while it is on the wheelchair using an electromagnet.

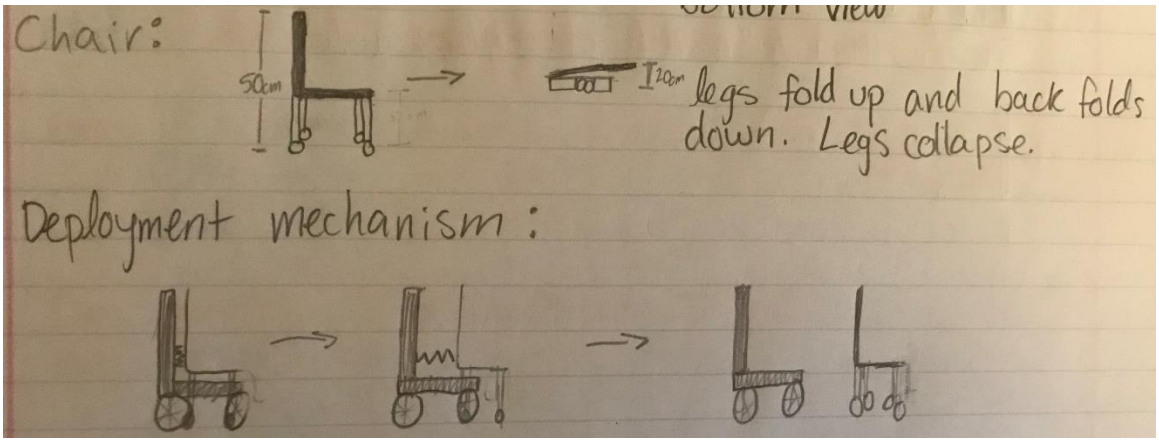

Figure 8: Foldable chair in compact position and deployment mechanism drawing

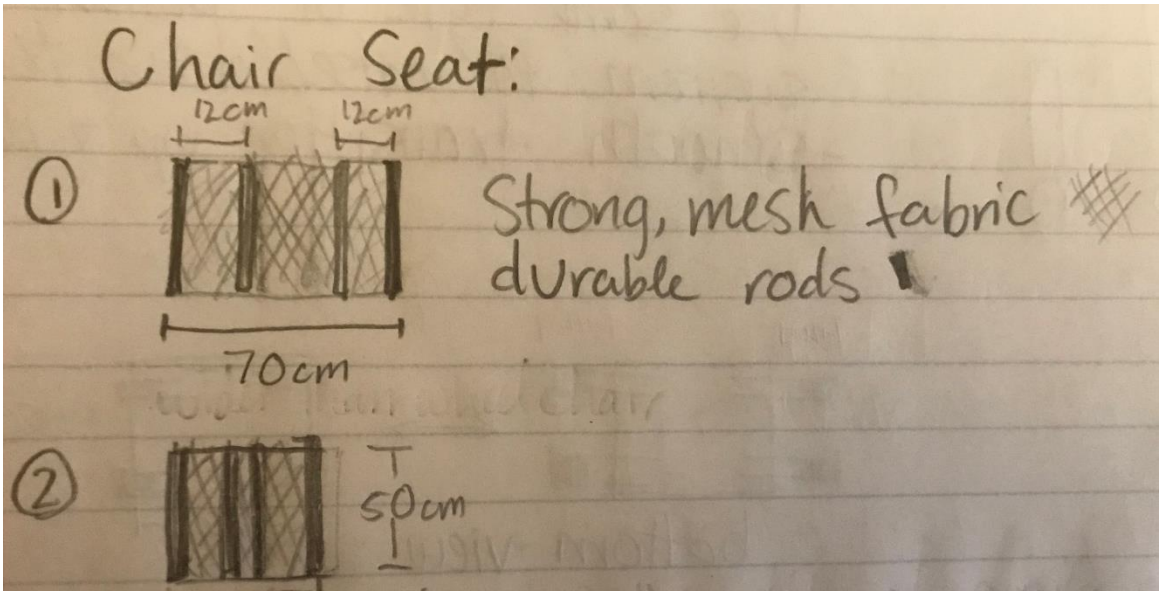

Figure 9: Foldable Chair seat, extended and compact drawing

Combo Chair

The Combo Chair takes the best parts of the Ramp Chair and the Foldable Chair and create an even better design. Its legs are similar to the Ramp Chair and more compact than the Foldable Chair's legs. Its width is also adjustable by having a 16" seat and legs attached to adjustable bars on each side that can extend to fit the legs over the wheels of the electric wheelchair when the client is in the airport. It includes the deployment mechanism from the Foldable Chair to secure the Combo Chair to the electric chair. The back of the chair also folds over to a compact shape that can fit under the seat throughout the duration of the flight.

