BME 4900 Final Report

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Lawn Mower for Shane and Projects for Sean

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Abstract

The design team is constructing two separate projects for two individuals who have Cerebral Palsy (CP), which is a nervous disorder which impairs motor conditions responsible for bodily movement. The first focus is to design and construct a modified lawn mower for Shane Davis, who is looking for this project to help with the ease of operation of a ride on lawn mower. In order to accomplish this task, the team will be modifying the steering mechanism, throttle movement, seat setup, and functions in order to make the mower joystick operated and easy to use. Shane hopes that by gaining the ability to mow his lawn, he can become a greater asset to his family, and gain more independence.

The other focus of the design team is dedicated to 13 year old Sean Stengelein, who is also an active young man with CP. Sean needs two past senior design projects to be repaired in order to restore them to proper function. These past projects are an Assistive Jumping Device (AJD), and the S-90 Go Kart. Another project the team has is to construct a bed safety rail called the Bed Railing Device (BRD) which is motorized to raise and lower itself using a button actuated switch. The device will be able to be plugged into a wall power socket to receive its power, and it also will be covered in a protective foam, wrapped in vinyl, for safety and comfort. The bed railing will serve as a protective boundary for Sean while he sleeps, and the actuated motion will provide a stress free mechanism to deploy and retract the railing as needed at given times of the day.

1. Introduction

1.1 Background

1.1.1 Lawn mower for Shane Davis

Shane Davis is a 20 year old male from Columbia, Connecticut, with CP and spastic quadriplegia. CP is a condition that damages the motor control centers of the brain, and is typically developed during pregnancy, childbirth, or the first few year of life. Effects of CP include limited development of movement, learning, and hearing. These medical conditions have left Shane with only limited control and movement of his extremities. Shane has tried a ride-on lawn mower with no modifications in the past, but experienced limited success. His condition limits how efficiently he is able to operate the mower, and also creates a great discomfort when he is driving unmodified lawn mowers. Ultimately, Shane would like to be able to comfortably and efficiently operate a ride-on lawn mower, with as much independence as possible. This project will incorporate several modifications to a ride-on lawn mower including a seat adjustment, a joystick-steering system integration, and automated mower controls, so that Shane will be able to mow his lawn with ease and comfort.

In this design the team will work to create a lawn mower that Shane can operate easily, comfortably and with little, to no, assistance from others. Shane has expressed that unmodified mowers have caused him a great deal of pain and discomfort when operating. Fatigue, while operating the various controls of the mower, is another factor that deters Shane from mowing his lawn. The lawn mower will have to consist of a joystick that will enable Shane to safely steer the lawn mower. The mower will also need additional security measures such as structural supports
to ensure Shane’s safety when he is operating the mower. He experiences limited strength and motion of his hands and arms, which will require modifications to the lawn mower’s blade, transmission control, and power switch to bring these controls into a reachable distance.

1.1.2 BRD and Other Projects for Sean Stenglein

Sean Stenglein is a 13 year old boy from Ashford, Connecticut, who was born with athetoid cerebral palsy. Athetoid cerebral palsy differs from cerebral palsy in that it encompasses involuntary movements usually of the face, extremities and abdominal region. Due to this, Sean faces challenges with everyday tasks and strives to overcome them. All four of Sean’s limbs are affected by this disorder and as a result he has a lack of balance and coordination. Despite the challenges Sean faces, he is at grade level and engages in physical activity on a daily basis. Sean’s family is a driving force in his development, and they are constantly pushing him to become stronger and healthier through regular exercise.

One goal of the Stenglein family is for Sean to establish a higher degree of independence as he gets older. Sean sleeps at night with a ten year old collapsible bed railing, which has become difficult to operate. The family’s bed railing is a hassle and inefficient to operate each morning and night. Getting Sean in and out of bed is a tiring ordeal for Sean and his assistant, so the Stenglein’s desire an easier, more comfortable way to help Sean in completing this task. The team will work to create a new railing device, which overall will help strengthen Sean’s muscles and motor control; by allowing him and his assistant more rest, enabling him to start his day off with more intensive exercises and activities that build independence. The new railing device will most importantly keep Sean safe and secure in his bed when he sleeps and while he is transferring in and out of his bed. The team will also be fixing Sean’s S-90 Go Kart and AJD to restore their original function.

1.2 Purpose of the Project

1.2.1 Lawn mower for Shane Davis

People who have cerebral palsy and other neurological disabilities often encounter difficulties when looking for jobs, due to their physical limitations. This creates a vast demand for adaptive machines as well as techniques that enable people with disabilities to perform tasks similarly to people who do not have disabilities. Developing a ride-on lawn mower, for Shane, will enable him to help his family mow their two acre plot, and could perhaps lead to employment by mowing other lawns in his local neighborhood. This will provide him with a potentially lucrative business, as well as helping him become a greater asset for his family and community. The modified ride-on lawn mower will above all else grant Shane a safe and effective means of maintaining his lawn.

1.2.2 Projects for Sean Stenglein

The main purpose of this project is to build a Bed Railing Device (BRD), which will assist Sean in transferring in and out of bed, as well as maintain a safe sleeping environment. Sean currently has a ten year old folding railing system that his assistant must awkwardly struggle with to get him in and out of bed.
Figure 1: Secure Comfort single bed rail

Sean’s current rail looks very similar to the one pictured above as Figure 1. [1] It consists of a clamp on either end of the rail, which locks and holds the rail in the closed position. Over time, the clamps on Sean’s railing have become worn, and now they mechanically fail to retract in a fluid motion. A railing device that could be motorized and electronically deployed, by the flip of a switch, would be a far better design than the Stenglein’s current bed railing. Sean’s current railing is unsafe, and could potentially cause injury as it lacks adequate padding if he were to hit it in his sleep. As Sean ages and grows, his current rail will also fail in providing adequate support to keep him confined to his bed.

Another problem with Sean’s current setup is that it lacks any safe permanent stair system to assist him in stepping in and out of bed. Sean currently uses a wooden block that is subject to instability when he steps on it. Also the wooden box is covered with a protective lacquer, which creates a slick surface created from the interaction of Sean’s socks and the lacquer. The stair device would be designed to fit underneath the deployed BRD. The stairs have a height adjustment to allow the stairs to be altered, because as Sean gets taller, the reach from his bed to the floor will become smaller; hence the need for shorter steps. The BRD will be designed with all safety and operational concerns in mind, and will be an asset in helping both the Stengleins, and Sean getting in and out of bed.

The second project for the Stenglein family is to troubleshoot the S-90 go kart that the family received from a previous design team.[2] The go-kart currently is inoperable because it cannot shift out of first gear or run for more than a few minutes at a time. The go-kart will have to be analyzed and repaired to ensure that Sean can use the go kart with its original function. The final project for the Stenglein family is to fix the Assistive Jumping Device (AJD) that was also produced by a past design team. [3] The AJD allows Sean to safely jump up and down on a trampoline, which gives him a fun way to stay physically active. A stopper that is located on the bottom of the vertical rail, which the AJD’s seat moves along, needs to be added. This addition will prevent the AJD’s seat from sliding off the main vertical rail while Sean is using the device. With the replacement of the stopper, the AJD will be returned to full working order, and Sean will be able to safely enjoy his trampoline by early spring.
1.3 Previous Work Done by Others

1.3.1 Products

1.3.1.1 Lawn mower for Shane Davis

Since 1988 the National Science Foundation has funded Engineering Design Projects to Aid Persons with Disabilities for engineering students at universities across the United States. The funded designs are posted yearly on the NSF website (http://nsf-pad.bme.uconn.edu/) and can be viewed through the system’s database. Many of the projects on the website are very similar to Sean and Shane’s projects.[4]

One project that was similar to Shane’s lawn mower is the clutch lever arm assembly, which can be seen below as Figure 2. It was designed in 1998 by Kevin Groff, Nick Homan, Ahmad Mamat, Shinta Maxfari, and Rudy Santoso at the University of Toledo. [5] The device is designed so a paraplegic operator can press the clutch foot pedal, with a lever, instead of with their feet. The lever has a spring loaded locking system so the operator can easily disengage the drive system with the lever and then shift gears. The push pull rod, seen below as Figure 3, serves as the base for the lever arm; transmitting motion from the lever arm to the clutch pedal. Students designed the lever so it could be easily disassembled and stored, which allowed other family members to use the lawn mower.

