UTransfer

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1. Executive Summary

The purpose of the UTransfer device is to provide a level of aid for individuals, particularly the elderly, who find it hard to enter and exit a vehicle. We began with an analysis of the current products on the market and found a clear need for a device that could aid in the full process of entering and exiting the vehicle. The current products consisted of cheap devices that would only aid a part of the ingress and egress, or very expensive custom chair installations. Furthermore, there is an expected growth of 200% for individuals aged 65 or older and car transfers are the second most common cause of non-crash related injuries. Therefore, with the help of our sponsor URise, we were able to identify a clear need for a mid-priced product that could fully aid the entire process of entering and exiting a vehicle.

Next, we conducted interviews with the target population to further our understanding of how the ingress and egress was accomplished, and what type of transfer aids they would be willing to use. Moreover, we found that there was a fear factor that many users experience, and there is a need for a device that gives them full confidence that they will be able to complete the transfer safely. Now that we had a better understanding of the shortcomings of the current products, we gained insight from a physical therapist to define criteria we would need to meet in order to make the movement as easy and safe as possible. This includes placing the user in a positon where they can utilize their strongest muscle groups, maintain continuous momentum, and proper positioning of feet under the body. Lastly, we returned to our sponsor to identify the criteria we needed to meet in order to be competitive in the market. This included a maximum retail cost of $250 and an ability to accommodate up to 300 pounds to appeal to a large range of users.

Having identified what our device needed to accomplish, we began researching the average dimensions within a wide range of vehicles to understand our design constraints. Next, we began creating prototypes and getting user feedback. Ultimately, we decided on a final design that allowed the user to achieve the ideal ergonomic position in a wide variety of vehicles. This final design features a semi-permanent car seat with two degrees of freedom that allows the user to easily rotate their bodies, and slide forward out of the vehicle. This enables the user to positon their feet on the ground, under their center of mass, and greatly reduce the amount of effort involved in the process of a car transfer. The device is designed to function on either the driver or passenger front seats, and has no interference with any car safety features. Additionally, the UTransfer device features memory foam and lumbar support to ensure comfort throughout its use.

Finally, from our preliminary user testing, the UTransfer device was able to cut the time needed to enter and exit the vehicle in half. User's also noted that the comfort of the device provided an additional level of much needed support. Lastly, a very conservative cost analysis of the UTransfer shows a profit margin above the desired 40% with a desired retail price below the $250 maximum.

2. Introduction

Car transfer accidents are the second most common non-collision source of automobile injuries. The necessary maneuvering proves especially difficult for elderly individuals, who have increasingly limited ranges of motion and reduced muscular strength as they age. The transfer also occurs in a spatially limited environment, as the car door, roof, and dashboard constrain the space available to maneuver. Due to the difficulty of the action, elderly individuals often require assistance to safely enter and exit a vehicle. Often, this aid comes from a caretaker who will help lift and stabilize the individual. Unfortunately, these car transfers are identified as high-risk maneuvers for caretakers as well as patients, and can cause strains and sprains for both the elderly individual and the caretaker. Adding to this challenge is the fact that many of these individuals continue to drive, and the steering wheel creates another physical obstacle to entry and exit, further limiting the freedom of movement. Also, many elderly individuals have uneven mobility problems, meaning that one side of their body is less strong or flexible than the other, especially in the case of a preexisting injury or stroke. All of these factors make car transfers a perilous task for elderly adults. To improve the safety and independence of elderly individuals, it is important to mitigate the risks associated with car transfers.

The stakeholders for this project include the elderly user, caregivers, the project sponsor company, manufacturers, competitors, government regulators, private insurance companies, and distributors. The most important stakeholders are the elderly user, caregiver, investor, and manufacturer. These stakeholders will not only define what is possible but what needs must be met in order for the product to be successful in the market. In regards to potential users, data collected in 2012 reveals 43.1 million people age 65+. Of this group, 24% of drivers required aid exiting their vehicle, 28% had difficulty entering the driver's seat, and 67% had difficulties exiting the driver's seat. This indicates a potential consumer group of over 28 million people who would benefit from a car transfer aid. Furthermore, census data predicts a 200% growth of that population by 2050, meaning a total elderly population of 85 million, and a future consumer base of 57 million individuals. This is a huge demographic whose needs are not currently met, opening the door for great innovation.

There are presently some products available that aim to aid elderly adults with car transfers, but they are overwhelmingly ineffective, and the few useful devices that exist are far too expensive for the average consumer. The available devices do not address the underlying movements of a car transfer, and ultimately provide minimal assistance to the user. The vast differences in seat heights, bucket depths, and frame structure also prevent these devices from realizing significant benefits. Thus there is currently space in the market for an effective and inexpensive car transfer aid for elderly adults. To be successful in appealing to this consumer group the device will need to address more of the steps during ingress and egress of a vehicle than current products, and must complete these tasks at a level that provides the user with renewed confidence in their car transfer abilities.

3. Objective

The goal of this project is to create a car transfer device that can be used in a wide variety of vehicles without intensive setup or installation. Moreover, the product should enhance the overall experience and feeling of the user and should stand out from current products by addressing multiple steps within the process of entering and exiting a vehicle. Ultimately the product will allow the user to perform ingress and egress independently with ease and confidence.

4. Research Summary

The primary research involved a full task analysis of the motions and actions required to make a successful car transfer. Interviews with the key stakeholders guided the process, namely elderly users, caregivers, the project sponsor, and physical therapists familiar with sit-to-stand transitions (Appendices F-G). These interviews introduced new perspectives to the problem, and revealed the underlying physical and behavioral challenges of car transfers.

4.1. User Interviews

Many of the elderly said that even though they are capable of getting in and out of a vehicle, there is still a fear that they will fall due to the variance of their bodies' capabilities from day to day. There is conscious mental preparation for the sit to stand transfer, which manifests in the careful positioning before the sit-to-stand movement in both ingress and egress. Regarding ingress, most interviewees stated that they "plop" back into the seat, which is likely due to a lack of strength required for a deliberate and controlled lowering. Interviewees also said that they do not like to be dependent on other people for daily activities. Providing them with a product that reduces or eliminates the element of fear, while maintaining their independence, would be a significant selling point for them. In addition, they would like to avoid the medical aesthetics that often accompany movement aids, which indicates that they do not like being viewed as helpless or infirm.

In addition to interviews, elderly individuals were observed entering and exiting their vehicles and the observations were compared to videos of physical therapists and caretakers demonstrating proper car transfer technique. This provided examples of many variations of how elderly users complete the task, which we used to create our task analysis (Appendix H). This introduced the concept of touch points, or areas in the car that are used as handholds and supports. They identified the ideal touchpoints as well as some touch points that are dangerous to use (Appendix A). A common but dangerous touch point people use is the door. The door can accidentally close on someone, or throw them off balance leading to a fall.

4.2. Ergonomics

A physical therapist provided insight on the physics involved in completing a car transfer, and illustrated the safest manner to perform the transfer. The ingress action begins with deliberate positioning to ensure that the individual's rear makes contact with the seat. This action is where many falls occur, as individuals sometimes miscalculate their trajectory and miss the seat. During egress, maintaining momentum is critical for a safe and smooth car transfer. It is important to keep the feet close to the body and under the center of gravity as well as utilize the strongest muscle groups to complete the transfer. The importance of momentum can be seen in the rocking behavior, wherein elderly individuals will rock back and forth a few times before making the attempt to rise. Therefore, it will be important to ensure that any device created during this project does not obstruct the natural movement of the body.