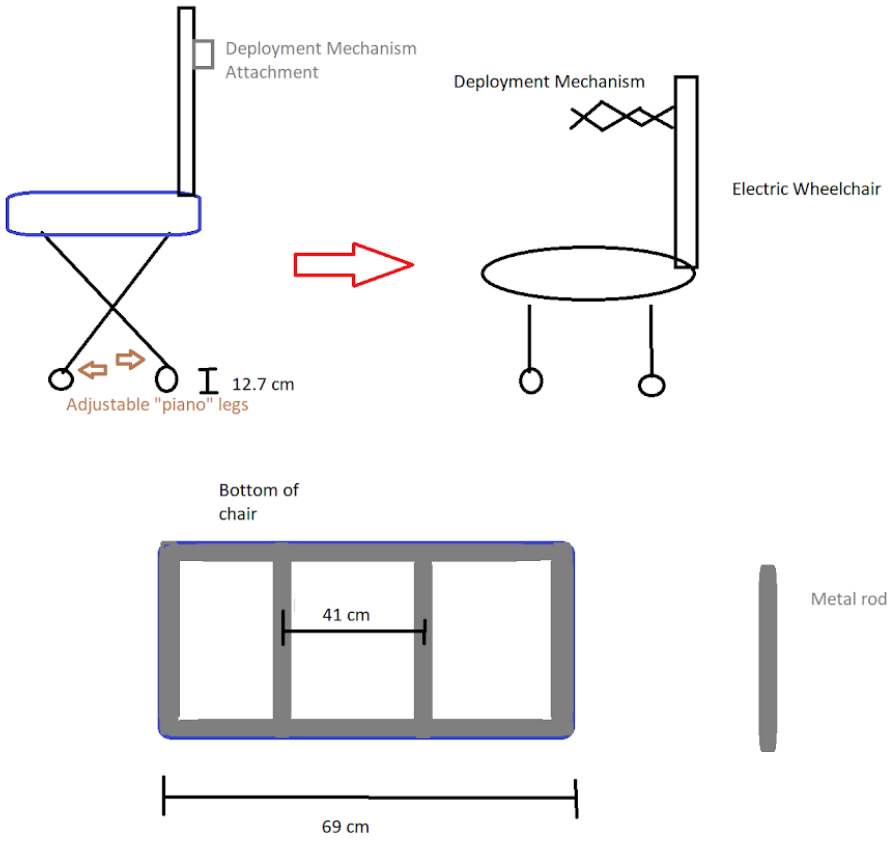

Figure 10: Combo Chair Drawing

Preliminary Design Evaluations

	1 - Ramp Chair		2 - Fit-In Chair		3 - C-Shaped Chair		4 - Foldable chair		5 - Combo Chair	
	Score	Wt. Score	Score	Wt. Score	Score	Wt. Score	Score	Wt. Score	Score	Wt. Score
Ease of Use/ Effectiveness (20)	3	12	4	16	2	12	4	16	4	16
Safety (20)	4	16	4	16	3	12	3	12	5	20
Adjustability (15)	5	15	2	6	4	12	5	15	5	15
Compatibility (15)	5	15	1	3	3	9	5	15	5	15
Durability (10)	3	6	5	10	3	6	2	4	4	8
Ease of Fabrication (10)	1	2	5	10	2	4	2	4	4	8
Cost (5)	2	2	5	5	4	4	4	4	5	5
Innovation (5)	5	5	2	2	5	5	5	5	5	5
Total (100)	73		68		60		75		92	

Table 1: Design Matrix

Design Matrix Summary

The Fit-In Chair and the C-Shaped Chair both scored too low to be considered. The Ramp Chair and the Foldable Chair both scored similarly, so the Combo Chair was designed to incorporate the best features of these chairs. With their combined strengths, the Combo Chair scored the highest with no close comparisons.

Proposed Final Design

Using the Design Matrix, our team concluded that the proposed final design is the Combo Chair

Fabrication/Development Process

Materials

- 2 yards of fabric at $5/yard
- 4 omni directional wheels with brakes (estimate $20 per wheel)
- Metal for frame of device
- Crank for changing height

Testing

- Once the prototype is fabricated, our group will test it with weight loading and direct use of the device to eliminate transfers
- Sandbags or free weights can be used to test the weight supported by the device (this determines the safety of the device)
- Group members will use the device to transfer to a mock airline chair and test the overall effectiveness of the device
- Results will allow our group to re-evaluate the strength of the device and its functionality

Discussion

Traveling with a disability can be a difficult process due to electric wheelchairs not being allowed on flights. A person with a disability that requires the use of an electric wheelchair must transfer to a manual wheelchair, assisted onto the airplane, and then removed again from the wheelchair and placed onto plane seat. This may cause a great deal of unnecessary distress to the individual. This leads to our first ethical consideration. We would like to design a secondary mobility device that is safe for our client and everyone around him.

In the first four preliminary designs, each single design has significant shortage to fulfill the standards we set for the final goals. For instance, the C-Shaped chair would not be able to work in limited space nearby the airplane seat. The Ramp Chair could not promise the safety for the client. The Fit-In Chair is not foldable to fulfill the client's expectation. The Foldable Chair had too many working parts that were not feasible to fabricate within our timeline.

Thus, a final design was made after a meeting in which we discussed the functions and mechanisms of each design in great detail. The final design was created after comprehensive evaluations and thoughts from each team member. It combines the ideas of all the four previous designs to create a high quality, safe device.