![Figure 2. Lever arm assembly](image)

Another similar project is the Mower Deck attachment for a Golf Cart. The device was created by Charles Banas, Russel Bieler, Donald Home and Jack Sullivan at SUNY Buffalo in
1995. [6] Their client was paralyzed, resulting in limited use of his legs. Instead of a typical lawn mower the team modified his personal golf cart with a mower deck attachment. Two stainless steel struts connect the golf cart to ball joint mounts on the deck of the mower attachment; thus allowing for free movement. A four stroke Briggs & Stratton engine is directly mounted to the deck, and deck consists of four rubber swivel wheels for movement. This particular deck design allows for the cart to move in any direction while conforming to changes in terrain. Struts were detachable by quick release pins which allow the client to store the mower attachment once the lawn had been mowed.

Lawn mower adaptations for people with disabilities are not only reserved for university students. A company called Life Essentials, based in Brookston, Indiana, specializes in customized hand controls for a variety of motor vehicles.[7] For lawn mowers, the company has products that can be personally modified for the clients disability and can be added to almost any control on the lawn mower. Controls for the clutch, brake and throttle can be integrated into the lawn mowers control panel for easy interface, and can be seen below as Figure 4.

![Figure 4. Life Essentials hand controlled adaptation products](image)

1.3.1.2 Projects for Sean Stenglein

As for Sean’s bed railing project, there are some similar projects that have been done in the past. One of these projects was the bed rail assist designed by Chris Jantzen, Steve Corletta, Vitaly Shusterov and Jeremy Rosen at SUNY-Binghamton in 1998. The device was a simple rail device that could be placed next to a persons bed and allow the user to transfer themselves in and out of bed.[8] A PVC pipe is mounted to a circular plywood base to form the central part of the rail device. One PVC panel is attached to the main PVC pipe and can slide underneath the bed mattress to ensure a sturdy rail device. The panel can be adjusted vertically to match the height
of the bed frame. The rail handle on the top of the device can be lowered or raised to adjust to the customers needs and can be rotationally adjusted to be used from any direction.

Another similar device that was found was bed rails for children with cerebral palsy created by Technical Aid to the Disabled (TAD), based in New South Wales, Australia. TAD is a charity organization that raises money to provide assistive devices for people with disabilities. Three rails were added to the previously purchased bed frame with the fourth side of the bed against a wall. The railings at the head and foot of the bed were raised to the same height and the rail on the third side was divided into three sections. Two of these sections went towards the foot board end of the bed and are hinged to form a gate. The locking mechanism of the rail is placed on the lower frame of the bed; putting the locking mechanism out of reach and preventing any potential harm that may be caused.[9]

TAD also created bed access stairs that allows people with cerebral palsy to get in and out of bed with ease. The designed stairs have three steps that led up to a platform that allows the child to get into bed. Stair support rails are accessible on both sides of the stairs and have a bar to prevent the child from falling laterally underneath the rails. The stairs are modified with a non-slip surface and its edges have black strips so the child can easily see the edge of the step. One flaw in the design is that the stairs are custom built for a child’s body of approximately twelve years of age so the stairs cannot change as the child ages.

1.3.2 Patent Search Results

1.3.2.1 Lawn mower for Shane Davis

An internet search revealed that currently there are no patents for a lawn mower specifically for a person with disabilities. There were many patents for other similar lawn mowers and lawn mower products. One example is a patent for a drive wheel steering system for a lawn mower. It was patented by Harlan Bartel from Newton, Kansas on June 22nd, 2010. The device has a handle bar that pivots vertically to control the motion of the lawn mower and rotates horizontally to control the speed of the lawn mower.[10]

1.3.2.2 Projects for Sean Stenglein

Another internet search showed that there is an almost identical patent for a bed railing for a person with a disability. The portable bed railing was patented by Amy C. Baker on June 27th, 2002. This bed railing is different than standard bed rails in that it is portable and can be retrofitted to existing bed frames. The United States Patent number is 6,401,280.[11]

1.4 Map for the rest of the report

The remainder of this report will be focused on an in depth description of both the lawn mower modifications and projects for Sean. These descriptions will be broken down into several sections outlining the design process and the optimal design and its respective components. After the design is discussed, other topics which were considered such as constraints and safety issues, ethics, and the life-long impact of each project. Then a section describing individual contributions to the process will be covered, describing each team member’s progress and future work to be done. Next a timeline of the project, and budget will be covered. Finally the report
will show the progress made on the projects in total from the semester, and any other additional information and acknowledgements.

2 Project Design

2.1 Introduction

2.1.1 Lawn mower for Shane Davis

In order to plan for this project, three alternative designs were created, and then an optimal design was settled on. The three alternative designs will be overviewed and then the optimal design will be discussed. Each subunit, of the optimal design, will be analyzed and discussed extensively to prove its validity in the design plan. Figures and Solidwork diagrams will be used to illustrate and help explain particular aspects of the optimal design.

The first alternative design for the lawn mower consists of a modifying the existing seat and adding armrest. The armrests can retract into an up position allowing for Shane to transfer from his wheelchair to the mower without the armrests being in the way. The first design also incorporated a system of linear actuators that motorized the mower’s gas, brake, and PTO lever. The method of controlling the steering system of the mower will be a joystick, which will be able to control a rack and pinion actuator; thus steering the lawn mower.

The second alternative design for the mower also incorporates a modified seat with armrest and a rack and pinion actuator to control the steering. The second design involves extending the back of the seat in order to provide Shane with more abdominal support. A seatbelt is also incorporated into the modified seat of this design. A manual lever-pulley system is used to control the lawn mowers gas, brake and PTO lever.

The third and final alternative design for the mower involved an extended seat and seatbelt, similar to alternative design two. The third alternative design’s steering system is controlled without the use of an actuator. A knob will be placed on the steering wheel. This knob will be located at ten o’clock on the steering wheel, relative to driver. This is done because Shane is stronger with his left hand, and a knob closer to his left side will enable him to maneuver and control the lawn mower more efficiently. The lawn mower’s gas, brake, and PTO lever will be controlled by a lever system that will enable Shane to mechanically apply the force needed to operate each control.

The optimal design included elements from each of the alternative designs because each alternative design proved to have valuable components, which would be incorporated into the final design. The extended seat, the joystick-rack and pinion actuator steering system, and the motorized mower controls, the gas, the brake, and the PTO lever.
2.1.2 Projects for Sean Stenglein

Sean’s BRD project was designed in the same manner, with three alternative designs and an optimal design being created. The three alternative designs will be discussed in the following sections. Aspects of the alternative designs that affected the final plans of the optimal design will also be discussed. Next each subunit of the optimal design will be evaluated. Finally each subunit of the optimal design will be justified for its use in the design.