4.3. Market

The sponsor, URise Products, provided insight from a business perspective to determine to be competitive in the market. They set the maximum retail price of $250, with a desired gross margin of 40-50%, and the minimum weight capacity of 300 lbs. These are based on the industry standards, as well as the market openings identified by the CEO, Ken Paulus. Upon further discussion, the sponsor also chose to limit the scope of the project to sedans, excluding larger vehicles such as SUVs.

The final research consisted of evaluating devices that are meant to aid car transfers, as well as mechanisms with functions that could be applied to a car transfer device. This included products that are currently sold as car transfer aids, sit-to-stand aids, and relevant mechanical patents. Existing products were purchased and evaluated by the team, and consumer product reviews were recorded and analyzed, and the product was place in the market analysis (Appendix I). The current products fall into one of three main categories, a fabric handle that is attached to the window frame (Appendix J), a low-friction seat swivel (Appendix K), and a portable hand hold that can be attached to the door frame (Appendix L). The team found that the swivel seat was often obstructed by the bucket of the car's seat, and had difficulty turning as the bearing was not located under the center of gravity. The removable door handle was more effective, but relied on the individual's limited upper body strength, and did not address the pivoting motion of the transfer. The window handle was the most difficult to use, as it relied on upper body strength applied at arm's length from the body, a maneuver that is difficult for individuals of average strength. It was also very sensitive to the direction that the force was applied in, and any force that was not applied straight down would result in the car door closing on the user. The team's findings were confirmed by product review that were found online. Comments stated that the users felt awkward using the devices, were afraid the device would damage their car, and that they were only useful if the individual had full strength and range of motion in their right hand. The reviews also stated that the benefits were so marginal that they could not justify the relatively low price of $20 to $30. The majority of the relevant patents were for mechanisms that lift the user off of the seat (Appendices B-E). There were no patents that were intended to address the pivoting and sliding motions associated with car transfers. Thus there is an opening in the market for a product that covers multiple aspects of car transfers and provides more benefit to the user than existing products.

4.4. User Testing

The initial design addressed all three actions in the car transfer process, namely the swivel, slide, and lifting aspects, the mechanisms for which are seen in Appendix O. Initial user testing was highly successful. The prototype was shown to a caregiver, who was very pleased with the combination of swivel, slide, and lifting. She believed that this device would have been very useful when her father was alive. She said in lower cars getting up was the most difficult for her elderly father. Although elderly individuals can generally perform the actions, they move very slowly due to their lack of confidence and their difficulty in overcoming the frictional forces of the seat to slide and swivel. These functions would make it hassle free, like getting in and out of a car used to be. The caretaker was excited by the prospect of greatly reducing the time to enter and exit the car, as well as the added comfort of gel inserts, memory foam, and lumbar support. The caregiver also responded well to the idea of adding materials to provide additional comfort, as many of the elderly spend a large amount of time sitting, making them more sensitive to the surfaces the have to sit on for an extended period of time. Any additional comfort that can be provided will make the product more attractive and feasible for users.

The conceptual prototype also received a great deal of positive feedback from potential users. Every individual interviewed stated that the device would help either them, or someone that they knew. Many reiterated that this was a common and well-known problem for themselves or their friends. Most individuals stated that they would be interested in purchasing this product when it became available. Users were also shown images of various lumbar supports and seating pads, and asked to choose the ones that they thought would be the most comfortable. They consistently chose the several familiar, low-profile designs, shown in Appendix R. Some commented that the seat inserts didn't look like something to sit on, and others looked distinctly uncomfortable. Users that had experience with the supports and inserts also believed the same set of inserts and supports to be the most comfortable.

5. Criteria for Success

Based on our research we were able to develop an extensive list of criteria (see Appendix M). These criteria range in level of importance from desires to mandatory components. We will use these criteria to rate our concepts and will be able to use that rating system to decide which concept is best.

5.1. User and Sustainability

The car transfer assist device needs to have a life cycle of at least ten years, as well as be utilized by a wide range of individuals. More precisely, the device needs to be able to withstand a weight capacity of at most 300 pounds and for heights ranging from 4'11" to 6'2". The main demographic that will utilize this device will be in the 65 years and older range, however; it must be adaptable to younger individuals with mobility-limiting disabilities. Furthermore, the device needs to be aesthetically pleasing so as to enhance the user's psyche.

5.2. Ergonomics

For this device we will aim to accommodate about 90% of the population by focusing on the 5^{th} percentile of females through 95^{th} percentile males. This encompasses a height range of 4′ 11″ to 6′ 2″. Based on these measurements, acceptable dimensions for the product are a 20" seat width and

27" of leg room. Since many elderly users have manual dexterity difficulties, it is important to consider how their grip may differ from the rest of the population, as seen in Table 1. In addition to this, muscular strength fades as a function of age. Therefore, it is crucial to promote the use of the strongest muscle groups in the body, namely the quads, hamstrings, glutes, and core. Upper body should not be the main source of support it should only assist the legs in lifting. The device will also address the thoracic immobility that also accompanies aging by minimizing the degree and force of twisting. Comfort will also be a key to success. The user must be able to use the device for several consecutive hours, as would occur during long road trips, without incurring any aches, pains, or stiffness beyond what is normal for remaining motionless for extended periods of time. The seat should also maintain the stability of the user during the ride. This would mean that the device should not allow the user to rotate more than 5° when in the locked final position. It should also prevent translational movement of the seat in excess of 5 mm during transit.

5.3. Market

Most existing products currently only aid in either the ingress or egress of a car environment, but our product aims to aid in both. Moreover, the vast majority of products in today's market are either inexpensive and ineffective, or highly effective professional installations costing thousands of dollars. Our device aims to enter into a mid-level price range that provides similar levels of aid to the professional level car installations. Appendix X shows a 2x2 analysis of the current products on the market and the area our device aims to enter.

5.4. Manufacturing and Distribution

The production of the device needs to be able to be produced on a small scale at the entry of the market. Once demand for the product rises, production levels can be increased with a goal of producing the device at the cheapest possible price. The maximum retail price of the car transfer assist device is not to exceed $250, and maintain a Gross Margin of 40%. Competing products in our same sector have similar profit margins of 30% and our goal is to exceed this margin through production efficiency analysis and material analysis of the device. Initially, the device will be sold solely from URise Products LLC, but if demand increases substantially, then third party distribution will be considered. Additionally, URise Products LLC owns its own manufacturing, so there is a clear advantage to the products production and distribution, which could lead to further price reductions.

5.5. Environment and Safety

Although the device is intended to remain inside the car at all times, it will be subject to the temperature and humidity conditions inside the car. It must withstand a wide range of temperatures, from -30°C to 75°C. Therefore, the materials used to create the device need to strike a balance between minimal cost and sufficient environmental resistance.

Safety is the most important design specification for this device, so failure prevention is of the upmost importance. The device must also fit within the dimensions of the car without modifying the underlying structure of the vehicle. In essence, the device will not be permanent, though it will be able to remain assembled in the vehicle for an extended period of time. For the initial design, the device will be optimized for small and mid-sized vehicles. Future iterations may be expanded to larger vehicles. The average seat width of all cars is 20", which creates the width constrain of the device. Seat buckets range from 1" to 4", therefore the device will need to have a substantial base to overcome the bucket wall.

The mechanisms used in the device should not require any external power sources beyond the power that can be drawn from a standard car cigarette lighter. In order to lift a 95th percentile male age 55+ by 3 inches, the device must produce an upward force of 69 lbf. To maintain stability, it will also need to counteract a torque of 780 Nm produced by the user's position while exiting the vehicle.

