Final Report: *Walker and Stairlift*

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Project #4

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Abstract

A seven year old, Thalia, requires assistance with mobility on stairs, as well as around the house. She is diagnosed with Spina Bifida, which has resulted in limited leg mobility. She relies mostly on the use of her upper body to perform everyday tasks and must move around in a wheelchair and makeshift walker.

We have installed a motorized chair lift system to transport her through her split-level home. The split-level staircase required a design that encompassed a tight turn in a confined space. In addition, the user can safely operate the system while traveling up and down the stairs. The Excel Stairway Lift system was an ideal choice, as its separate rail design allows for a safe mode of transportation while traversing the stairs of her split level home. User controls are located at the top and bottom of the stairs, as well as on the chair itself to ensure Thalia or a family member can operate the chair irrespective of its location. A foldable chair has been used to minimize intrusion for other family members. A special feature of this project is that a pivoting chair is included in the Excel Stairway lift design allowing for safe transfer between the two stairway lifts.

For mobility around the home, a walker has been optimized to fit Thalia. Current offerings are adult size and require significant leg mobility to move and turn. A walker that utilizes upper body strength while maintaining stability has been obtained to meet the needs of the client. A squeeze-to-go braking system is incorporated within the design to ensure Thalia’s safety. Modifications to the vertical tubing portion of the walker have been made to allow for additional height adjustments as Thalia grows older. Both devices created in this project have been specifically designed to fit Thalia.
1.1 Background

Heidi Almeida is the mother of a single child, Thalia Almeida. Thalia is a seven-year-old female with Spina Bifida on Lumbar (L4) and (L5). The disease is caused by the incompletion of neurotube closure as well as the vertebrae being opened and not fully formed [2]. The disease progresses with exposure of the spinal cord, and in extreme cases, the spinal cord protrudes through the bone of the spinal column [1]. The debilitating effects of Spina Bifida can range from weakness in the legs to deficiencies in cognitive skills, planning, organizing as well as working memory skills. Thalia is mainly affected by weakness in the legs while presenting with normal cognitive skills.

With Thalia growing older, it is becoming exceedingly difficult for her Mother and Father to carry her up a winding set of stairs in their two-story home. As Thalia grows older, she is also learning to be more independent, especially in terms of mobility around the house. With that said, two devices have been designed to assist Thalia and her growing needs. These two devices consist of a walker to suit Thalia’s height and mobility needs, as well as a stair lift system that can bring Thalia up and down her winding staircase. Each of these projects have taken into account Thalia’s size as well as her mobility, mostly consisting of strong arms and limited leg strength.

1.2 Purpose of the Project

The purpose of this project was to develop a chairlift for the split level staircase in Thalia’s home as well as a walker. The Excel stairway lift system was installed in order to give Thalia the independence she needs to move around her home. The use of two individual stairway lift systems ensures that she can easily move from level to level. And the characteristic pivoting
chair design on the stairlift systems has allowed for Thalia to easily move from one chair to the other. In addition, the purchase of the Excel Stairway lift system we meet all FDA certifications, which would not have been met with our novel designs. Thalia is 45” tall and 65 pounds, so the system chosen accommodates her height and weight. An expandable side loading chair has been implemented to ensure that she can use the chairlift system as she grows. The weight capacity is up to 300 pounds to ensure her safety as well continued usability as she grows older.

The walker designed for Thalia has been modified to specifically match her height. As most of the force she can provide to move the walker is from her upper body, an additional squeeze to go bar is located in front of the walker making the new walker very similar to the one she currently uses. The use of wheels with a squeeze to go setup ensures that the walker only moves when the handles are pressed. As soon as the bike brake type handle is released, the walker stops moving, ensuring that any loss of balance she has is contained before a fall can occur.

1.3 Previous Work Done by Others

1.3.1 Products

Previous work conducted by Steven Zetts et al. for a stair lift system was created for a gentleman needing assistance to his basement. Confined to a wheelchair, the team created a lift system which, “includes a cantilever platform, a chain driven lift and two structural channels for support” (Zetts). There project consisted of major reconstruction to the house including a replacement of the door, a narrowing of the staircase, as well as a removal of the original stairs to allow for proper clearance of the stair lift system.
The construction done on the Almeida’s house is not as drastic. However, the Zetts’ project did install a motorized system, which is implemented onto the stair lift design for Thalia. This motor system consisted of, “A chain driven system…the brake motor flange mounted on a helical-worm gear drive with a hollow shaft output” (Zetts).