The first alternative design for the BRD involved a deployable vertically telescoping stair system composed of aluminum. The frame would be deployed in an side to side motion; meaning that it will slide outward from a central point. The frame will be connected to a slotted lower support piece, which will allow for the frame to be slid open along the lower support piece. The BRD will be manually operated by Sean’s assistant. The frame will be covered by a protective foam and then wrapped with a medical grade vinyl for aesthetic pleasure.

The second alternative design for the BRD also had a manually deployable telescoping stair system. This design used a non-slick surface as a coating on the stair system to prevent Sean from accidently slipping on the aluminium. This design also incorporated protective foam and vinyl as did the first alternative design. The BRD’s method of deployment in this design is the use of a stepper motor, which will enable small changes in angular rotation; while still maintaining enough power to move the BRD. The method of attachment of the stepper motor to the BRD will consist of a cylindrical rod that extends through the lower support piece of the frame. This rod will be interlocked with the upper frame, which is connected to the lower support piece. When the motor is activated the locked cylinder will spin causing an upper frame to swing outwards; pivoting on three hinges.

The third alternative design for the BRD also incorporated protective foam, vinyl, and a telescopic stair system. The BRD’s method of deployment is controlled in this alternative design by a stepper motor. The stepper motor will be integrated with the frame through a U-shaped joint. In this joint the motor head will be mounted in between the opening. Two metal pieces will interlock the motor head into the opening of the joint. When the motor is activated by the operator the interlocked motor head will move about the U-joint, rotating 180 degrees. As a result the BRD will swing towards the operator and still leaving room to pull out the stair system underneath the bed.

Several aspects of the alternative designs for the BRD were incorporated into the final design. The protective foam and vinyl and the stair system were design requirements made by the Stenglein’s. The stepper motor and a U-shaped was chosen as the best means of deploying the BRD.

2.2 Optimal Design

2.2.1 Objective

2.2.1.1 Lawn mower for Shane
The goal of the project for Shane is to modify an existing lawn mower in order for him to operate it safely. Ellington Agway Power Equipment donated a 17 horsepower, 42 inch mowing deck Troy-Bilt lawn mower. Modifications to the lawn mower will take Shane’s capabilities into consideration in order to ensure safe operation. CP causes Shane to have a loss of motor control resulting in a lack of stability in his abdominal region. During extensive use of the lawn mower Shane will need additional support, which will help prevent fatigue. The driver’s seat will be structurally altered giving it an extended back; giving Shane abdominal and lower back support. The seat will also have padded arm rests that will give support to his upper body while using the mower. The lawn mower will have additional structural features such as a step and handle bar to assist Shane in transferring from his wheelchair to the mower.

On the mower there are some general parts that need to be fixed, which will ensure a smooth operation by our client and leave the lawn mower looking professional. The carburetor needs to be replaced because it currently sends too much air and gasoline to the engine while it is running. This causes the lawn mower to leak gasoline and over time it would lead to damage and inefficiency in the engine. The lawn mower currently does not have the plastic lens that covers the head lights. A new lens will give the lawn mower a professional look and also ensure that the electrical wires for the headlights are not exposed to weather conditions.

Shane will need the mower’s controls to be within reaching distance to the mower’s seat. The team will modify the lawn mower’s steering control, the power take off lever (PTO), manual steering, the seat, the brake and the accelerator. Shane will mainly operate the mower with a joystick that will be mounted to the left armrest of his seat. The back of the seat will be raised to give Shane more support and it will also have arm rests to keep Shane secure in his seat.
power take off lever (PTO) allows the mower to engage the cutting deck and will need to be modified to allow Shane to easily switch between modes of operation. Another feature that needs to be altered is the accelerator and brake pedals. The accelerator and the brake will be modified with linear actuators that are connected to the cables underneath the footboard of the lawn mower. An emergency shutoff switch (kill switch) for the mower must be incorporated with the mower design to ensure client safety.

2.2.1.2 Projects for Sean

Sean’s project objective is to create a bed railing device (BRD) that will maintain a safe sleeping environment and providing adequate assistance for his mother or living aid when getting him in and out of bed. The BRD will need to be padded in order to prevent the hard aluminum frame from harming Sean if he hits it at any point. Sean’s assistant will use a switch to activate the motorized deployment of the frame. The railing system will also come with a step to give Sean the needed height to step in and out of bed. The stairs will have an adjustable height so they remain functional as Sean ages. The stairs will consist of one step and a platform. The top part of the step and the platform will have a non-slip surface to ensure that Sean can safely get in and out of bed.

A stepper motor will be used to move the BRD its full 180 degree motion and hold the frame once it has reached its desired position. The team will use a transformer to convert the AC current from the outlet to required DC voltage for the motor. With the proper current the motor will then turn until the desired position is reached. A rod will run the inside length of the frames 80/20 aluminum base and will have a bearing on the end to allow the frame to have a full range of motion. The motor will be housed in a plastic encasement to avoid objects getting snagged in the BRD’s mechanical system. This will ensure proper operation of the BRD and that it can be safely used by the Stenglein family. As for Sean’s other projects, the team will fix the go-kart so
it can drive in forward gear and that it is safe to operate. The Assistive Jumping device will be fixed to ensure proper operation and to allow Sean to enjoy his trampoline.

2.2.2 Subunits

2.2.2.1 Lawn mower for Shane

In order to make the functions of Shane’s lawn mower work, there are several mechanical components which must be designed and integrated together to work as a fluid machine. These components are a joystick, two linear actuators to control the throttle and brake, a stepper motor for precise control over the steering of the system. The mechanical components will be powered by the lawn mower’s battery, and will be operable when the mower’s engine is on. In addition to these mechanical parts, there will also be modifications made to the seat for safety and stability. Shane will also benefit from a modified mounting and dismounting system, including a handle to grab onto, and retractable armrests for ease and comfort.

2.2.2.1.1 Circuitry

In order for this project to run smoothly, a central circuit will be used to interpret all the signals the operator commands, and it will be respond with the correct action according to the signal. This circuit will incorporate a microcontroller, and speed controller, which will be programmed in order to achieve this task, and provide the needed power to the components. In addition to the major motor functions of the mower, the circuitboard will also include a safety override switch connected to a large button located near the operator’s reach. This override switch will act similar to the seat cutoff switch, and in case of a component failure, for instance if an actuator loses power while stuck accelerating, Shane will be able to easily disable the mower and prevent the device from going out of control.

2.2.2.1.2 Microcontroller

When Shane is operating the lawn mower a microcontroller will be responsible for interpreting Shane’s desired direction through the joystick. The microcontroller selected for this design is a 16-byte PIC microcontroller, from Microchip, seen below as Figure 7. [12] Programming of the microcontroller with be done in C. The microcontroller will interpret the specific direction and to what degree Shane has engaged the joystick. Once Shane has engaged his intended direction on the joystick the microcontroller will send the interpreted signal to a speed controller. The processed direction and how intensely Shane has engaged in that direction will be fed to the speed controller, by the microcontroller, and then the stepper motor and or actuator will rotate in the intended direction. The interpreted signal will remain constant for the duration that the direction of the joystick is held. The signal will cease when the joystick’s direction is released, and returned to its neutral position.
2.2.2.1.3 Speed Controller

The speed controller will reduce the amount of voltage applied to the stepper motor and actuator resulting in the correct desired speed. The speed controller used for the control of the steering actuator will be the 12V IFI Victor 884 see below as Figure 8. [13] The reason for choosing this particular speed controller is that it has been designed to be used in various robotic steering systems. Advantages to choosing this speed controller are that it can operate at high levels of current, and also having low voltage drop with high switching speed rates. The steering system of the lawn mower will experience fast changes in direction, as Shane changes directions, and as a result the fast switching speed capability of the speed controller will aid the motor in maintaining constant rotational direction as it changes from forward to reverse. Maintaining a constant rotational direction, and there not being a full rotational stop of the motor, is important in order to develop a smooth and responsive steering system. A similar speed controller will be used on the actuators that control the gas and braking of the lawn mower.
2.2.2.1.4 Joystick

In this project, the joystick is the key to controlling the operations of the mower’s functions. This joystick will be able to control the turning of the mower, as well as the braking and speed of the mower. Ideally the joystick we will use will be as close in design to what Shane already uses for his current power chair as possible, so that control will feel similar to what he already knows how to use. The joystick will be precisely calibrated to allow for accurate turns, and smooth speed adjustments. The team was donated a joystick from one of Shane’s old power chair to aid in the design.