Conclusions

Our client needs a secondary wheelchair which can provide him convenience when taking flights. Specifically, he would like to avoid transitions during boarding as much as possible. Our proposed final design, the Combo Chair, is the best and most effective product. Taking the previous designs into account, the Combo Chair includes each design's advantages and includes them in one product. The Comba Chair is comprised of legs that can adjust the height or fold into a compact size when not in use. We made many measurements and thought of all aspects the design in order to make it practical and feasible.

In the future, we would like to focus on the material lists and ordering the items we need. In addition, we expect to start the fabrication soon. During the fabrication, it is important to be careful with supporting each junction and corner to ensure client safety.

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Appendix

Product Design Specifications

Function

Traveling with a disability can be a difficult process. Electric wheelchairs are not allowed on flights. A person with a disability that requires the use of an electric wheelchair must transfer to a manual wheelchair, assisted onto the airplane, and then removed again from the wheelchair and placed onto a seat on the airplane. This may cause a great deal of unnecessary distress to the individual. A secondary mobility device would theoretically attach to the client's normal wheelchair. The client would then be able to travel through the airport on their own wheelchair, along with the secondary attachment. When it comes time for boarding, the client would simply detach the secondary device from the electric wheelchair and use it to board the airplane. Once boarded on the airplane, the secondary device should be foldable so that it can either fit under the client's seat, or in the carry-on luggage section.

Client requirements

The device must be original, easy to use, and fit over the client's wheelchair. It should minimize transfers and need for assistance

Design requirements

Must be compact, hopefully fitting under the seat of an airplane

Performance requirements

The device should be easily manipulated by the flight attendants and they should be able to transfer the client without any difficulties with the device.

Safety

The product must be able to consistently support 250 pounds (113.4 kg) without any risk of bending or breaking, which could result in injury for the client. Safety straps will also keep the client secure on the device.

Accuracy and Reliability

The device should be 100% reliable within the shelf life and the operating environment specified below.

Shelf Life

The device is expected to last a minimum of ten years. It should be able to work consistently if the client is using it frequently within a short period of time, but should also be able to maintain its usability if it is in storage.

Operating Environment

The device should be able to withstand multiple, consecutive uses under drastic climate and temperature changes. It should be functional in 0-100% humidity, and temperatures from -50 to 55 degrees Celsius. This accounts for temperatures in a car trunk and temperature in the cargo hold of an airplane. In addition, most uses of the device are in the airports with flat platform, so we do not need to account for rocky terrain.

Ergonomics

Client should be comfortable when sitting in the chair for 2 hours if needed. The chair should also not be taller than his wheelchair and adjustable if needed. The seat should be less than 2 in. thick (5 cm).

Size

The device must fit on an airplane (Approximately 20 in. (50.8 cm) wide) and be able to fit under the seat of an airplane once it is done being used (8 in. tall x 14 in wide x 18 in. long (20.32 cm tall x 35.56 cm wide x 45.74 cm long)). [5]

The device should be lower than the airplane seat.

Weight

The device should be easily carried and stowed by an adult with average strength. The group estimates that the product should weigh no more than 30 lbs. (13.6 kg).

Materials

The material should be strong enough hold the client (about 113.4 kg) and hold study during the client transitions. It should also be lightweight, with a maximum weight of the device at 13.6 kg. The material must withstand varying pressure, altitude, and temperature changes.

Aesthetics, Appearance, and Finish

The client places priority in the functionality of the device, however the group has determined that a smooth seat without sharp corners will ensure both safety and some aesthetic appeal.

Quantity

Only one unit is needed for the client.

Target Product Cost

The client would prefer a budget of $500 or less, however said he is open to some flexibility if impressed with our design.

Standards and Specifications

The device must comply with all airline carry-on restrictions and guidelines.

Customer

The most important characteristics for the customer are the chair is easy to use and is shorter and less bulky than the previous designs. He wants a compact design that is easy for flight attendants to assist with. “Thinking outside the box” is highly encouraged, since he wants an original, creative design.

Patient-related concerns

This section is not applicable for this project.

Competition

Our client has reached out to engineering student in the past for the same device. The students created two quite similar designs. The second design was 14” wide and 18” tall. A couple key features of this design were that the hind legs were foldable so that the chair could fit onto the client’s electric wheelchair and it had 4” diameter caster wheels, making it easy to transport the client.

The Karman Healthcare Airplane Aisle Chair sells for around $2,000. It is designed with wheels that are 61 cm in diameter. When these wheels are detached, the width of the chair decreases to 35.5 cm. Smaller wheels attached to bottom of wheelchair are utilized when larger wheels are detached [3].

The Columbia Medical Aislemaster Unfoldable Boarding Chair costs around $2,500. It has a width of 33 cm and features padded seat, backrest and headrest, as well as flip-up armrests for ease of transfer [1].

The Columbia Medical Aislemaster TransportMate Compact Wheelchair was originally designed for an on-flight wheelchair under the 1986 Air Carrier Access Act. It collapses compactly to a height of 18 cm from an unfolded height of 85 cm. It has a width of 41 cm including the wheels [2].