The design being modified and installed in the Almeida home is not be for an individual confined to a wheelchair. Due to spatial restrictions, the design calls for a collapsible built in chair system. Equipped with a seatbelt and a remote, this allows for independent mobility up and down the stairs.

1.3.2 Patent Search Results

A patent search indicates there are multiple stairway lift systems similar to the Excel Stairway lift system we used in this project. One such device is listed as patent number US2005224293, invented by Gordon Molnar and Peter Shaw on behalf of Rutherford Independence Ltd.. This device contains a floor track system and a collapsible chair design, this device is very similar to the Excel Stairway lift in this project. An alternate idea was developed by Todd Edmunds and is listed as patent number US 7096998 B1. This device operates using a vertical lift system combined with a movable staircase. This design does not seem feasible given the split level setup of Thalia’s home.
1.4 Map for the Rest of the Report

Included in this report will be, other alternative designs, as well as the basis for our optimal design selection. The optimal designs chosen, will be explained in further detail. This includes all subunits of the projects as well as how the will work together to form our final product.

The prototypes developed will be shown to have met the criteria set forth by our clients. Other considerations such as economic, engineering standards, environmental, sustainability, manufacturability, ethical, health and safety, social, and political considerations will also be discussed.

Safety was of upmost importance in both of these projects, and will be addressed thoroughly throughout the report. Scrupulous notes were maintained in regards to the budget as well as time spent on each of our projects. This will also be discussed within our report. Each team member will show their hourly contribution to each of our projects, stating what they have done, and how they have worked together to create our final product.

Finally, our report will be concluded with an appendix, acknowledgements, references, as well as a report summary.
2. Project Design

2.1 Introduction

Alternative Designs for Stairway Lift

*Double Hinge and Hook Stairlift Design:*

As a self-designed model, safety and special constriction were a main concern in this design. With a collapsible chair, and a double track guide along the wall as seen in the appendix, this design will sit snuggly against the wall, and the chair can be raised up and collapsed for passage through the narrow stairway. Using a series of pulleys and hinges this design is perfect for going up a single flight of stairs. And the hook above the pulleys is a backup safety net if a problem were to occur with any of the four pulleys. Also equipped with a seatbelt, this design covers every basis of safety requirement.
The cost would be severely reduced from newly purchased commercial design, and should only be between $1000 to $1500 for parts and labor costs. This is less than half of the price of a newly purchased device, and is also half as bulky as well.

However, with the double hinge, quadruple pulley system, a few problems seem to arise. When placed onto the tracks, the top pulleys would be the sole bearer of the weight of the user, and there is nothing to divert any of the force in the x-direction from the moment of the user sitting in the seat. This would place too much weight on the back of the design, and would cause a certain malfunction.

Another problem arising from this design would be the sharp turn at the top of the first flight of stairs. This 180-degree transition would not be handled properly by the quadruple pulley system. They are much too wide for a pivot of this angle.

*Double-Pulley System, Two Rail Stair- Lift:*

This next design is optimal, for safety, price and compact design with the unique double pulley system, the weight of the patient, and the moment of the force in the x-direction will be compensated by the *Two-Pulley-System*. And with the base-pivoting design, the patient will remain in an upright position going up stairs, and turning corners at a flat platform midway between the two stairs. The compact hinge design of the chair will allow for a slim design for family members to easily and safely move past up and down the stairs. Not shown in the design, will be a cable winch system moving the user up and down the stairs, by handheld remote. This is a commercial part that must be purchased for this design. And even though these customized parts will be costly, they will be necessary, and will be much less in price.
This design will also use a two-track system, and will be capable of making tight turns around the winding staircase in the Almeida home.

Many small parts will be necessary for this chair design. Consisting of frames, pulleys, and pivot systems, these pieces are created in order to perform several tasks at once. Consideration with long-term use, each part will be designed out of non-corrosive material. The pulley and backings of the chair will be fabricated out of Aluminum, and the chair will be highly durable plastic, both capable of withstanding years of high amounts of usage. As safety is a main concern as well in this project, duplicate pieces will be used on the chair backing in order to carry a maximum capacity much greater than necessary for our patient.