5.6. Aesthetics

In order to insure that the user does not feel singled out, incapable, or disabled, the device should not resemble a medical device. Ideally the device should blend into the environment or be easily stored. The device should also be as sleek as possible so that it is not taking up unnecessary space and will therefore also have a more appealing appearance. The device should also have an inviting and comforting appearance so that the user will feel comfortable approaching it and using it. The product will only come in the color black, at least for the initial introduction into the market. It could possibly have more sleeves of decorative additions consumers can purchase to add onto the base model. The material could possibly be stamped faux leathers, or could be a more functional and breathable microfiber. We will aim to pair both aesthetically pleasing and functional materials to this device.

5.7. Legislation

Due to the Intermodal Surface Transportation Efficiency Act of 1991, which requires all cars and light trucks sold in the United States have to air bags on both sides of the front seat, it is essential that the device does not impede the airbags in any way. Similarly, the device will permit the use of the vehicle's built-in seat belts, and will not obstruct the driver's sightline with rearview and side mirrors.

6. Design Overview

The final device addresses the pivoting and sliding actions performed during a car transfer. Ultimately, lifting was not pursued, as the cost to benefit was too high. Any lifting mechanism would have added several inches to the overall height of the device, and reduced the head clearance within the vehicle. This would have been in direct conflict with the goal of accommodating the 95th percentile male population. Additionally, it would have required significant power to produce three inches of lift in any reasonable amount of time, which exceeded the capacity of the standard cigarette lighter. It would have been necessary to add some form of external power, increasing the manufacturing costs of the device. Therefore, it was ultimately decided to eliminate the lifting feature.

The final concept can be seen in Appendix S, and combines a lazy Susan bearing with extending sliders to aid in the positioning of the body. This greatly reduces the friction during movement, thereby reducing the amount of force needed to complete the transfer. The bottommost layer is placed on top of the seat in order to overcome the bucket, as seen in Appendix T. The entire device can be secured using ties that encircle the base of the existing seat from back to front. These can be tightly cinched in order to secure the seat as well as compress the existing seating material to increase head clearance. The seat itself is formed plastic, memory foam, and gel. There is a lumbar support in the back, and the entire seat is upholstered with black vinyl.

7. Design Details

The final design of the device addresses the swiveling and sliding aspects of a car transfer. This would involve the use of a lazy Susan and a set of slider bars within three layers of support plastic. Memory foam and a gel insert will provide padding and comfort to the user, and a lumbar support consisting of a stiff foam core and memory foam casing will support the back of the user. The entire device will have vinyl upholstery, and the plastic layers will be dyed to match the color of the vinyl.

7.1. Mechanisms

The lazy Susan bearing would be between the first and second layers, centered at 9″ from the front edge. The lazy Susan used in the prototype has a capacity of 1000 lbs. 18″ drawer slides would be between the second and third layers of polypropylene, and they would be spaced at 6″ from the center to the inner edge on each side. When in the final position, 300 N of the user's weight would rest on the 10 cm extension. These drawer slides have a capacity of 445 N when fully extended, and thus will be able to support a user up to 400 lbs.

7.2. Geometry and Spacing

The bottom layer would be the deepest, extending a full 22″ into the seat of the car, and span the full 21″ width of the seat. The second and third layers of plastic would extend only 20″ deep, and would be flush with the front of the seat. This is to allow appropriate space for rotation without interference from the curvature of the seat back. The plastic seat core would also be 20″ by 20″, with a curvature depth of 2″. The lumbar support would be 4″ high, 12" wide, and 2" inches thick. This will fill the space between the seat back and the user, as the seat is set forward from the back of the car seat. Added lumbar support will allow the user to relax, and prevent slumping in order to rest against the seat back.

7.3. Aesthetics and Comfort

The seat will include a gel filled bladder in the basin of the seat, which will be composed of a mixture of mineral oil and baking soda. By using a viscous gel, the seat will distribute the pressure of the user's weight across the entire gluteal region, reducing the discomfort caused by the pressure points of the hip bones. Memory foam padding around the gel provide additional structure to the gel. The gel and foam is held in a bowl shaped flexible vaccumform mold. This provides structure to the seat for the user while being flexible enough to fit to a wide range of users. Going forward after testing the seat in a moving car, additional padding will need to be added to the front edge of the device. When going down hills the user would feel like they might slide forward due to the seat decreasing the sitting angle and the smooth fabric. The extra padding in the front would make the user feel more secure in the seat.

For the cover of the device we are considering a material called Arnedry. It is a breathable material with the look and feel of leather. It is also thermoformed, washable, anti-bacterial, and water resistant. The seat would also have material breaks to provide accents to the seat. The upholstery lines are particularly important to define the shape of the seat due to its tendency to change shape based on how the gel is squished. The defined upholstery lines prevent the device from having a mushy look in the seat. The material break accents could come in different colors and textures if customizable sleeves are developed after the initial introduction to the market does well. View Appendix P-Q for Form and Upholstery exploration.

8. Design Performance

The focus of the device is to aid users in achieving the best ergonomic position to complete a sit to stand transfer, namely allowing them to be centered on a stable seat with their feet in full contact with the ground when they begin the sit to stand transfer during egress. The device greatly reduces the amount of effort expended in the sliding and swiveling actions, which leaves more energy to complete the sit to stand transfer successfully on the first try. Additionally, the device relocates the target area during ingress closer to the body, which makes it easier to lower oneself onto the center of the seat accurately. This will also alleviate some fears of missing the seat and falling, as it will be closer to the user's legs than the preexisting car seat.

8.1. Security and Collisions

The cinches used to secure the device to the car seat would be 6′ nylon tie-downs rated to support 3600 N of force. This would allow them to keep the seat secure even in the event of a head to head collision, which would incur 3 Gs of acceleration and produce 270 – 360 N of force based on the mass of the device. This would keep the device secure in the case of a collision. Additionally, 2″ wide Velcro strips with 10 cm of overlap would be used to prevent swiveling and sliding during transit. Because the ends of the Velcro are not fixed, and will therefore remain parallel, the most likely method of failure during a collision would be shearing. The Velcro would withstand a force of at least 120 N of shear force before separation. The device is intended to be worn with a seat belt, which would stop the weight of the user. In a head-on collision, the device itself would produce 270 – 360 N of forward force. Assuming a 10° angle between the shear direction of the Velcro and the plane of the seat, there would be a shear force of 65 N on the Velcro, which is within the maximum allowed shear force.

8.2. User Testing

When tested with users, the device reduced the amount of time needed to get into and out of the car by 50%. Users noted that the device had very smooth transitions, and that it was much easier to get into and out of the car. There was initially some confusion about how the swiveling and sliding were ordered; however, once the user attempted the movement multiple times, they better understood the utilization of the device. There was also some confusion over the locking mechanism, namely that users would forget to unlock the device before attempting egress. This also dissipated with multiple uses. Users found the seat to be very comfortable and supportive. When given the choice between "less comfortable", "equally comfortable" and "more comfortable" than the existing car seat, users typically rated the device as "equally comfortable".

Negative feedback targeted the height of the device, which placed users 3 inches higher than they would normally be seated. This flaw would be addressed in production, once the materials of the layers is changed to 1/8″ polypropylene. The switch would reduce the total height by 3/8″, or potentially as much as ¼″ if the second and third layers are converted to 1/16″ polypropylene. There was also some concern over the price of the device, although mobility challenged users were more comfortable with a retail price of $250. There appeared to be a slight correlation between the user's difficulty with car transfers and their approval of the price, meaning that the more challenging a car transfer was for the user, the more willing they were to pay $250 for the device.

Overall, more than half of interviewees stated that this product would be helpful for them in their day-to-day lives. Of those individuals, approximately one third stated that they would be willing to pay $250 for the device.