2.2.2.1.5 Actuators

In order to control the mower’s speed and braking, a system of two linear actuators will be incorporated into the mower design. The actuators chosen will be from a variety of companies, including the Motion Systems Corp. 9234C120-R10 linear actuator, seen below as Figure 9. [14]

![Image](image)

Figure 9. Motion Systems Corp. actuator

These actuators will work in tandem according to the signal sent from the joystick. When the joystick is at a neutral position, both actuators will be in neutral as well. If the joystick is moved backwards, the brake actuator will deploy, and the mower will slow down. If the joystick is moved forwards, the actuator controlling the accelerator will be deployed. When the joystick is returned to neutral after a deployment is made (either to the acceleration or brake), the actuators will reset to their neutral positions automatically. Also, safety mechanisms will be incorporated so that both actuators will never be deployed at the same time. This will prevent wear on the mower’s engine, and the actuators.
2.2.2.1.6 Steering - Stepper Motor

In order to control the lawn mower’s steering, a stepper motor will be integrated into the original steering mechanism, providing the same steering as it would be normally, except motor actuated. The benefit of a stepper motor is that it can produce precise rotational control at the desired speed. This will be important in producing a sufficient amount of torque and small angular velocities, which will occur frequently when Shane makes minor steering corrections. The stepper motor gear can be seen in the diagram below, colored red for ease of comprehension:

Figure 10. Mower steering with stepper motor

Another benefit of using a stepper motor to control the steering is that the original steering mechanism can still be used, and this will make the action, which is much easier to motorize. The stepper motor will be mounted in a fashion that the gears can be easily mechanically pulled apart for manual steering, or kept together for motorized steering. The stepper motor will be mounted underneath the engine compartment where the steering gear is, and this will also prevent foreign objects from becoming lodged in the gears for added safety.

2.2.2.1.7 Seat

The modifications to the seat for the lawn mower will be relatively simplistic. The group will be purchasing a new seat with a high back, most likely from the NEAT marketplace. This seat will also have holes drilled into the back of it for us to mount our armrests to. The joystick will also be attached to the seat through the armrests, and will be mounted on the left side, by Shane’s request. The seat will be sturdy and safe, and the armrests will provide Shane with a place to support himself while he operates the mower; as maintaining good posture can be challenging if the seat does not have adequate support. The seat will also be designed such that the existing safety cutoff switch will be utilized, and if Shane becomes dismounted, the mower will shut off.
2.2.2.1.8 Mounting and Dismounting

Shane’s power chair is much lower than the lawn mower’s seat height. This means that in order for Shane to mount and dismount the machine, he needs to traverse a rather large gap between the two devices, as well as a vertical component must be overcome. In order to help Shane with this problem, we will be including a handle mounted to the mower’s side, and a progression step located halfway between his power chair height and the mower’s seat height. This will allow Shane to transfer in a more gradual fashion and the handle will provide him with support when mounting and dismounting the mower.

2.2.2.2 Projects for Sean- BRD

The team intends to build Sean an inexpensive bed rail device out 6105-T5 Aluminum from the erector set company 80/20 Inc. [15] This inexpensive design would allow the team to use the majority of the budget on ways to ensure Sean’s safety and proper motion of the BRD frame.

2.2.2.2.1 Projects for Sean- BRD Bed

The bed that the BRD will be used on is a full size bed and is Sean’s own bed from his house. Since Sean will have the same bed for the foreseeable future, the BRD can be designed to the bed’s dimension to ensure a safe and sturdy structure. Both the headboard and the footboard have a one and five-eighths of an inch width on both of the end posts to allow for the motor to be mounted to the bed. A motor will be mounted on the footboard and will be encased in a plastic compartment to ensure that nothing can be ensnared in the mechanical system. The motor will be placed on the footboard so that it is away from the entrance of Sean’s room and it is not a safety hazard to those who enter the room. There will be 3 inches between the post and the BRD frame to ensure that gears and other mechanical components do not become a safety hazard for Sean.
2.2.2.2.2 Projects for Sean- BRD Railing

The horizontal and vertical supports of the railing frame skeleton will be made from part number 1020 from the erector set company 80/20 Inc. Part number 1020 is a one inch by two inch T-slotted profile made out of clear anodized 6105-T5 Aluminum. This allows for easy assembly and ensures a sturdy rail design for Sean’s BRD. Also the T slotted profile increases its vibration dampening ability so when it is constructed as the frame it will not vibrate while being raised or lowered.

Figure 12. The clear anodized 6105-T5 Aluminum erector set that is used for the railing frame.

The railing consists of six structural components: two horizontal supports that run the length of the frame, and four vertical supports that will support the frame and give it its structure. Horizontal supports will be 70 inches in length and be made out of 1020 aluminum. Hinges will be attached to the bottom horizontal railing support and connected to the rail support system to ensure 180 degree folding when the frame is raised and lowered. Hinges will also be purchased from 80/20 Inc. as part 2086 to ensure proper compatibility with the 1020 horizontal supports and T-slotted extrusions. The hinges are made out of 6105-T5 clear anodized aluminum so they have excellent corrosion resistance which will allow for the BRD frame to maintain its functionality as it ages with Sean. Weight capacity for the hinge is 40 pounds so three hinges will be able to support the BRD frame for its lifetime of use.

A bolt kit is needed for every hinge, and each kit consists of 4 assemblies of 80/20 part number 3386. The assemblies consist of a Flanged Button Head Socket Cap Screw (FBHSCS) and a slide-in economy T nut. The FBHSCS has a black zinc finish, is three eights of an inch in length and has a thread count of ¼-20 (one quarter inch in length with 20 threads). The slide-in economy T nut is part number 3785 in the 80/20 catalog and was used in the bolt assemblies for the inside corner bracket and the five hole joining plate.
Figure 13. The slide-in economy T nut and the FBHSCS used for the bolt assemblies.

Figure 14. Technical drawing of the 2086 hinge.

Figure 15. Technical drawing of 1020 pieces joined by the aluminum hinge.

Table 1. Corresponding measurements in inches for A through K in figures.
Four vertical supports will be placed in between the two horizontal rails to properly support the frame. Two supports will be on the end of the horizontal pieces and two will be evenly spaced out within the frame. All supports will be 15 inches long and have the profile of the 1020 aluminum. In order to connect the two end vertical supports with the horizontal supports the team will use part 4114 from 80/20 to ensure that the frame does not experience torsion and is structurally sound. Part number is 4114 is a eight hole corner inside corner bracket that allows bolt kits to firmly place the bracket in the T-slots of the 1020 profiled supports. Approximately four inside corner brackets will be used to support the BRD.

Figure 16. 8 hole inside corner bracket used to connect vertical rails to the horizontal rails.