Designed in SolidWorks, this device will be easily created in the machine shop on the lathes and with the plasma torches. All parts are 3-D capable and measured out precisely to necessary specification for fitting in the 35 inch staircase.
Beginning with the smallest yet most significant design of the chair, the swiveling pulley system is a major component of the stairway lift design. From left to right a piece-by-piece process is constructed above into the final swiveling pulley system design. Starting with the far left, this piece will be attached to the chair backing by the square base, and is designed to allow for 360 degree rotation of the pulley system on the chair backing. This will allow for the rotation of the chair to take place, keeping it in horizontal, upright position as the chair ascends the staircase along the two-rail system. Once the chair reaches the flat midway stage of the staircase, the swivel system will allow for the chair to remain level throughout the slanted and level sections of the multi-dimensional staircase.

The block is the framework for the pulley system and will be the housing for the swivel attachment system along with the two sets of pulleys (side and top) on this device.

With a side pulley’s contour shape to snuggly follow the top of each of the two tracks along the stairs, as well as a cylindrical bottom pulley to disperse the weight from the moment produced by the sitting patient, this system will allow for a smooth, practically frictionless, and upright ride, up and down the stairs.

Fashioned together with cylindrical inserts, each pulley will be able to rotate at 360 degrees, allowing for a frictionless roll along the tracks. Much like normal pulley systems, the outside will be free to move, while the inside, cylindrical insert will be fixed using a large bolt. The far right of fig. 1 is a depiction of an inside view of the workings of this pulley system device.
Displayed above is the complete design of the Swiveling Chair Pulley system. Depicted in the center of Fig. 2 is a display of how the Swiveling Pulley system will be installed into the chair. Using two Swiveling Pulley Systems to disperse the weight will allow for a safe and secure ride time and time again. An “F” shaped frame is introduced to the chair’s back in order to maintain extra stability of the Pulley systems.

As seen from the two profile views, this chair is designed with a middle attachment piece, connecting the back and bottom of the chair. This design will allow for a collapsible design, capable of folding in while not in use to allow for stair access of the non-users of this device.

Also seen in the profile view are the two sets of swiveling pulley systems, which will sit on the two separate tracks aligned against the stair wall. In between the two tracks will be a winch cable that will attach to the “F” frame, giving the chair remote mobility up and down the staircase.
A final depiction of the design is given below in fig. 3, this shows the final solid display of our optimal design.

Allowing for a more realistic view of the design, this solid view is a very close representation to how the final product should look. Depictions of both our small part Swiveling Pulley system, as well as our Swiveling Chair Pulley Design are show have been designed in SolidWorks, and will either be constructed in a Machine shop for customization, or bought off the shelf and fine-tuned for our design.
Commercial Design Excel Stairway Lift System:

Commercial systems such as this are made and installed to produce the safest of results. With a large comfortable chair, this design is ideal for a large house, and a broad stairway. With the single track lining the bottom of the staircase, the load of the chair is placed on the ground instead of on the wall. Including several safety devices, this system can detect if there should be anything in its path, both on the track and on the built in footrest. With a built in motor, the user would be able to turn the chair on and off even in mid-decent/climb. Using a worm gear system, this design is of highest possible safety if failure should occur. In the case of system failure, a worm gear will automatically lock in place allowing for a patient to remain safe, not sliding down the lift due to the force of gravity.
Even though safety is such a huge factor in this design, the price and size outweighs the benefits of this design. With a large comfortable chair, and a track placed on the ground placed on the ground, our 35-inch wide staircase is perfect for this design. However, in the price range of up to $30,000.00, this device is also 3 times what we would like to spend on our design for the Almeida’s.

Initially, the optimal design of choice was the winch based Double Pulley system. This novel design was relatively inexpensive and met the design criteria for the client. After visiting the NEAT marketplace, another alternative design split level stairway lift system has been found. This stairway lift system normally would cost upwards of 5,000 dollars. As stated in our alternative designs, the only reason for not using a commercial system as the basis of our project was the economic (budgetary) constraint. In addition, use of an originally existing device has reduced the environmental impact by minimizing the purchase of new materials. To meet the political and social constraints an already designed and FDA approved system seems a more ideal choice given the device has been rigorously tested. After negotiating the price of the used Excel Stairway Lift system to a far lower price, the choice was made to fabricate and modify an optimal design to this device. Doing so would has ensured that the design criteria was met, safety was maximized, and the budget was used more efficiently.