8.3. Criteria Evaluation

Currently, the device meets most of the criteria for success outlined at the start of the project. It aids in the positioning of the body in the car transfer and reduces the overall time needed to perform the car transfer. It safely accommodates up to 400 lbs, exceeding the desired maximum weight. The locking mechanism allows only 2 mm of translational motion, and 4° of rotational movement. Based on the criteria of a 10-year lifetime, the slides and lazy Susan bearing can perform 6 trips per day, which is greater than the expected use of the device. If the device were to be used in an average of 3 trips per day, the lifetime would double to 20 years. Because of the low-profile design, it does not prevent the function of any safety equipment in the car, namely airbags, seatbelts, or mirrors. If production exceeds 1000 units, it can be sold for $235 and generate a profit margin of 45%. The only criteria that is not surpassed is the accommodation of a 6′2″ male. The current design would allow head zero clearance for an individual of that height, and this is an area for improvement in future iterations of the design.

9. Value Proposition

For elderly users who struggle with getting in and out of vehicles, our device is a car transfer aid, that provides a safe, easy, and comfortable experience for the user. Unlike the current car transfer devices on the market, our product provides a luxurious seating experience with both safety and comfort in mind while helping the user complete the car transfer in the smoothest and most natural way possible. This is because our device eliminates the struggles associated with the positioning preparation of the car transfer, which include pivoting and sliding into and out of the seat. This seat reduces the energy required from both the user and the caretaker to position the user in the seat properly, allowing them more energy to complete the sit to stand transfer, and decreasing the amount of time needed to perform the car transfer. U-transfer can position the user in the seat after sitting in as little as two seconds. This step typically takes seven seconds or more. Some users cannot complete the step at all without the help of a caregiver.

10. Manufacturing

Machining Specifications

The product would be manufactured using the sponsor's current manufacturing facility, Allotech Inc. The support layers would be made of 1/8" polypropylene plastic, in keeping with the industry standards for car seats. Polypropylene has a modulus of elasticity of 1.5 GPa, which would provide the stiffness needed in such a thin layer. The seat layer would also be made of polypropylene, and it would be thermoformed to have a slight curve. The bottom layer would be milled to have two slots on each side, through which the security cinches would be threaded. These slots would be 2.25" in length, and ¼" in width. They would be centered at 8" from the centerline of the base, and would be 1" from the front and back edges of the seat.

The foam core would be cut down to size using a band saw, and the memory foam components would be molded to the proper shape. The gel insert is prefabricated and contains a mixture of baking soda and mineral oil, which allows for mold ability and comfort. The lazy Susan and drawer slides are also prefabricated, and would only need to be installed properly during production. The nylon security straps are prefabricated, though it would be possible to create a custom cinching mechanism.

10.1. Cost Analysis

An initial cost analysis can be seen in Table 2. Conservative Unit Prices were based on the best available price for 100 units, while the Optimal Unit Prices are based on the best available price for 1000 units. Conservative labor and machining costs were based on median national values. The profit margin was calculated for each case using a $250 retail price, and then retail prices were calculated for 40% and 45% profit margins. In order to achieve the target profit margin of 40%, it would be necessary to produce over 100 units. The target scenario would be production of over 1000 pieces at a retail price of $235. This would fall within our maximum retail price constraint, as well as surpass the desired profit margin of 40%.

Table 2. Cost Analysis for 100 and 1000 Units

Part	Qty	Unit	Conservative (100 pc) Unit Price	Conservative Total	Optimal (1000 pc) Unit Price	Optimal Total
Polypropylene	288	in^3	$ 0.07	$ 18.72	$ 0.04	$ 12.02
12" Lazy Susan	1	each	$ 5.00	$ 5.00	$ 4.00	$ 4.00
Drawer Slides	1	pair	$ 6.25	$ 6.25	$ 6.00	$ 6.00
Mounting Screws	16	each	$ 0.02	$ 0.32	$ 0.01	$ 0.16
Memory Foam	1	lb	$ 2.00	$ 2.00	$ 2.00	$ 2.00
Structural Foam	0.5	lb	$ 2.00	$ 1.00	$ 2.00	$ 1.00
Vinyl	1.5	yd	$ 6.00	$ 9.00	$ 4.00	$ 6.00
Security Straps	1	pair	$ 7.00	$ 7.00	$ 5.00	$ 5.00
Velcro	2	ft	$ 3.00	$ 6.00	$ 2.00	$ 4.00
Gel Insert	1.0	each	$ 4.00	$ 4.00	$ 3.00	$ 3.00
Packaging	1	each	$ 8.00	$ 8.00	$ 4.00	$ 4.00
Labor	1.5	hr	$ 36.00	$ 54.00	$ 30.00	$ 45.00
Machining	1.5	hr	$ 25.00	$ 37.50	$ 25.00	$ 37.50
			Total Cost	**$ 158.79**		**$ 129.68**
	Margin for $250 Retail			36%		48%
	40% Margin Retail Price			**$ 265.00**		**$ 215.00**
	45% Margin Retail Price			**$ 290.00**		**$ 235.00**

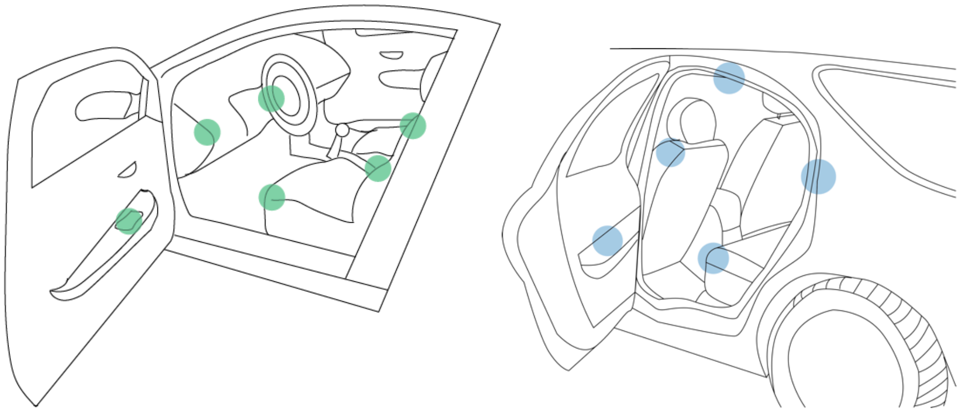
11. Future Work

Currently, there are a few items that need to be addressed in future work. The design should be modified in a way that allows more head clearance for a 95th percentile male. This would improve the overall comfort and ease of using the device. There is also potential to improve the locking mechanism, by way of a single button or lever, which would be easier for the user, and further limit seat movement during transit. Further user testing would be needed to confirm the benefits of the current design, as the user testing sample size was limited. A dynamic crash analysis would also be useful in confirming the safety calculations. Finally, it will be necessary to review the initial cost analysis with the manufacturing company to verify the estimated costs.

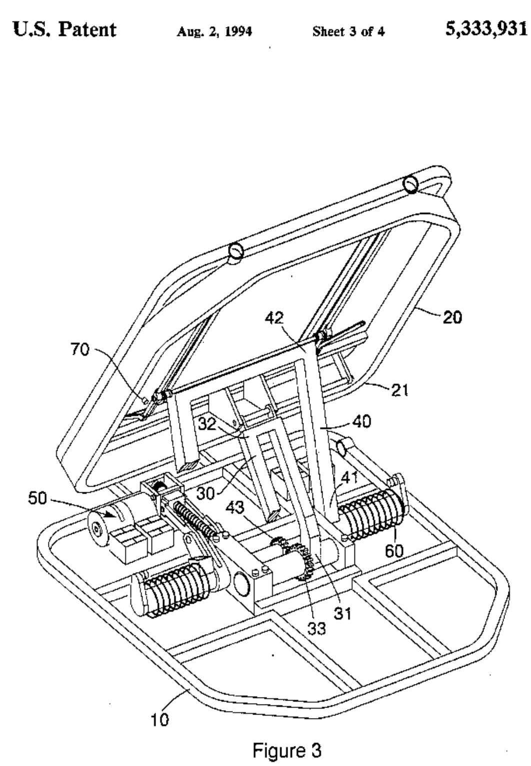
12. Conclusion

Due to the quickly rising 65+ years population, a need for aid getting into and out of the car is only going to continue increasing. Since there are currently no extremely effective and affordable products on the market today, UTransfer is able to bring a lot to the market by providing security, effective sliding and turning into and out of the vehicle, and an overall sense of independence for the user, while still being affordable. UTransfer is able to create more enjoyable and relaxing trips for both the user and the caregiver, giving them more time to bond and less time stressing.