In order to mount the inside corners to the frame the team will use 32 bolt assemblies, with eight assemblies for each frame. The bolt assemblies from 80/20 Inc. are denoted by part number 3393 and consist of a Button Head Socket Cap Screw (BHSCS) and a slide-in economy T nut. The BHSCS has a black zinc finish, is one half inch in length and has a thread count of ¼-20 (one quarter inch in length with 20 threads). The slide-in economy T nut is part number 3785 in the 80/20 catalog, has a centered ¼-20 thread count and also has a black zinc finish. The synchronized thread count ensures that the bolt assemblies will work and be successful in mounting the inside corner brackets to the frame.

The two inside vertical supports will be connected to the horizontal supports by a 5 hole tee joining plate on both sides of the horizontal rail. The part number for the 5 hole tee joining plate is 4140 in the 80/20 catalog. Joining plates width and height are three inches (denoted by A in the drawing) and the ends that go over the one inch horizontal profile view of the 1020 supports are one inch in width (denoted by B in the drawing). Eight joining plates will be used in the assembly of the BRD.
In order to mount the joining plates to connect the supports the team will use 40 bolt assemblies, with five assemblies for each plate and eight plates on the frame. The bolt assemblies from 80/20 Inc are denoted by part number 3321 and consists of a Flanged Button Head Socket Cap Screw (FBHSCS) and a slide-in economy T nut. The FBHSCS has a black zinc finish, is one half inch in length and has a thread count of ¼-20 (one quarter inch in length with 20 threads). The slide-in economy T nut is part number 3785 in the 80/20 catalog and was used in the bolt assemblies for the inside corner bracket.

![Flanged Button Head Socket Cap Screw (FBHSCS)](image)

In order to protect the ends of the BRD frame the team will use part number 2025 from 80/20 Inc. Part number 2025 is a one inch by two inch end cap that is one-eighth of an inch thick.
and can fit the extruded profile of the 1020 frame. The team will order six of these end caps to ensure that the frame’s rough edges are not exposed, thus preventing Sean from any potential harm. All end caps come with the necessary fasteners to ensure a clean fit with the 1020 profile.

![Figure 20. End cap for the 1020 end caps and their respective fasteners.](image)

Another key component for the BRD railing is foam padding. Foam padding will be used as a safety measure to ensure that if Sean rolls into the frame when he is sleeping or bumps into while transferring from the bed that he will not be hurt by the frame. The team will purchase soft closed cell tubular foam from McMaster-Carr to cover the BRD’s aluminum frame. All foam padding will be cylindrical with a two and one-eighth inch inside diameter, a half-inch wall thickness and a three and one-inch outside diameter. The foam tube has an adhesive slit that will allow for the foam to be spread apart, placed over the horizontal and vertical supports, and then secured by the adhesive foam to ensure a tight fit on the frame. Since the foam comes in six foot tubular lengths, two tubes would be used for the horizontal rails and one tube would be used for the four 15 inch vertical supports. All tubes will be cut to their specified length for the support that they will be covering.

![Figure 21. Cylindrical foam for BRD railing frame.](image)

Once the rail frame has been covered in foam a vinyl coating will be applied to the BRD frame. A roll of vinyl will be purchased from US Cutter and will be used to cover the BRD frame. The team is going to use a 15 inch by 10 yard roll of ORACAL 751 High Performance Cast Vinyl will be used as a safety measure to ensure that if Sean rolls into the frame when he is sleeping or bumps into will transferring from bed that he will not be hurt by the frame. Sean will be able to pick out the color the vinyl so he can choose whatever color he desires. All vinyl coverings will be cut to their specified length for the support that they will be covering. In between the vertical frames will be a soft fabric mesh. The mesh will serve as a protective barrier and will also prevent Sean from injuring himself if he hits the BRD.
2.2.2.2.3 Projects for Sean- BRD Railing support system

The railing support system will also be made of clear anodized 6105-T5 Aluminum and the upper support uses the same 1020 extruded profile as the BRD frame. The horizontal support piece will be the same length as the BRD frame (70 inches) and will have the same 2025 end caps. Hinges will also be mounted to the horizontal support piece and allow for 180 degrees of folding motion. All hinge bolt assemblies that were used in the frame is used in the BRD railing support system.

![Image 22. Total assembly of the BRD support system.](image)

The three vertical supports have the dimensions of the 1020 extruded aluminum and all are approximately eight and one quarter inches tall. All vertical supports are connected to the horizontal support by a 6 Hole Inside Corner Bracket, 80/20 part number 4175. Bolt assembly part number 3393 will be used as the plate fastener and 6 bolt assemblies are used for every plate. The design of the BRD support system will use 6 Inside Corner Brackets to keep the pieces together.

![Image 23. Drawing of the 6 Hole Inside Corner Bracket.](image)

The lower portion of the vertical support will be fit against the bed railing of the bed frame and on top of a piece of plywood that runs across the trusses of Sean’s bed. The vertical support is connected to a 52 inch base mounting piece that is made out of the 1010 extruded profile. The 1010 extruded profile is an one inch by one inch profile that consists of clear anodized 6105-T5 Aluminum. A 3 Hole Inside Corner Bracket, 80/20 part number 4176 is used...
to keep the 3 base mounting pieces firmly secured to the plywood base. A Bolt assembly, Part number 3393 in the 80/20 catalog, is used to secure the brackets for the BRD support system.

![Figure 24. 1010 extruded profile and 1010 technical drawing.](image)

The vertical support is connected to the base mounting piece by a 6 Hole Center Inside Corner Bracket, part number 4111 in the 80/20 catalog. Six bolt assemblies, part number 3393, are used for every mounting corner piece, with three corner pieces needed to connect all the mounting pieces to the vertical rails. The center inside corner bracket ensures that the BRD will have a sturdy base for optimal performance.

![Figure 25. Drawing of the 3 Hole Inside Corner Bracket](image)

![Figure 26. 6 Hole Center Inside Corner Bracket Technical Drawing.](image)
2.2.2.4 Projects for Sean- BRD Stairs

The stairs will be made out of a durable aluminum frame with slotted steps that can adjust as Sean ages. The platform can adjust using the slotted notch feature and so can the step. All pins will have a connector system to ensure that the stairs remained locked in place. Grip tape will be applied to the edges to ensure that Sean has a non-slip surface to transfer to and from bed.

![Stairs Diagram](image)

Figure 27. Stairs that will be used for the BRD.

2.2.2.5 Projects for Sean- BRD Motor/ Electronics

The motor selected for the BRD is the 23Y High Torque Stepper Motor from Anaheim Automation. [16] This motor can be seen below in Figure 28. This motor was selected because it has eight leads enabling for various configurations: series, unipolar, and parallel. A stepper motor was selected because it can produce large amounts of torque with small changes in angular movement, which will be needed to smoothly operate the BRD. This motor will adequately produce the needed holding torque of 160 oz-in and will be capable of deploying and redeploying the BRD’s 40 lbs total load. [17] Also this motor was selected because it operates with little vibration and noise, which will be important because the BRD will be used at night and the morning and should not disturb other family members.
An AC DC transformer will be used to convert the AC current from the outlet to the DC current used by our stepper motor. The transformer converts the AC current from the outlet to 2.8 Amperes and 2.8 Volts so it compatible to use with the stepper motor. The motor will be housed in a plastic encasement to ensure that nothing gets snagged during motor operation. The plastic encasement is attached to the footboard of Sean’s bed to ensure safety.

The stepper motor that will turn the frame will be aided by a custom machined ring piece. The mechanism allows the shaft of the stepper motor to be hard mounted to a rod on the bottom of the BRD frame. As the stepper motor turns, the frame’s path will be guided by the ringlet piece, completing the downward/upward motion.
Figure 30. Solidworks design of the motor and the frame turning mechanism.