**Stairway lift Prototype:**

After finding the stairway lift at the NEAT marketplace, upholstery and electrical fabrications have been made to ensure that this system is working properly. Originally constructed by Access Industries, we have made further fabrications to this device to suit the needs of your home. This lift is easy to operate and is known as the “Cadillac of Stairway Lifts”.
Even so, proper operation must be followed and maintenance is required every so often. Please read and adhere to these instructions in this operator’s manual to avoid unnecessary problems and less frequent maintenance.

This Stairway lift is equipped with access switch boxes at the bottom and top of the stairs as well as directly under the seat for direct access from all points in the house.
As seen above, after fabrication and modification of the Stairway lift, a licensed professional joined us and assisted in the installation of the stairway lift into the Almeida home. With a collapsible design as well as a tight to the wall installation, there is still much space to access the stairs by foot as well.

In order to fit this device into the Almeida several steps of measurements needed to be taken in order to designate if this was a correct fit for the home. After measurements were made, the installation process could take place and testing of the device could be conducted within the home. This Excel Stairway lift was an ideal size and fit for the home, and now additional alterations needed to be made to the device after measurements. With a licensed professional assisting in the installation of this device, all legal basis were covered for the state of Connecticut.

The modified and fabricated stairway lift can now be used safely and effectively in the Almeida Home.
Alternative Designs for Walker

2.1.1 Introduction
The process for developing alternative designs for the walker is different than for the stairway lift systems. Walkers that are currently available on the market cost in between 50 to 150 dollars, so alternative designs were chosen from currently available commercial walkers.

Alternative Design #1

This Medline Rollator walker design encompasses all of the design criteria for Thalia's walker. This walker is currently available from Medline and even meets our design requirements including a chair and bonus in-built storage compartment. A braking mechanism was already in use, however it would have to be modified (when the breaks are pressed the wheels are released...
instead of the current setup). The use of wheels will greatly reduce the friction encountered during operation in comparison to her current walker. This may improve Thalia's posture and ease maneuverability around her home. The current design is for people from 4 feet 10 inches to 6 feet 2 inches tall. Since Thalia is only 3 feet 9 inches tall, sections of the steel tubing will need to be removed and re-connected to accommodate her height. This walker seems like the best alternative design assuming a squeeze-to-go walker cannot be found. This design modification of the braking system and a low investment cost of one hundred dollars.

Alternative Design #2
This design is closest to what Thalia uses as a current make shift walker. Though this is simply a play school chair, the frictional properties of the plastic material allow her to stop and move as she chooses. Basing a design off of this play chair would ensure Thalia would know how to operate it safely. In addition, height adjustments could be easily made by placing small cup shaped discs on the base of the legs. The height could continually be adjusted as various discs are added below the legs of the chair, ensuring the device would remain usable as she grows. The device also includes a place to sit if she gets tired. The disadvantage of using this design is that the legs (with their flat bases) are prone to get caught if there is any obstacle in the chair's path. The trim piece at the transition point from carpet to tile flooring in the kitchen is a prime example of where the legs of the chair would get stuck. Not only could this cause a problem in maneuverability, it could also lead to tipping and a potential for injury. Clearly this poses a major issue with this design, however it can be remedied by placing a rounded edge on the chair legs which would allow for clearance over smaller obstacles. The low cost of the chair (thirty to fourty dollars) would leave plenty of room for money to be spent on modifications. Overall this design is not really ideal since it’s not as maneuverable as a wheel based walker would be.