Appendix



Appendix A: Touch Points



Appendix B: Patent No. US5333931A

U.S. Patent Jan. 21, 1992 Sheet 1 of 5 5,082,327

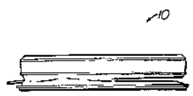


FIG 2A

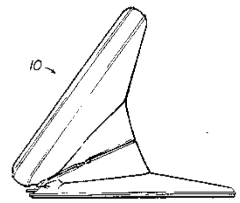


FIG 2B

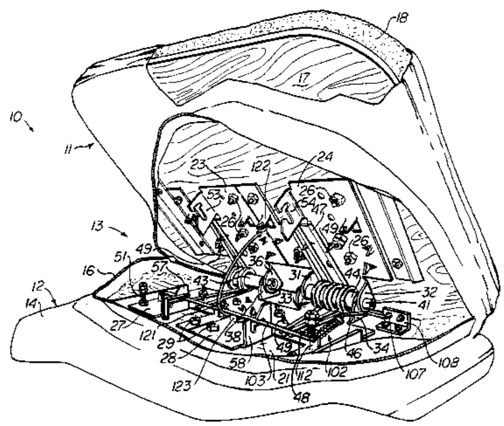


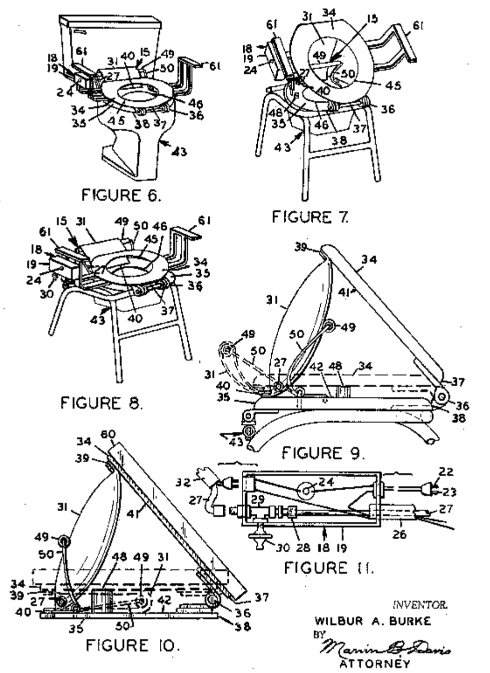
FIG 1

Appendix C: Patent No. US 5082327A

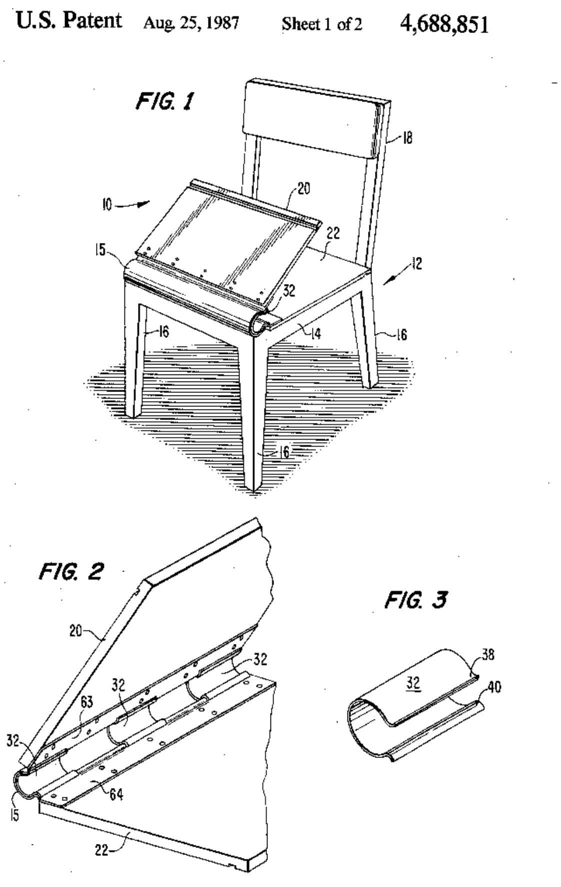
Nov. 18, 1969 W. A. BURKE 3,479,087

PNEUMATIC POWERED SEAT ERECTOR FOR AN INVALID

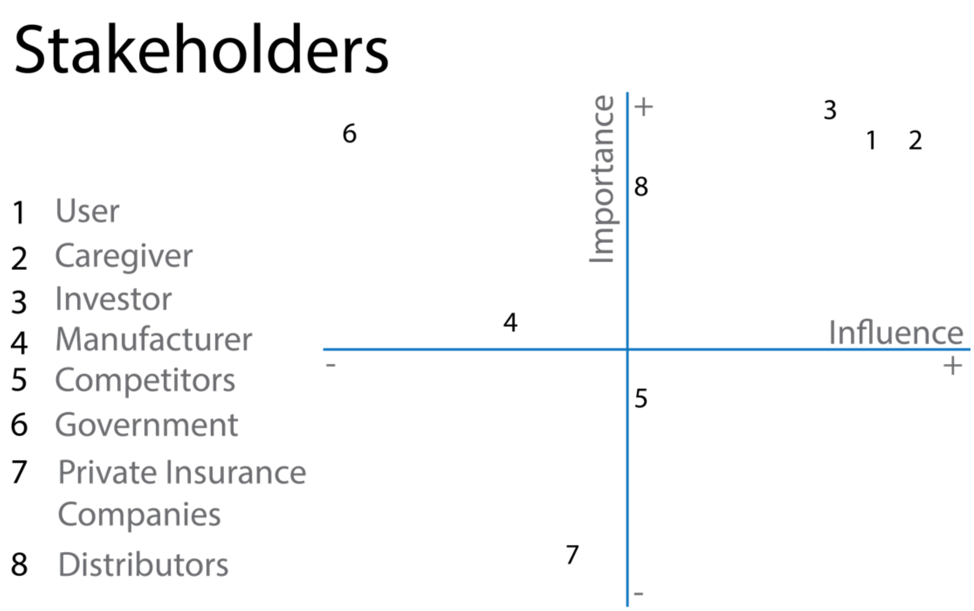
Filed Aug. 28, 1967 2 Sheets-Sheet 2



Appendix D: Patent No. US3479087A



Appendix E: Patent No. US4688851A

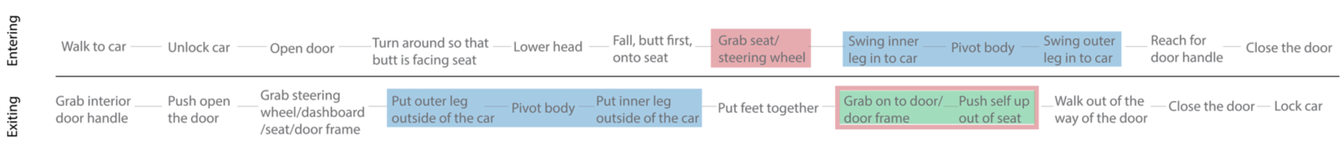


Appendix F: Stakeholder Analysis

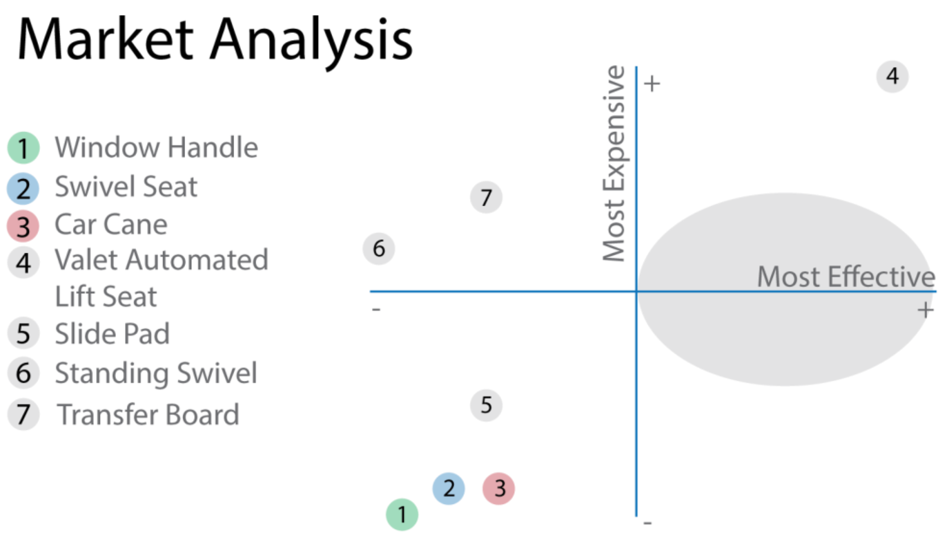
	Stakeholder	Interests	Impact/Effect	Importance	Influence
1	Disabled User	Indepence Safety	Can injure user/ Could get sued	5	5
2	Caregiver	Ease of use Safety	Can injure them/ Could get sued	5	5
3	Investor	Safety Cost-effective	Lawsuits/loss of money Pull out investment	4	5
4	Manufacturer	Safety Speed of production and assembly	Incorrect instructions can waste time and money	2	3
5	Competitors	Make a better product The tech we create	More successful/create competing products	3	2
6	Regulators/Governments	Health/safety standards Conforms with Safety Consumer Product Commission	Our product requires new regulation/gov issues new regulations	1	5
7	Private Insurance Companies	Durable Safety	Prevent future claims/save money and market on our behalf	2	1
8	Distributors	Net Income Efficient shipping and packaging	New product to sell/Increase our revenue	3	4