Figure 31. Solidworks design of the guiding ring
2.2.2.2 Projects for Sean- AJD

The design team will be fixing a previous project, the AJD. Currently the AJD is out of working order because of a missing mechanical piece. The design team believes this piece, made of aluminum, was misplaced or accidentally removed by the Stengleins. This missing piece acts as a stopper which prevents the AJD’s seat from sliding off the vertical rail when in use. The integration between the vertical shaft, vertical rail and the seat can be seen below as Figure 33.
The design team believes that the part in question has been misplaced because there is no visible damage to the vertical rail. Deformation of the vertical rail and or damage to the missing piece’s screw insert holes would be expected if the part had been ripped off.
If the AJD’s missing piece was damaged, and not misplaced, there would be an obvious deformation to the vertical shaft or the screw holes, which cannot be seen in the above Figure 34. In order to remove the seat, and adjust the harness, the missing piece would need to be removed from the vertical shaft, and was probably misplaced. The newly constructed piece will fit the dimensions of the old missing piece, and return the AJD to full working condition.

2.2.2.2 Projects for Sean - S-90 Go-Kart

As the Go-Kart stands at this point, the device is not working properly. In order to fix the device, the team is working in conjunction with Sean’s father to diagnose and repair the problems. From this point it seems as though the Go-Kart is suffering from a simple hardware failure somewhere in the system. The battery could be having issues, the electric starter could be malfunctioning, or there could be a disconnect somewhere in the system. The starting issue will be resolved, and then the team will be able to focus on fixing the transmission error. Hopefully the transmission is suffering from a simple mechanical problem, but until the Go-Kart is running again, the diagnosis on the transmission will be unable to proceed.

Figure 35. The S-90 Go-Kart.
3. Realistic Constraints

3.1 Economic Constraints

3.1.1 Lawn mower for Shane

The lawn mower project is by far the more expensive of the two projects we are constructing. The main difficulty has been in acquiring a lawn mower for us to modify. Fortunately, Ellington Agway Power Equipment donated a Troy-Bilt 17 horsepower lawn mower for our senior design project. This was a major help for our project and allowed our team to allocate funds which would have been spent buying the machine, to instead be used for our mower modifications. The lawn mower was serviced and a new carburetor will be purchased to have the lawn mower running properly. A plastic lens headlight will be purchased to house and protect the lawn mower headlights. After these preliminary safety factors have been taken care of, there will still be a lot more money needed to purchase actuators and stepper motors, circuit boards and seat modifications, and many other various components for the lawn mower. It will be very difficult to maintain the balance between cost of the two projects.

3.1.2 Projects for Sean

The BRD project also has economic constraints in that the budget allotted for the railing must be considered with regards to the lawnmower, a much more expensive project. The BRD has several features we plan to install, but some of them might be less necessary than others. In the event of a budget shortage, shortcuts might be needed in the means of padding the device. We have plans to make a railing which is sleek and fun looking, but might be forced to cut corners and stick with a device purely based on utility, not aesthetics.

The economic constraints for the AJD and Go-Kart are also an obstacle for the team. With the lawn mower and the BRD being extremely costly, little budget will be left to pay for repairs to these previous projects. The AJD will require the machining of a small aluminum part which will be very inexpensive, which is beneficial to note. Unfortunately, because the Go-Kart has many unknown problems, it could turn into a very costly endeavor for the design team and possibly the Stengleins. The Go-Kart might require a new transmission, new electric starter, or a new battery, and all of these are very expensive components. Hopefully the Go-Kart will not need these expensive repairs and the problems can be resolved with simple mechanical adjustments.

3.2 Environmental Constraints

3.2.1 Lawn mower for Shane

Several features of the lawn mower modifications will need to be addressed in terms of protection, because it will be operated outdoors. The circuit components of the mower controls will experience varying degrees of climate change. The mower will be in use from the spring until the fall, so it will encounter an approximate temperate range of 40-110 degrees Fahrenheit. The terrain in which the mower is operated on will also be subject to change. Varying degrees of steep terrain will subject the mower’s modifications to displace. Due to rough terrain the linear
actuators, electrical circuits, and protective cases all need to be securely mounted on the mower. The circuits will also experience varying degrees of humidity during spring and summer months. Extra care will be taken to enclose any electrical components in order to prevent them from being exposed to any moisture. A resin will be used to shield and protect each electrical circuit.

3.2.2 Projects for Sean

The BRD is operated in the confines of Sean’s bedroom. Even though the BRD is used indoors certain aspects of the design must be addressed to ensure the BRD will operate successfully. The motor is to be enclosed in a protective case to prevent any bed sheet or piece of Sean’s clothing from being entangled in the motor. Also the gears responsible for moving the frame will need to be housed for the same reason. The circuits are susceptible to damage when exposed to moisture or other small particles. Their protective cases will be sealed with a resin to prevent any moisture or particles from damaging the circuit.

For the AJD designed part, it will need to be weather resistant as the AJD remains outside at all times. The piece cannot be subject to large amounts of oxidation because this may cause weakness of the piece. The part also must be sturdy enough to withstand a potential blunt force from the jumper chair colliding into it; in case of bungee failure.

The Go-Kart is already constructed ruggedly with the weather effects in mind, and the repairs we make to the machine will be minor. Thus the environmental effects should be unaltered as the machine had been made to operate in outdoor conditions. Any changes the design team makes to the electrical components will need to be properly resealed with resin to prevent any water damage. The changes the team makes integrate with the original system as much as possible, and it will operate under the same guidelines as it had been constructed by the previous design team.

3.3. Sustainability

3.3.1 Lawn mower for Shane

The mower modifications are susceptible to deterioration as they are used. Shane inflicts immense amount of derogation on the joystick of his everyday wheelchair. As the mower increases in the number of times it has been used the accuracy of the joystick may degrade. Due to the vast number of electrical components on the lawn mower, there is a great chance of electrical failure. Failure of any electrical component will render the lawn mower inactive; due to the mower controls solely being operated through the electrical circuits. In the event the mower shorts out or becomes inoperable, the lawn mower should still be able to be operated manually, in the case of an emergency. The linear actuators cannot subject the mower control levers to a force that will degrade the levers overtime. A minimal amount of force must be used to ensure that the lever remains intact, yet enough force to ensure proper lever function.
3.3.2 Projects for Sean

The BRD is subject to failure as the length of time of its operation increases. Structurally the BRD will experience forces and strains in nearly all directions; set forth by Sean when he is sleeping, or when dismounting or getting into bed. Random sleeping motions subject the BRD to derogation at welding joints, hinge joints, frame to netting connections, and frame to protective foam connections. Precision in connecting metal to metal and metal to non-metal and quality materials ensures that derogation of these aspects of the BRD happen as slowly as possible. Strains may also be put on the bed frame in which the BRD is attached to. When the BRD is removed from the bed, in order to change the sheets or the mattress, it must happen in such a way where the bed frame is undamaged.

The AJD stopper the team is constructing will be made such that it can be easily stored with the remainder of the components when the jumper is stored between uses. This will help with preventing the part from becoming lost in the future. The part will be ruggedly made, as it must serve as an emergency protection for the chair if the bungee cords fail to keep the seat attached to the crane. This part will need to withstand a great force if failure occurs, as the chair with all of Sean’s weight will be impacting the stopper at a high speed coming down from a jump. These conditions have all come into consideration, and the part will be safe and connected in a way to withstand the great force that could potentially impact it.

For the Go-Kart, the original design was solidly constructed, but the machine has failed to operate for a long period of time. The machine was built in 2009, and failures have occurred over the course of its two year lifetime. This is unacceptable, and after the team fixes the design flaws, the kart will be restored to working order; providing entertainment for Sean for many years to come.