Alternative Design #3
This design is essentially the most generic walker available. It is ideal for those with adequate muscular strength in the legs but limited leg mobility. In Thalia’s case, she does have some muscular strength in the legs but lacks the ability to coordinate leg movement. The advantages of using this type of walker include a high level of stability and maneuverability in tight spaces. A seat could be added by placing a flat piece of wood in between the two supports as shown in the diagram. Similar to alternative design one, sections of tubing would have to be removed on all four legs to obtain the proper height for Thalia (current Approx user height: 5'4” - 6'2”). The fact that this design already contains two points from which it can be held is ideal as it
provides an additional height adjustment as she grows. With a cost of around eighty dollars, this device falls in the middle of the price of alternative designs one and two. The main disadvantage to this design is that it needs to be lifted slightly as each step is taken. Though this design is light as it made from aluminum tubing, Thalia would struggle to completely lift the walker off the ground due to her lack of leg mobility. Therefore this alternative design is not ideal, as a wheel based walker design seems far more feasible for day to day use for Thalia.

*Commercial Design Squeeze-to-Go Walker:*
Originally, it appeared that the Medline Rollator walker would be the best alternative design to implement as the optimal design. The main shortcoming of the Medline Rollator design is that it would require further modification to implement the squeeze-to-go braking system. However, after visiting the NEAT Marketplace, a different brand of walker became our optimal design as it
already utilized the squeeze-to-go braking mechanism that Thalia needs. The walker also has an additional bar towards the front which can be squeezed (in addition to the individual brake handles). This seems ideal for Thalia as she generally leans forward to help her build momentum while pushing the walker.

The walker obtained from the NEAT marketplace is less expensive than all standard walker designs (alternative designs one and three), therefore making it better suited to the economic constraints of this project. In addition, using a refurbished walker from NEAT marketplace reduces environmental impact by ensuring fewer materials are used when compared to the new alternative designs. The squeeze-to-go walker fits within social and political constraints as fewer modifications were needed to be made to the walker (since the squeeze-to-go brake was pre-installed). Using a proven design ensures that the design meets FDA requirements unlike the proposed alternative designs one, two and three which require substantial modifications. The squeeze-to-go walker exceeded alternative designs in terms of health and safety since there was an additional hand brake towards the front. The additional brake enhances usability and even allows Thalia to be pushed safely by someone else if necessary. Manufacturability and sustainability of this squeeze-to-go walker will remain consistent as the only modification to the walker is an additional height adjustment. This modification is far more feasible in terms of manufacturability when compared to alternating the entire braking system of alternative design one. Based on all of these factors, the squeeze-to-go walker from NEAT marketplace was chosen as the optimal design.

2.2 Optimal Design

2.2.1 Objective
The optimal design chosen has met all design criteria set forth by the client. In addition, this design meets all realistic constraints with a low cost and less fabrication than other designs. The squeeze-to-go walker is a wheel based walker. The use of wheels at the base greatly reduces the friction encountered during operation when compared to standard walker designs. The wheels make the walker easier to use while increasing its maneuverability. Since safety is one of the most important design criteria, a squeeze-to-go brake design was chosen. This ensures the walker will stop unless the user is pressing the handle, reducing the chance for a loss of control or tipping. The brakes themselves can be operated via three handles, one of which allows Thalia to lean into the walker while pushing (similar to how she uses the walker now). The walker height was also adjusted to meet the Thalia’s needs. In addition, a modified adjustable design was implemented so the walker remains usable as Thalia grows. The placement of a seat within this design increases the usability of the walker as Thalia will be able to remain at a position she moves to if she deems it necessary.
2.2.2 Subunits

Subunit 1, Squeeze-to-Go Walker

The walker purchased at NEAT marketplace formed the base for the entire design. Since a squeeze-to-go braking system was already in place, testing was performed to ensure the device was fully functional. After the device testing occurred and all components were determined functional, the vertical tubing of the handle was cut to allow for a lowering of the height for Thalia’s needs. The form of this design is compact which increases maneuverability in the tight corners of the client’s home. The function of this component is to perform as a versatile walker for Thalia. By cutting the vertical bar and welding the shortened piece together, 5 inches of vertical height were removed from the walker to fit Thalia’s needs.
Subunit 2, Height Adjustment

The walker was modified as its standard height is higher by about four inches than what Thalia needs for it to be usable. The function of this component is to allow for an additional height adjustment or the walker as the current design is too tall. In this modification, a four inch section of vertical tubing has been removed from the walker. After measurements were taken of the inner tubing diameter, a smaller piece of tubing was purchased with a matching outer diameter. This would allow for proper welding of such a thin piece of metal to a much thicker piece to maintain stability of the device. Once this process was complete, the additional height adjustment ensures the walker remains usable as Thalia grows. The form of this bar ensures that the design remains compact and no real change in form to subunit 1, Squeeze-to-Go Walker occurs.
2.2.3 Prototype

By testing the device several times with our client, modifications could be made to suit the needs of Thalia’s height and mobility needs. We have diagnosed several issues with our optimal design and have modified our squeeze to go walker in both height adjustments and brake positions.