Appendix G: Stakeholder Analysis Matrix

Task Analysis



Appendix H: Task Analysis



Appendix I: Market Analysis

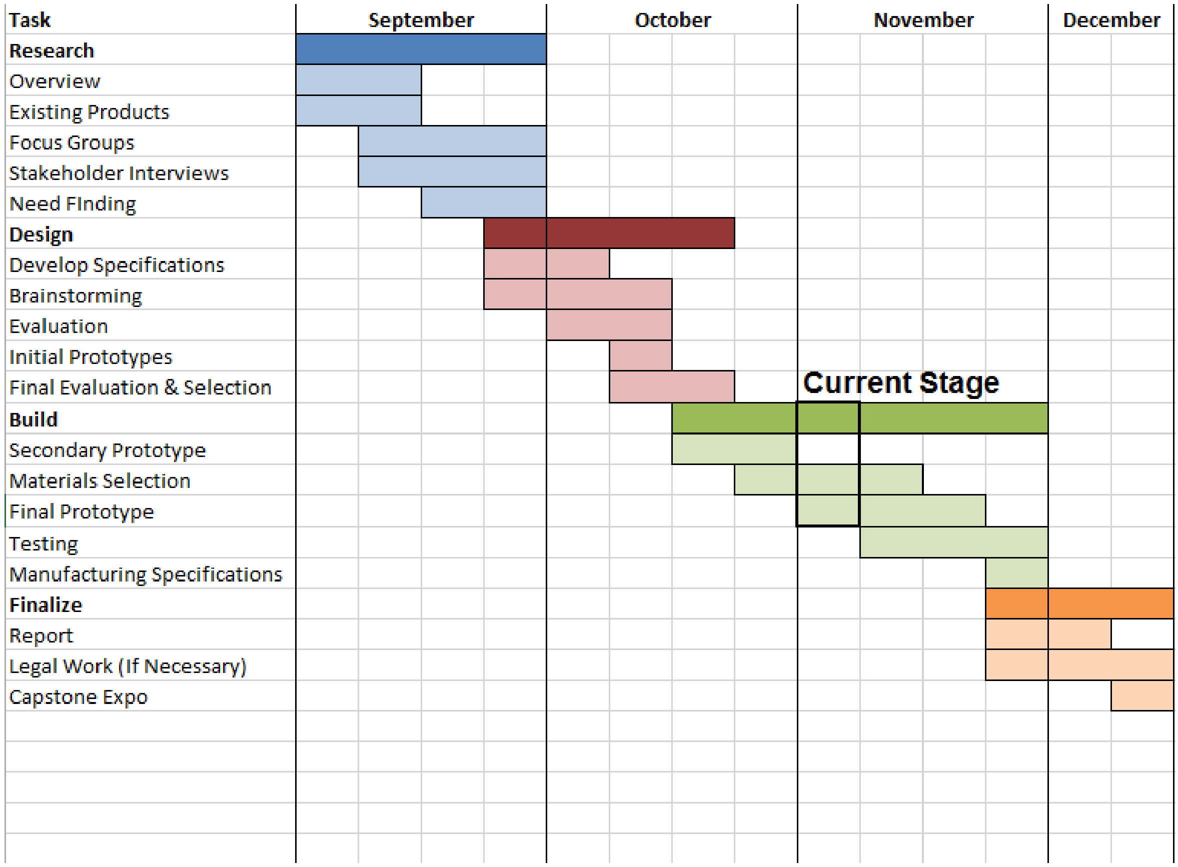
Appendix J: Window Handle

Appendix K: Swivel Seat

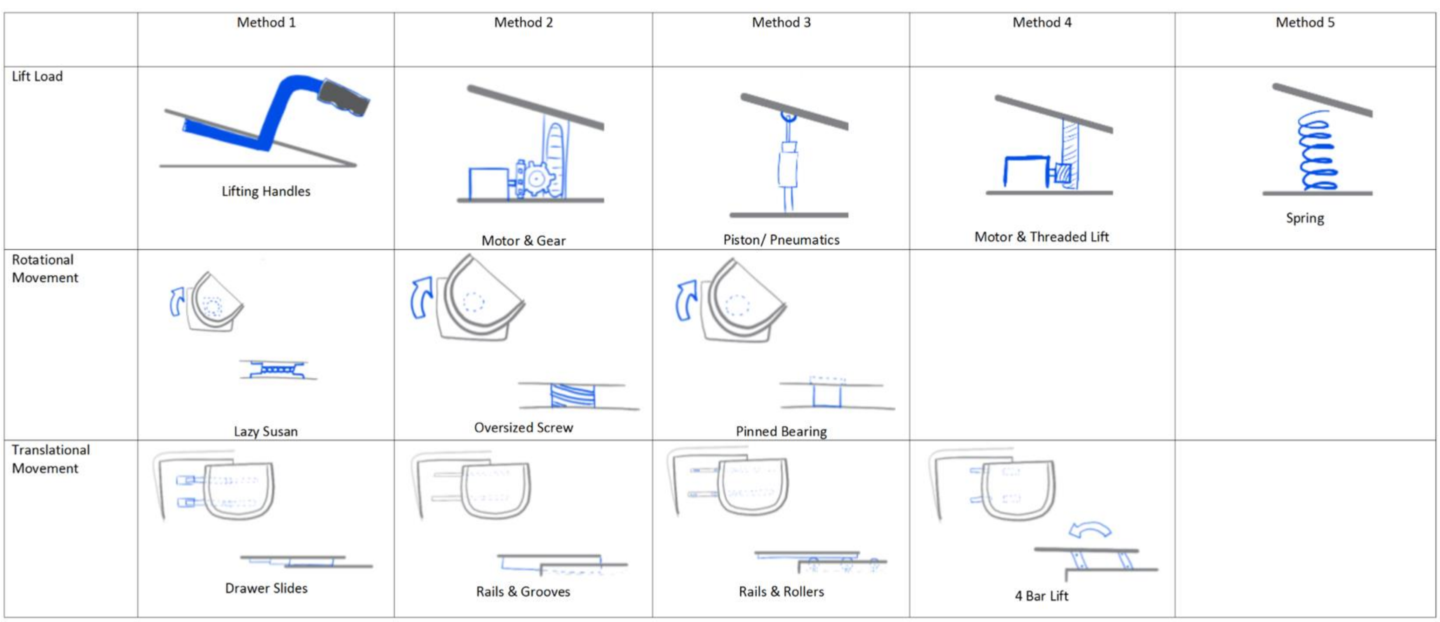
Appendix L: Car Cane

Requirement	Demand/ Wish	Responsibility	Source
Cost			
$250 max retail price	D	Engineering	URise
40-50% gross margin	D	Engineering	URise
Maintenance			
Easy to assemble and insert	W	Engineering	Team
Ergonomics			
Support hip width of 12.2"-15.9"	D	Engineering	FSAE
Diameter no larger than 45"	D	Engineering	Team
Material			
Support up to 300lbs	D	Engineering	Urise
Withstand temperature range -25[Equation]-60[Equation]	W	Engineering	Team
Safety			
Zero interference with mirrors, airbags, seatbelts	D	Team	Team