3.4 Health and Safety

3.4.1 Lawn mower for Shane

The lawn mower’s electrical components pose a risk to the operator. There could be an electric shock caused by the circuits, which could result in burns or neurological damage. When operating the lawn mower, Shane will be subjected to forces that could dislodge him from the mower or have the lawn mower tip. Seat modifications will ensure Shane is safely seated in the lawn mower at all times. Actuators will be housed underneath the foot board of the lawn mower to ensure they do not harm our client during their action.

3.4.2 Projects for Sean

Several aspects of the BRD must be addressed before it can be implemented in Sean’s home. The BRD must not cause injury to Sean while he is using the device. The distance between Sean’s mattress and the BRD is minimized, which will prevent Sean from pinching himself against the frame. The foam and protective netting must be made of a material that when tested does not cause irritation to the skin when Sean rubs against it during the night. The hinges of the BRD will be subject to high levels of stress while being operated, and will need to be resistant to degrading from the frame’s load when operated. It will be important to accurately
secure sturdy hinges to the frame; if they are not correctly secured then the frame could collapse onto the bed or onto the floor.

The AJD being a potentially hazardous activity for Sean, its functionality must be very precise. The replaced piece must be have the correct dimensions in order for the piece to remain a safe aspect of the design. Electrical components of the S90 Go-Kart will need to be properly housed away from the user to prevent any unexpected electric shock. Mechanical and electrical failure of the kart, will create an unsafe operating environment for Sean; in that he could lose control over one of the kart’s functions while he is operating it.

4. Safety Issues

4.1 Lawn mower for Shane

In order to design this project to be as safe as possible, we considered many safety factors that the operator may encounter during use. In order to prevent electrical damage, all wiring and circuits will be housed in watertight units, sealed with resin, and tucked away underneath the plating of the mower. The actuators used in controlling the mower’s speed and braking will be concealed underneath the footplates of the mower, so that they are out of the way of the operator, and will not be obstructed during use. The rack and pinion motor for the steering will also be located within the internal engine compartment, to avoid objects getting lodged in the gears. Shane’s condition makes it difficult for him to remain upright at all times, so to help with this the mower’s armrests will keep Shane comfortably and safely confined to his seat. The team also considered Shane’s preferences for control, and is using an old joystick he has used before in order to control the mower’s functions. In addition, a safety emergency off switch will be incorporated into the design, which will provide Shane with a way to shut off the mower and automatically apply the mower’s brakes in case of a part failure or a loss of control.

4.2 Projects for Sean

Safety is a major concern when designing a device that is intended to protect the individual who it is used by. The stability of the stair system must be addressed because they are not supported by or connected to any part of the bed frame or the BRD. The actual steps of the stairs must be able to withstand the derogation facing them after Sean uses the device twice a day for the rest of his life. When Sean puts his weight on each individual step; the adjustable connections controlling the height of the step can not be subject to large wearing. If the connections are worn down the ability for the stairs to adjust is compromised. The non-stick surface of the stairs must be a material that will not damage Sean’s feet but at the same time prevent him from slipping down the stairs. Improper design of the support legs will cause the BRD to fail during operation. The point of connection between the support legs and the mattress is designed to apply enough force normal to the mattress in order to prevent the BRD from moving linearly.

The main safety concern associated with the AJD is the ability of the device to maintain a safe operating environment. The main vertical shaft cannot become altered by the addition of the missing aluminum piece, and the replaced missing piece can not have any effect on any other
component of the design. The attachment point of the missing piece to the vertical shaft must be strong and be able to withstand the jumping force produced by Sean when he is using the AJD.

The repairs made to the S-90 Go-Kart will also need to keep Sean safe while he is using it. The electrical components that will be modified to return the kart to working order will need to remain in an enclosed, waterproof environment to ensure Sean’s safety from electric shock. The kart will also need to run efficiently; not leaking any fluids or dispensing fumes that may be hazardous to Sean’s respiratory function.

5. Impact of Engineering Solutions

5.1 Lawn mower for Shane

Success of the modified lawn mower will have a great effect on a variety of aspects of Shane’s life. Operating the lawn mower gives a higher level of personal satisfaction when Shane is able to maintain his lawn. Even though this device is not as crucial to his life as his wheelchair is, the lawn mower provides Shane with an increased amount of responsibilities and an increase in physical activity. People with disabilities sometimes experience a limitation on certain activities that others may not realize. The completion of a modified mower will leave Shane with a desired experience, cutting the lawn, which many people take for granted on a weekly basis.

The mass production of the modified Troy-Bilt lawn mower, on a global scale, provides Shane’s experienced to other individuals who are unable to mow their lawn. Doing so improves on the life of the operator and operator’s family because there is an expansion of responsibilities and an increase in exercise, which is a fairly common goal for families with disabled persons. Despite the modifications made to the mower; it remains environmentally safe and friendly. A lack of toxic fumes and a relatively low rate of carbon dioxide emission do not cause a large enough impact on the environment for them to be relevant.

5.2 Projects for Sean

Such a protective device as the BRD does not exist in an inexpensive non-hospital environment. The designed BRD is able to maintain a safe sleeping environment inexpensively and in within the home. Despite the immense importance of a protective sleeping device one does not exist that can be made affordable and marketed towards the general public. As for the S-90 go-kart, the modifications and fixes will allow Sean to enjoy the outdoors. The fixed Assistive Jumping Device (AJD) will allow Sean to safely use his trampoline and get the needed exercise that allows him to have a healthy lifestyle.

Global implementation of the BRD gives a wider range of people with disabilities with a safe means of sleeping. Currently crude railing devices are in use in many homes, which places great risk of injury on the individuals being protected by the railing. Rails that can be found in many homes consist of a rail built to protect a young child and are not adequate to protect a fully grown adult.
Environmental concerns for the BRD are limited due to the fact that it is operated indoors and produces no emissions. The two electric motors do not affect any environmental variables because they use a small amount of electricity, which is insignificant in the amount of electricity consumed daily. Above all else the BRD allows Sean to be well rested and more alert during because he has expended less energy getting in and out of bed.

6. Life-Long Learning

Both design projects for Shane and Sean utilize various fields of engineering to effectively solve a problem. The two designs require strong abilities in electrical circuits, structural mechanics and computer programming to create successful devices. In order to control the various electric motors and actuators a great understanding of microcontrollers was needed to create a safe working device. The program MPLAB IDE was learned to help program the microcontroller. MPLAB is helpful in the developing of embedded applications on microcontrollers, which serve to control specific functions of the design project. Circuit schematics are designed and evaluated in Multisim. Multisim provided experience in circuit theory and also provided a fast and inexpensive means of testing and building electrical circuits.

Structural visualization of the design components was necessary to accurately design a working device. CAD software was the most useful tool in generating a visualization of the design projects. The particular CAD program used is Solidworks, which provided assembly of parts made out of various materials. Solidworks is also able to aid in the testing of the devices in order to get a better understanding of structural integrity and weakness.

Another valuable aspect of the design projects is the experiences gained from working together in a team. Developing effective communications skills and project management skills was a crucial stepping stone to having successful designs. Microsoft project is used to track daily, weekly, and monthly progress of team objectives and our designs. Various work and learning styles emitted by each group member brought a wider range of ideas and theories to the team; expanding the capabilities of the design team.
7. Budget and Timeline

7.1 Budget

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# 7.2 Timeline

## 7.2.1 Lawn mower for Shane

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### 7.2.2 Projects for Sean

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8. Team Members Contributions to the Project

Randy Corriveau

Randy spent a majority of his time on the Solidworks for the BRD design. He first completed a model of the bed and the BRD support system. Once the models were complete, he compiled Eric’s BRD frame design into the first model assembly. As the design process moved along Randy constructed the models for the motor housing unit and the hinge set up for Sean’s BRD. Randy facilitated most of the conversation with the Stenglein family and also spent time researching products for 80/20 Inc that could be used to fabricate the BRD. He contacted 80/20 representatives for price quotes and did a majority of the cost benefit analysis for BRD 80/20 purchases. He researched stepper motors for the BRD and computed calculations on required holding torque. Randy also was present when the lawn mower was picked up from Ellington Agway and when the service analysis was performed. In the future Randy will update the BRD Solidworks as needed, work on lawn mower control mechanisms and turn his focus to helping out with the circuitry and computer programming.

Ian Wallis

In the beginning of the semester Ian allocated time researching cerebral palsy to better understand what specific design characteristics would need to be incorporated. Next his time was spent brainstorming, sketching and discussing the method of deployment, as well as the foam and vinyl protective features of the BRD. Ian was also involved in developing ideas for the BRD stepper motor-frame connection piece, as well as research of stepper motors and speed controllers. Ian was responsible for being the design team’s contact with Shane Davis. Also regarding the lawn mower for Shane, Ian discussed ideas for the structural configuration of the needed seat and armrest requirements. Then he spent time researching the necessary electrical components needed for the design. Research was done on the proper microcontroller and the basics of programming it in C. Ian was also responsible for researching what electrical components would be needed for building the project’s circuits. Techniques were developed in Multisim needed to test the circuits to ensure proper voltages and currents are applied to the motors. Future work will include continuation of the programming of the microcontroller and further development of Multisim circuit schematics. Next semester continuation of parts ordering as well as the projects will be built and tested in the machine shop.

Eric Nastuk

A majority of Eric’s time was spent on the lawnmower project. He mainly worked on constructing multiple Solidworks designs based on modifications he created for the project. He researched potential lawnmowers at various vendors and websites, and is largely responsible for pursuing the donation from Ellington Agway. Eric also made the necessary contacts with the Tiger Team at UConn to facilitate the retrieval of the mower itself. Most of mechanical functions and modifications, as well as integration with the mower was completed by Eric, as well as research for the mower operation and how to best modify it to fit Shane’s needs. For the BRD project, Eric created the first sketches of the bed railing frame, which was then modified by Randy to suit the 80/20 aluminum design. He also has worked closely with Randy to design a
working Solidworks design for the steps the team will be fabricating. Eric also worked on designing the hinge mechanism, motor integration, and mounting on Sean’s bed. In addition to the projects, Eric also maintains the website and is responsible for uploading all necessary documentation for the team.

For future works for each team member, throughout the course of the winter and into next spring, the team will be working individually to order parts, and have them shipped to UConn. By early to mid-spring project construction will be well under way. Further stepper motor research and programming will be done in the intersession, and the research will all be coordinated online until the group reconvenes in the spring. Both projects will still need a great deal of troubleshooting and progress in the spring, but the team is well grounded in its current accomplishments and research and believe the design is possible.

9. Conclusion

The project design for the lawn mower is focused on creating a safe and comfortable way for Shane to mow and help his family in this chore. Currently Shane has no lawnmower, and with an unmodified lawnmower, he has had a cumbersome experience attempting to operate the machine. The optimal design for his mower will be constructed with his specifications in mind, and will be as similar to driving and operating his current power chair as possible, for ease of use. The team will construct the device in the spring, and perform multiple tests at UConn for safety and function before presenting the device to Shane. In order to make sure the mower operates seamlessly for Shane, the team will meet with Shane multiple times in the Spring to test the device and ensure it functions according to his needs.

For the BRD construction and modifications of previous projects, Sean’s needs will be taken into full consideration. Presently the family lacks a good way for Sean to get himself in and out of bed. Sean’s AJD cannot be operated safely without the missing part, and the Go-Kart can’t function due to its component failures. As soon as the BRD device is constructed, the team will do multiple tests on the product through a rig built in the design lab. Once the device is thoroughly tested for safety in a controlled environment, the team will make sure the project works according to the client’s requests by meeting with the client and demonstrating its effect. The AJD and Go-Kart will be modified and tested by the design team for safety and function both before and after presentation to Sean and his family. This will ensure that not only the products will be safe, but will also function according to his needs.

The designs for all projects have been thoroughly researched and a procedure for construction is already planned. Over the winter intersession continued work will be done by individual members on ordering the exact component parts, as well as the circuitry and programming for both devices. Additional time will be needed to plan the foam and vinyl integration for the BRD, as well as further research on the development of the modified seat for the mower. With a majority of the setbacks with regards to the lawn mower out of the way, now construction can begin, and the team is eager to begin work on the build in the spring.
10. References


<https://www.bme.uconn.edu/sendes/Spring09/Team3/Final%20Tramp.pdf>


[6] NSF reports, Chapter 8, State University of New York at Buffalo, Mowing Deck Attachment For A Golf Cart: For Those Who Can’t Use A Riding Lawnmower  

[7] AbleData devices, Customized Hand Controls,  
<http://www.abledata.com/abledata.cfm?pageid=19327&top=13932&ksectionid=0&productid=186008&trail=0&discontinued=0>

[8] NSF main website, Bed Rail Assist  

[9] AbleData devices, Technical Aid to the Disabled (TAD)  
<http://www.abledata.com/abledata.cfm?pageid=19327&top=11613&ksectionid=19327&productid=199317&trail=0&discontinued=0>


<http://appft.uspto.gov/netacgi/nph-Parser?Sect1=PTO2&Sect2=HITOFF&p=1&u=%2Fnetahtml%2FPTO%2Fsearch-bool.html&r=36&f=G&l=50&co1=OR&d=PG01&s1=%22cerebral+palsy+railing%22&s2=%22bed+railing%22&OS=%22cerebral+palsy+railing%22+OR+%22bed+railing%22&RS=%22cerebral+palsy+railing%22+OR+%22bed+railing%22>


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11. Acknowledgements

Our team would like to Acknowledge:

- Dr. John Enderle: Advice and moral support
- Marek Wartenberg: Advice and moral support
- The Stenglein Family: Project planning and development
- The Davis Family: Idea generation and clarification of design
- Peter Glaude and Serge Doyon: Machine Shop help and advice, help with lawn mower
- Matt Person from Ellington Agway: Lawn mower donation, service help and technical support
- Pat from Ellington Agway: Technical advice and lawn mower service
- George Assard and Martha Besade: Tiger team help/ truck for lawn mower delivery

12 Appendix

12.1 Updated Specifications

12.1.1 Lawn mower for Shane

12.1.1.2 Mechanical

- 2 Linear actuators with 8 inch stroke
- Stepper motor
- Joystick

12.1.1.3 Electrical

- Circuit board
- Microcontroller
- C-based programming

12.1.1.5 Environmental

- Operation in outdoors
- 40-140 degrees farenheit

12.1.1.6 Safety

- Modified seat
  - High back
  - Armrests
  - Joystick
- Killswitch
- Under seat
- Manual override off switch

12.1.2 Projects for Sean

At this time, all preexisting specifications for Sean’s BRD and other projects are the same as originally defined.

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Franklin, MA 02038

**Phone:** 508-528-3020

**Contact Name:** Victor Mott

**Authorization:**
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| Address: |                     |
| Phone:  | 860.875.050 |
| Contact Name: | Matt Person |

**Tax:** $8.53

**Total:** $158.53

**Authorization:**