Originally this walker had a design to meet the needs of an average individual with slight walking issues. With Thalia’s short stature, this design is not ideal. This was seen after our first interaction with her using the walker. Standing on the tips of her toes, Thalia could not reach up high enough to push the walker forward, and the brakes were out of her reach.

As seen below, a significant amount of vertical height was removed from the walker, to lower the system approximately 4 inches lower.
This resulted in a beneficial change for Thalia, who could now comfortably use the walker in a correct posture for her walking needs. By removing 5 inches from the height adjustment handle, we lowered the device as well as maintained stability necessary to put weight on the walker similar to our original design. This prototype was not complete and could be seen after our next visit.
As seen in figure 3, the brake handles are placed fairly far back for an individual leaning forward in this device. The braking bar was also an issue for her originally as she could not reach up high enough and her hands were not strong enough to squeeze the brake while she was reaching upward. But after the height adjustment of the device, the brake bar was much easier for her to grasp and squeeze.

And with Thalia’s small hands, she explained having difficulty using the bike like brake handles when they were so far back on the walker. For this reason, we made yet another modification to the walker system. This was done by removing the original bike brake handles and relocating them further forward on the system. This can be seen in the figures below.
Figure 6 Brake Prototype SideView

Figure 7 Brake Prototype AngleView
In comparison with figure 3, this made a significant impact on the use of the device for Thalia. She now had easy access to both brake systems, and has all around better control of the walker. By angling the brake handles outward, they could be accessed by Thalia in a way that meets her small handed needs.

Lastly, when we interacted with Thalia, and watched her use of the new walker design, she seemed to benefit from using the seat quite frequently. While she would use the device Thalia needed to prop herself into the seat by the use of her upper body alone. As seen in the original image, Thalia needed to pull herself up using the slick metal frame of the walker. We saw this as not an ideal situation if she is to use this method frequently. And with much deliberation, our team chose to slide the grips, originally placed on the top of the walker, to the side of the walker as seen in the image below.
As seen in the figure above, by moving the grips from the top of the walker to the side and corner position, Thalia will now be able to have a firm grip on the system as she props herself into the walker to sit comfortably. This keep Thalia from needing to use excess strength to grip a well-polished, smooth surface of the powder coated metal, and will allow for a much safer entrance and exit into the seat in general.
With the modifications fully completed, Thalia now has full access to all aspects of this device, and can use this walker currently, and as she continues to grow and mature.

3. Realistic Constraints

3.1 Engineering Standards

All engineering standards were met in the development and production of the stairway lift and walker. Through use of the Solidworks design software, all parts have been constructed and analyzed for the device prior to actual fabrication. Many safety issues have been addressed already and improved upon with the optimal designs dictated in this report. The stairlift and walker designs developed do not appear to infringe upon any patents or intellectual property currently available.

3 Realistic Constraints

Economic:

With a budget of 1000 dollars, the parts for both the chairlift and walker were chosen very carefully. The previous unit was replaced with an alternative optimal stairlift design. After visiting the NEAT Marketplace, a professional Stairlift design was obtained that reduced spending significantly.

The previous design of the Walker system called for modification of the braking system, to a “squeeze to go” design. Again, after visiting the NEAT Marketplace an optimal design was obtained with this modification already installed. This reduced cost and labor significantly.

Environmental: The materials chosen were recyclable and environmentally friendly. Modifying
an existing, previously owned stairlift and walker model, we reduced cost and use of materials. Modification keeps a product that may have been discarded or would be sitting in a storage unit, and allows for it to be used again. The previously used product is therefore recycled without the use of new materials.