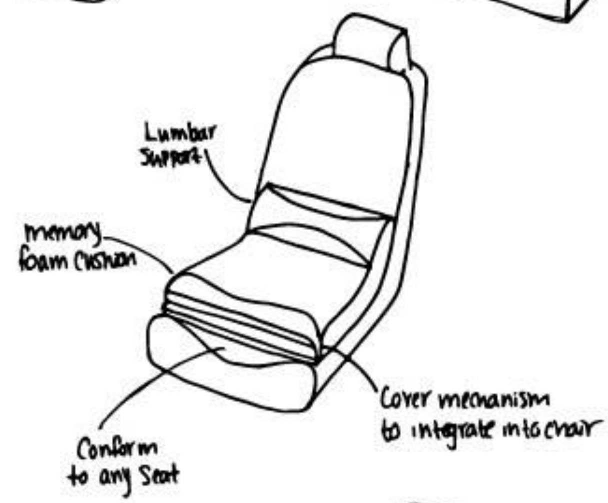
Appendix M: Specifications for Design

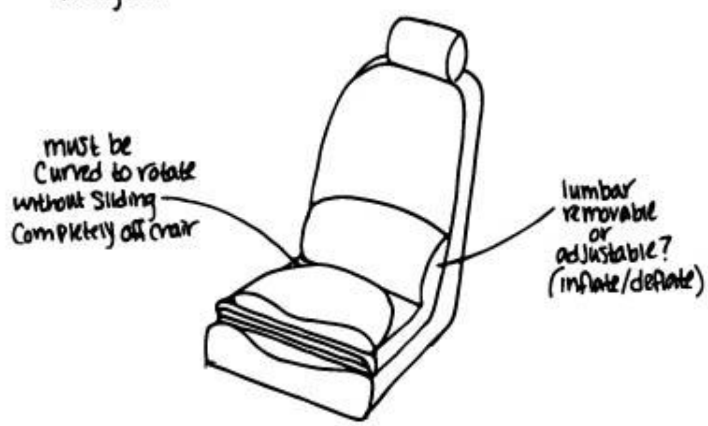


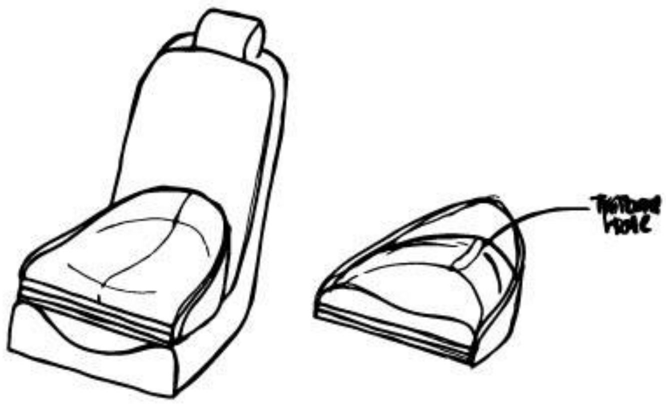
Appendix N: Gantt Chart

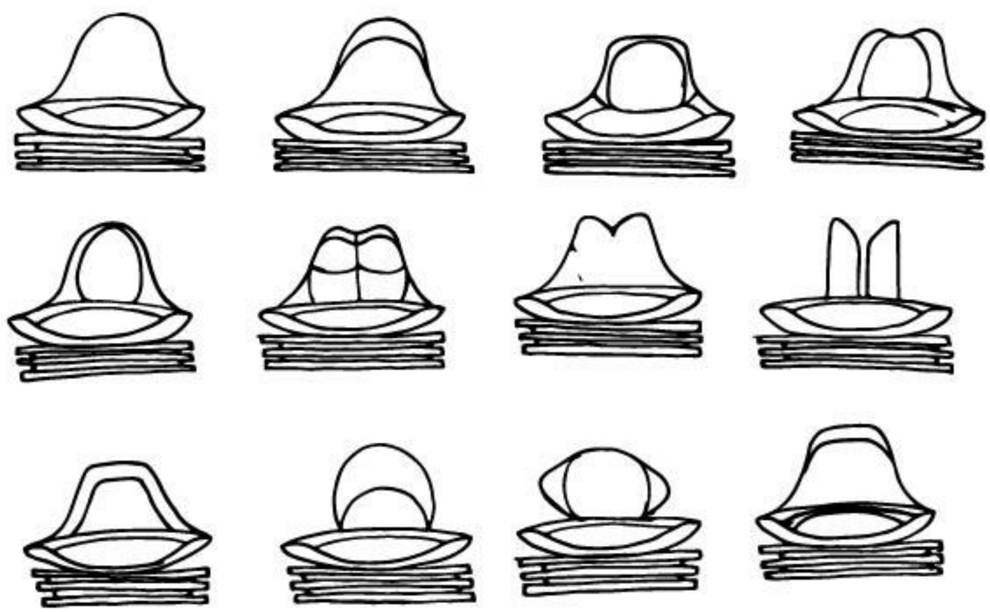


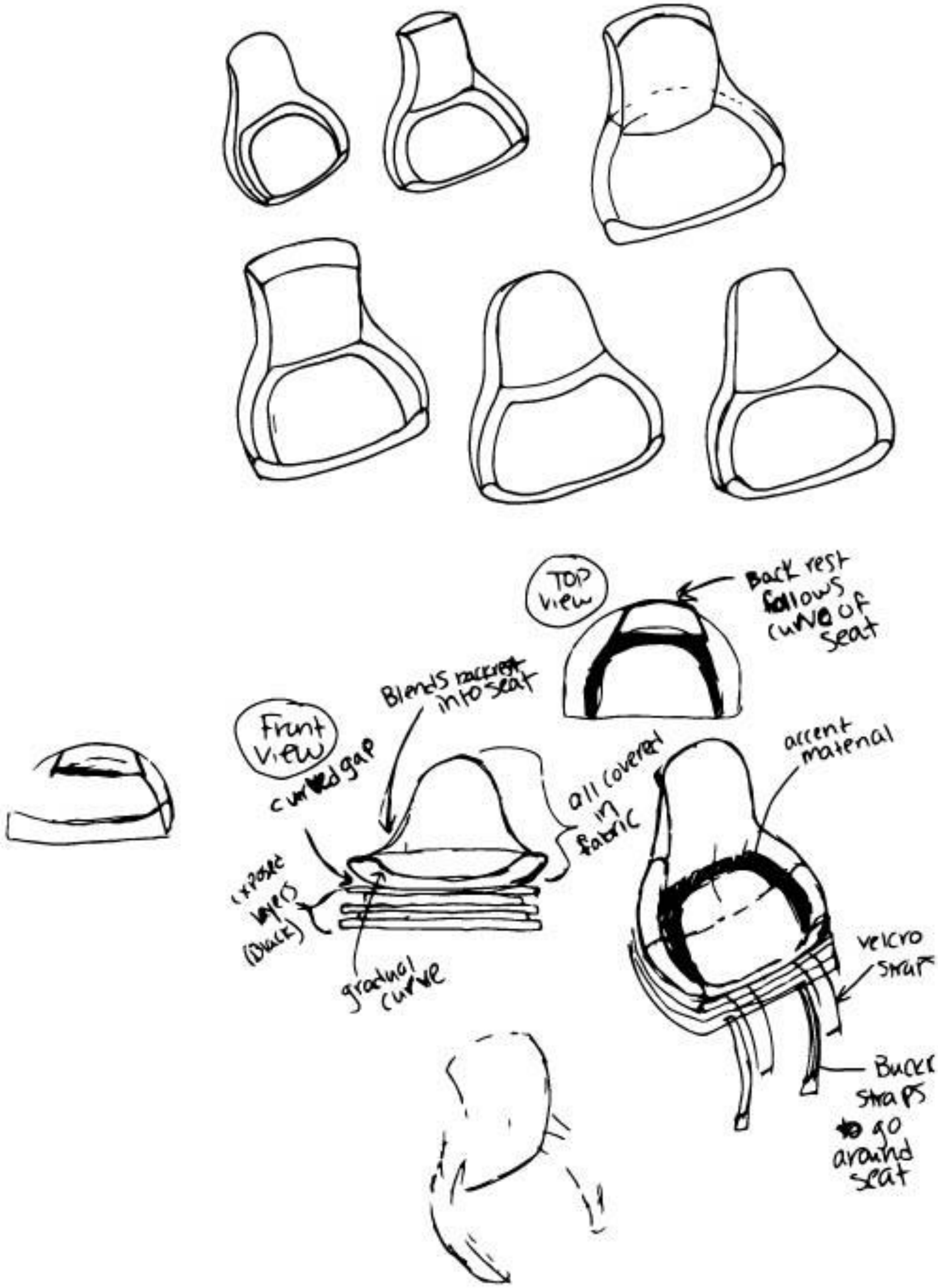
Appendix O: Morph Cart for Mechanisms


Lumbar support
memory foam cushion
Cover mechanism to integrate into chair
Conform to any Seat


must be Curved to rotate without Sliding Completely off chair
lumbar removable or adjustable? (inflate/deflate)



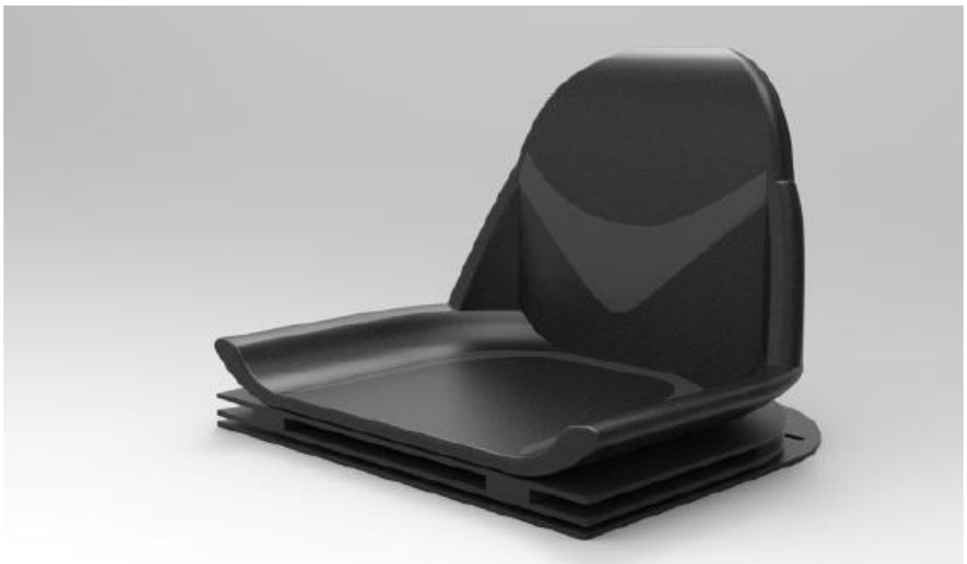




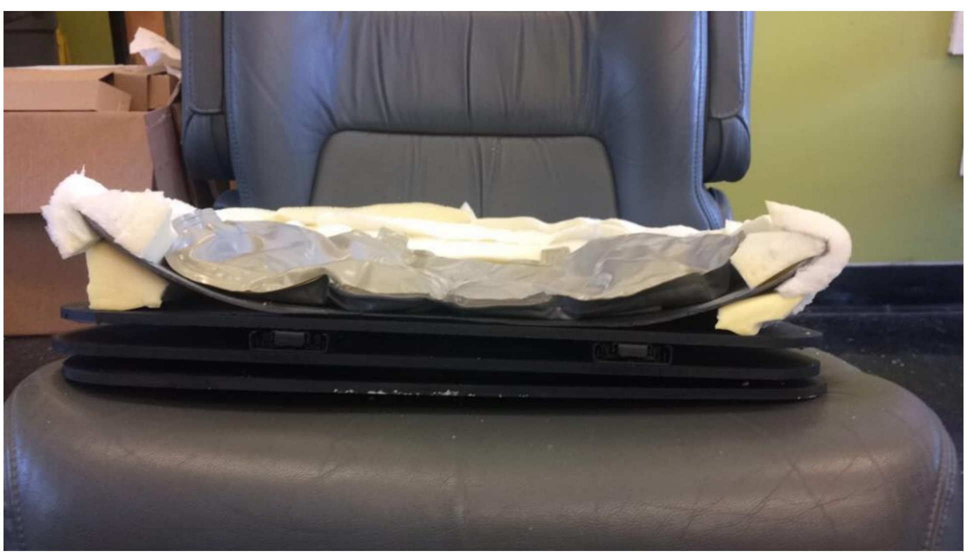
Appendix P: Form Sketches

Appendix Q: Upholstery Exploration

Appendix R: Cushion Testing



Appendix S: Final Design



Appendix T: Bottom Layer on Bucket Seat

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http://www.cdc.gov/nchs/data/nhsr/nhsr010.pdf

http://usability.gtri.gatech.edu/eou_info/hand_anthro.php (grip chart)

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