**Sustainability:** Stainless steel or other types of non-corrosive material with an anodized finish are being used in the walker and stairlift designs to ensure longevity of the devices. This prevents oxidation of the material ensuring that no rusting or deterioration will occur. The Access Industries Excel Stairway lift has been tested rigorously during its production process. Further testing has been performed with heavier occupants than Thalia in the senior lab design to ensure the device is functioning properly. Certain components which appear to have experienced significant wear were replaced such as the swivel handles and up/down switches. This will ensure that the product remains sustainable and less upkeep is required.

**Manufacturability:** Both the walker and stairlift system being used are slightly modified versions of previously manufactured products. The Access Stairway lift system has been in use for over a decade and is still widely distributed as a safe and reliable stairlift system. The squeeze-to-go base design of the walker was also produced on a large scale and the slight modification (height reduction), is easily reproducible during any future manufacturing processes.

**Social/Ethical:** There are no broad scale social ramifications of the walker and stairway lift systems, the goal of this project is to improve the quality of life for the client.

**Safety/Health:** A huge component of this project is Thalia’s safety. Many fail-safes have been implemented to ensure that the device ceases to operate in a predictable manner if any sort of failure were to occur. In addition, the other family member’s safety will be kept in account. The
chairlift design implemented is foldable and compact so it does not interfere with their ability to traverse up and down the stairs.

4. Safety Issues:

A huge component of this project is Thalia’s safety. Many fail-safes have been implemented to ensure that the stairlift device ceases to operate in a predictable manner if any sort of failure were to occur. There are remote controls located on the chair, as well as on the top and bottom of each staircase which will ensure that the lift can be stopped at any time the user deems it necessary. There are multiple obstruction sensors in place to ensure there is nothing impeding the path of the stairway lift or the footrest. An important part of the design is that a worm-gear has been used to ensure that in the event the motor stops working the chair remains locked in place. The stairway lift has been thoroughly cleaned and refurbished to ensure that there are no sites at which injury could occur. Refurbishing has also reduced the likelihood of corrosion and has resulted in an increase in the length of the time the stairway lift can be used.

In addition, the other family member’s safety will be taken into account. The chair for the stairway lift is foldable and compact so it does not interfere with their ability to traverse up and down the stairs. The walker contains multiple features that ensure Thalia’s safety. The use of a wide based walker that is squeeze-to-go will decrease the likelihood of tipping during use. The reduction in height will further lower the center of gravity to ensure the walker remains upright. The main safety feature implemented for this device is the squeeze to go braking system. This is ideal for Thalia, as with her limited leg mobility, she needs precise control of when the walker
moves to ensure that she can remain stable. The walker therefore is designed with a squeeze to go brake setup, in which the walker can only move if the handles are depressed. Clearly, multiple safety measures have been taken into account in the designs of both the stairway lift system and walker.

5. Impact of Engineering Solutions

Creating, testing and designing both a walker and a stair lift for the needs of an individual with Spina Bifida will allow for a standard model for not just individuals with this specific disorder, but also an entire community of people who lack mobility in lower extremities. Injuries to the spinal cord, stroke victims and paraplegics can all benefit from one or both of these devices. There are a variety of related products on the market for both the stairlift and the walker. Many of the stairlift products available are both very high in price (over 10,000 dollars) and not suited for a split-level home. The increased cost of taking care of a person with a disability often puts many families in a position where they cannot afford the devices they need. Our stairlift has a much more reasonable cost, increasing accessibility to many families who may need it. The idea implements different methods than traditional stair lifts, as it uses a compact design along with a winch based system. This method drives down cost and uses a proven device to ensure longevity and reliability of the product.

The walkers currently available provide a viable starting point, however they will need to be modified to accommodate Thalia’s size. The brake type will be reversed to ensure Thalia is able to move safely, and at her own pace. A walker like this has yet to be designed, and with its relaxed breaking system, can be used for patients suffering from various ailments that result in decreased leg mobility. Modification of a current walker would decrease environmental impact,
as a new factory would not need to be developed for parts production. A much smaller operation could satisfy the changes that need to be made during modification and assembly. The impact of the optimal designs has the potential to improve the quality of lives of many at a reasonable cost and with little harm to the environment.

6. Life-Long Learning

There was a vast amount of new material learned through this design process. Firstly, working with an end user first hand was an eye-opening experience as it allowed us as engineers to fully address the needs of the consumer. Through meeting with the end user, additional factors in the design process came into play including cost, safety, as well as reproducibility. These considerations were not really made when designing smaller devices in previous engineering courses. An additional challenge was also introduced when having to actually implement the design. The amount of testing that needs to be done before fabrication can occur to ensure safety and viability of the design was another learning experience. The ability to design and model in the software Solidworks was a newly acquired skill, which proved very useful in preliminary testing and 3-D modeling of the designs. Testing through this method also allowed us to correct any potential design flaws before building of the actual device commenced.

Further insight was also gained in how to go about contacting companies to order parts and in negotiations for those parts. A vast amount of research was performed before parts purchase to ensure the most ideal part was obtained for the lowest price. This process had to occur for both the walker and stairway lift system. In doing so, experience was gained in how to facilitate transactions and how to find new vendors. Since the stairway lift required a license to
install, information was gathered regarding how FDA approval and state legislation works in regards to medical devices. Through this project many new design skills were acquired. In addition, an introduction to the ethical, legal and social ramifications involving medical devices also occurred.

7.1 Budget

Stairlift:

After purchasing our stairway lift for $75 for two separate fully functional lifts, we obtained an installer to complete the job legally for us for a final price of $999. With this being the most important part of the project, the installation project was the most expensive. We have found an approximate estimate for inspection and installation. And with the help of Pelton’s Home Healthcare, we have safely and legally installed our stairway lift system.

Walker:

We have found and purchased a fully functional reverse breaking, “squeeze to go” walker at $50. When the modifications are made to make them adjustable, and to decrease the height of the walker, the insert piece originally quoted at $20 was obtained at our machine shop for free. This insert will allow for stability to be maintained in the walker even after the cutting and welding of a thin walled metal tubing.

8 Team Member Contributions

With the three projects we have been specified for this semester, we have split them into parts, and given the responsibilities of each project to each of our three team members. Samir has been
fully in charge of the design and modification of the hearing test application that does not apply to this report.

Nihit and Joe have been in charge of the these two projects, the walker and the stairway lift systems. Nihit being the director and manager of the walker and Joe being in charge of the stairway lift system. After designing a final solidworks project for the stairway lift our group ended up finding and purchasing a fully functional used stairway lift. With a full understanding of the solidworks program we have now switched our project over to the commercial design. Nihit has also encountered this with a full design established for the walker squeeze to go system, He has found a completely functional design to modify for our patient. Making our projects in solidworks obsolete.

Using these used devices, we have come to understandings about business and strategies in using previously designed equipment to create fully functional designs capable of sustaining the needs of a company, or a senior design project.

9 Conclusion

With the fortunate events that have occurred, we have discovered that modification of previously designed products is the most beneficial for our project at hand. After coming to a full understanding of the design process, and the alternative design opportunities, we have discovered that businesses can profit from using previously designed projects and modifying them for the needs of the specified user.

A fully functional and slightly modified stairway lift and squeeze to go walker have been designed for the Almeida family, and with a strong concern with safety and cost, a highly beneficial design has been achieved for the needs of the client.
With the split level stairway lift system, Thalia can now move up and down the split level home with safety and ease. With fully functional controls at the top and the bottom of the staircase, Thalia and her family can control the movement of the stairway lift whether they are sitting in it or controlling it from afar. Moving up and down the stairs with the control of her upper body strength, with an easily accessible pivoting chair to assist in transfer from lift to lift, Thalia can easily move from the basement to the second floor of her home.

With the Squeeze to go walker system, Thalia will be able to use a similar motion used in her previous favorite device for mobility around the house. However, it has been specially designed to allow for a greater range of motion. With 360 degree motion in the front wheels of this design, Thalia is able to maintain balance with her upper body, and can move with much more ease and functionality than her previous device. Moving from carpet to tile, the wheel system will be an easier transition than the friction based system currently in use.

With the walker system being adjustable, Thalia can grow with this system, learning how to use this device to her best abilities and adjust to this new product as she grows older.

With the two different systems Thalia will be given more independence to move around the house independently. And as she grows older, independence is a valuable characteristic in a child’s life. By keeping safety as an ultimate concern, Thalia will be able to be independent as well as safe moving around her house.
References:


