E-Racer

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E-Racer
Final Paper

University of Connecticut
Biomedical Engineering
Senior Design II

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Abstract

1. Introduction
   1.1 Background
   1.2 Purpose
   1.3 Previous Work Done By Others
      1.3.1 Products
      1.3.2 Patent Search
   1.4 Map for the Rest of the Report

2. Project Design
   2.1 Design Alternatives
      2.1.1 Design I
         2.1.1.1 Seat
            2.1.1.1.1 Seat Body
            2.1.1.1.2 Swivel Mechanism
            2.1.1.1.3 Restraint System
         2.1.1.2 Acceleration
            2.1.1.2.1 Joystick Mode Acceleration
            2.1.1.2.2 Wheel Mode Acceleration
         2.1.1.3 Braking
            2.1.1.3.1 Braking in Joystick Mode
            2.1.1.3.2 Braking in Wheel Mode
         2.1.1.4 Steering System
            2.1.1.4.1 Joystick Steering
            2.1.1.4.2 Wheel Steering
            2.1.1.4.3 Switching Mechanism
         2.1.1.5 Remote Kill Switch
      2.1.2 Design II
         2.1.2.1 Go-Kart
         2.1.2.2 Seat
            2.1.2.2.1 Seat Body
            2.1.2.2.2 Seat Swivel
         2.1.2.3 Safety
         2.1.2.4 Controls
            2.1.2.4.1 Handheld Controller
         2.1.2.5 Remote Kill Switch
      2.1.3 Design III
         2.1.3.1 Go-Kart
         2.1.3.2 Electric Motor
         2.1.3.3 Controls Systems
            2.1.3.3.1 Acceleration
            2.1.3.3.2 Braking
            2.1.3.3.3 Steering
         2.1.3.4 Seat
            2.1.3.4.1 Entry Mechanism
            2.1.3.4.2 Seat Body
            2.1.3.4.3 Seat Safety

5
6
6
7
8
8
10
10
10
10
10
10
10
11
12
12
13
13
13
13
14
14
14
14
14
15
15
15
15
15
16
16
16
16
17
18
20
20
23
25
25
26
27
27
28
28
29
29
29
31
31
<table>
<thead>
<tr>
<th>Section</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>2.3.7 Steering Wheel &amp; Shaft</td>
<td>106</td>
</tr>
<tr>
<td>2.3.8 Instructions for Use</td>
<td>107</td>
</tr>
<tr>
<td>3.   Realistic Constraints</td>
<td>111</td>
</tr>
<tr>
<td>3.1  Economic</td>
<td>111</td>
</tr>
<tr>
<td>3.2  Environmental</td>
<td>111</td>
</tr>
<tr>
<td>3.3  Sustainability</td>
<td>111</td>
</tr>
<tr>
<td>3.4  Manufacturability</td>
<td>112</td>
</tr>
<tr>
<td>3.5  Health and Safety</td>
<td>112</td>
</tr>
<tr>
<td>3.6  Social</td>
<td>112</td>
</tr>
<tr>
<td>4.   Safety Issues</td>
<td>113</td>
</tr>
<tr>
<td>5.   Impact of Engineering Solutions</td>
<td>113</td>
</tr>
<tr>
<td>5.1  Societal</td>
<td>113</td>
</tr>
<tr>
<td>5.2  Environmental</td>
<td>114</td>
</tr>
<tr>
<td>5.3  Economic</td>
<td>114</td>
</tr>
<tr>
<td>5.4  Global</td>
<td>114</td>
</tr>
<tr>
<td>6.   Lifelong Learning</td>
<td>115</td>
</tr>
<tr>
<td>7.   Budget</td>
<td>116</td>
</tr>
<tr>
<td>8.   Team Members Contribution to the Project</td>
<td>117</td>
</tr>
<tr>
<td>9.   Conclusion</td>
<td>118</td>
</tr>
<tr>
<td>10.  References</td>
<td>119</td>
</tr>
</tbody>
</table>
Abstract

This go-kart is being created for a young boy with cerebral palsy. The client cannot use his legs and control in his left arm is limited. The client would like to have a go-kart which resembles that of other kids, and provides him with an enjoyable and safe recreational vehicle. The client also would like the ability to switch between joystick control and steering wheel control. In addition, the client requires lateral support. An important consideration is that when the client is excited, his chin drops to his neck. This must be prevented while he is riding in the kart. The client’s family has expressed a desire to have an electric go-kart, due to the reduced safety hazards and maintenance requirements compared with a gas-powered go-kart. The client is seven years old, and hopes to ride the go-kart for a few years, so the finished product must be able to be adjusted as he grows.

There have been several previous engineering projects similar to this one, as well as a few products made. At the University of Connecticut in 2001, a biomedical engineering senior design team also completed an electric go-kart for a client with cerebral palsy. This kart had a joystick control. At Swarthmore College, a group of engineering students converted a gas-powered go-kart to an electric go-kart. However, their kart was not designed for disabled users.

A group of students at the State University of New York in Buffalo created a go-kart for disabled children which was essentially a platform which wheels onto which a child could steer their wheelchair. This is no a go-kart per se and would not satisfy the needs of the client. One commercially available go-kart for children with disabilities is commercially available, but it only travels as fast as the client’s go-kart. Finally, a patent exists which is attached to an automatic transmission and allows the user to operate the vehicle with only one hand. While this is similar to what must be accomplished in this design, it is not a complete vehicle.

The first proposed design included an electric go-kart. It also had joystick and steering wheel control. The design featured a new seat, a swivel mechanism for easy entry and a five-point harness. The first alternative design also had a remote kill switch. The second design had a gas-powered go-kart. The design also had a seat swivel mechanism and a three-point harness.

Since the client is familiar with video game controls, this design implemented a video game controller for the braking, acceleration and steering mechanisms. The final alternative design had a gas-powered go-kart which was converted to electric, a four-point harness, seat slider, and a joystick similar to that on the client’s wheelchair. The optimal design included an electric go-kart, joystick and steering wheel controls, a neck brace, foot straps, a seat swivel mechanism and a five-point harness.

There are many constraints imposed on this design. The total cost must come in under the $2000 budget allotted for the design. The environmental concerns associated with creating a new product must be considered, as well as the probability of success of the product on the market. The final budget came to $1898.69.

Since go-karts are inherently dangerous, and special precautions must be taken when a product is being made for a child with disabilities, the safety of this product must be heavily considered. The social implications of this design are also important to consider.

Allison primarily focused on the brakes, the seat, and the restraint system. Kevin focused on all of the programming and electronic components. Mike focused most of his energy on the steering system, including the actuator and the position transducer, and also maintained the
team’s website using Dreamweaver. Travis focused on the batteries and the potentiometer for the steering system.

1. Introduction

In order to fully explain the reasoning behind designing this project, this section explains the background of the client and why the go-kart is being designed for him. Also to understand more about the background of modifying go-karts for disabled clients, there is a list of previous research and design projects similar to the E-Racer.

1.1 Background

Found in an average of three out of every 1000 births, cerebral palsy is a non-progressive, but very serious disease that affects a patient’s entire life. Cerebral refers to the part of the brain that is affected, the cerebrum, while palsy refers to disorder of movement. Cerebral palsy can start affecting the motor control of a patient from the time of birth up until the age of three. Abnormal muscle tone, posture, reflexes, motor development, and coordination are all symptoms of this disease. In 2003, cerebral palsy was found to be the second most expensive disability to manage over the course of a patient’s life.

For patients with cerebral palsy, any simple daily activity requires the assistance of an aid and also takes much longer to perform. Every task is a struggle between controlling body parts properly and also preventing harm to the patient. The client is an eight year old boy from Alberta, Canada. His name is Mason McClement. He was a premature baby born at 25 weeks and he spent the first 55 days of his life on a ventilator. It took four months before Mason was released and his parents could take him home from the hospital. Mason visits rehabilitation clinics every week to help improve his muscle control and hopefully one day he will be able to walk on his own and carry out everyday activities without the assistance of an aid.

In an attempt to help Mason feel more comfortable around peers and potentially improve his motor control, a go-kart must be built that can be driven as easily as his wheelchair. The client has proven that he can correctly control the joystick on his wheelchair and also play video games very well, so a go-kart must be modified to mimic these two types of controls. An electric go-kart must be drastically modified to accommodate the client because he has no control over leg movement, limited control of his left arm, and his head often falls to his chest when he gets excited. This means that steering, acceleration, and braking must all be controlled with only his right arm. His mother also wants there to be easy in and out access to the seat, a wireless remote kill switch, a five point harness for safety, and the ability to switch to a manual steering wheel, brake and accelerator in the future if the client increases his mobility in his left arm.

In order to accommodate the changes in steering, braking, and acceleration, this design will include the addition of a joystick to the existing go-kart. Pushing the joystick forward will accelerate the go-kart accordingly through measured changes in voltage. Pulling the joystick backwards will apply the brake accordingly through measured changes in voltage. Pushing the joystick from left to right will also vary voltages recorded through rotary potentiometers in the joystick and turn the go-kart’s front wheels from left to right respectively.

Many other changes will be made to the original stock go-kart. The original seat on the go-kart will be modified so that it can rotate 90° to one side and slide outward. This mechanism will increase the client’s ease of entering and exiting the go-kart. In addition to the kill switch
built into the go-kart which can be used by the rider if need be, a remote kill switch will be added to the electric motor in order to completely cut off power from the battery. This kill switch can be activated by a button on the go-kart, a wireless remote that the client’s mother will be holding while the go-kart is in use, and also if the go-kart travels out of reach from the wireless remote. A five-point harness will be added to the go-kart to ensure that the client is securely positioned in the seat during travel. Additionally, there will be foot straps to ensure that the client’s feet are secure. While the seat sliders come with a locking mechanism and will attach the seat to the go-kart itself, this design includes a secondary locking system so that the level of stress imposed on the seat swivel mechanism is not too great. Finally, this design incorporates the need to restrict the client’s head movement slightly so that he does not drop his head and lose sight of the road. This will be accomplished by a foam donut which will be worn on the client’s neck.

An electric go-kart will be purchased and modified to accommodate the requirements of the client and his parents. The go-kart is called the Jeep Minimoto Dune Buggy and shown below.

![Jeep Minimoto Dune Buggy](image)

**Figure 1: Jeep Minimoto Dune Buggy.**

1.2 Purpose

Cerebral palsy is a very hard disease for patients and their family members to cope with. Every day, cerebral palsy patients must miss out on activities that involve fine motor controls that they often lack. Engineers, as a result, are constantly working to improve existing devices for patients with different disabilities, especially cerebral palsy. The only problem is that most clients have varying disabilities and a modified device that will work for one person will not work for everyone. This dilemma makes it hard for patients to use products unless they are specifically modified for their disabilities.

The proposed design is that of a go-kart which will satisfy the needs of a young boy, Mason McClement, with cerebral palsy who would like to enjoy recreational time with his peers. Since the client has cerebral palsy, he cannot operate one of these unmodified vehicles, because
they require fine motor control and muscle force that he lacks. Cerebral palsy has affected the client in many ways, and the client’s abilities must be considered at all times in the design and building of this device. There are many restrictions imposed on this design by the client’s abilities, budgetary concerns, safety issues, and general engineering standards of quality.

1.3 Previous Work Done By Others

1.3.1 Products

There have been a few other products which have attempted to address the requirements similar to those found in this project. One such product was created by a group of engineers at Swarthmore College called the Drive-by-Wire Go-Kart. These engineers created an electric go-kart in which they essentially adapted a traditional gas-powered go-kart so that it used an electrical control system. The final go-kart had a joystick controller which supplies inputs that are then processed with a microcontroller and then output to the motors. This go-kart is shown in Fig. 2.

Another go-kart was made by a senior design group at the University of Connecticut in 2001. This product was also called the E-Racer and was designed for a young client who had cerebral palsy. This go-kart also used joystick controls, and the client in this situation was only able to use his left hand. This go-kart included a 5-pt safety system and could travel up to 25 mph. The cost of this go-kart was $2500. This go-kart is shown in Fig. 3.
In 1994, a project called the Recreational Electra-Scooter for Special Children: A Fixed-Radius-Turn, On-Off-Control Wheelchair Carrier was completed at the State University of New York-Buffalo with NSF funding. This project was designed to provide a recreational vehicle for wheelchair-bound children. The Electra-Scooter is essentially a scooter with a wide platform and ramp on which the child can put their wheelchair. The steering mechanism in this case was such that the scooter could be fixed to move in a straight line or a circular path of preset radius, leaving little control up to the driver. The restraint system used was based on the restraint system used in buses for handicapped children, in which a bar fits through the spokes of the wheelchair and fastens to the deck of the scooter. The cost of materials was $870.

The only commercially available go-kart for disabled people is made by Mobility4kids. This go-kart is designed specifically for people with lower extremity, mobility, neurological or severe physical disabilities. The kart can be driven on gravel, grass or hard surfaces, has a group clearance of 4 inches and a turning radius of 10 feet. The controls are either joystick or switch control. The brakes are electric, and the power system is electrical with a 24-volt charger. The user’s feet are allowed to rest on the front of the platform. The go-kart can travel at a maximum speed of 7 mph and can accommodate a person weighing up to 250 pounds. The go-kart itself weighs 174 pounds. Mobility4kids also manufactures a go-kart for disabled people which has a steering wheel. This go-kart is similar to the go-kart with a joystick. These vehicles are priced between $5295 and $6890. This go-kart is shown in Fig. 4.
1.3.2 Patent Search

There is only one patent which is related to a go-kart for handicapped people. The device, created in 2002, is called the Handi-Driver and was designed by Keith Alan Roberts. The Handi-Driver combines three functions into a single steering column and can be used to operate any vehicle with automatic transmission by using a single hand control. The three functions incorporated into the one mechanism are steering, throttle, and braking. The Handi-Driver can be used by anyone who has use of at least one hand, and includes a kill switch. The Handi-Driver uses a steering column, steering and brake levers, a universal joint, a motorcycle type hand throttle, a brake and throttle cable, and a kill switch.

1.4 Map for the Rest of the Report

This report will detail the three alternate designs, as well as the optimal design for the E-Racer. It will also review the prototype and realistic constraints, including engineering standards, economic constraints, environmental constraints, sustainability constraints, manufacturability constraints, ethical constraints, health and safety constraints, social constraints and political constraints. The report will also detail safety issues, impact of engineering solutions, and lifelong learning. Finally, the report will discuss the budget and the individual contributions of the team members.

2. Project Design

2.1 Design Alternatives

2.1.1 Design I

Objective
In order to accommodate the client, who has fine motor control of only his right arm, the first alternative design makes use of an electric go-kart which can be controlled both by a joystick and by steering wheel-mounted controls. The ability to switch between two methods of control is the distinguishing feature of this design. Since the client is currently very capable of operating a motorized wheelchair that is controlled by a joystick, he will be able to safely, comfortably, and skillfully operate the go-kart as soon as it is delivered. Additionally, this design is desirable due to the fact that once the client is satisfied with his ability to control the kart through the use of the joystick, he will be able to enjoy the challenge of operating the vehicle through a steering wheel with hand controls for braking and acceleration. In this way, the kart will always allow for a control method that is comfortable for the client, while allowing the client to develop and improve fine motor control if he chooses to do so. Further modifications include the installation of an entry mechanism to ease the task of entering the vehicle. Finally, safety features such as a five-point harness and a remote kill switch help to ensure that the client is well-protected during the operation of the vehicle.

To facilitate the changes in steering, braking, and acceleration, this design includes the addition of a joystick to the existing go-kart. The client can control his motorized wheelchair very well and the goal is to mimic this design for the go-kart. Pushing the joystick forward will accelerate the go-kart accordingly through measured changes in voltage. Pulling the joystick backwards will apply the brake accordingly through measured changes in voltage. Pushing the joystick from left to right will also vary voltages recorded through rotary potentiometers in the joystick and turn the go-kart’s front wheels from left to right respectively.

Additionally, the go-kart will have a steering wheel which will allow the client to control the go-kart in a way similar to the controls found on a traditional go-kart. This was one of the desires of the client. The steering wheel and joystick will function independently and will offer the client flexibility in his control options based on his confidence in his ability to drive the go-kart. The system will also allow the client to have good control of the go-kart as soon as he receives the device; there will be no adjustment period as the joystick control will mimic the control he uses on his wheelchair.

The original seat on the go-kart will be modified so that it can rotate 90° to one side and slide outward. This mechanism will increase the client’s ease of entering and exiting the go-kart on his own. A kill switch which will be added to the electric motor in order to completely cut off power from the battery. This kill switch can be activated by a button on the go-kart, a wireless remote that the client’s mother will be holding while the go-kart is in use, and also if the go-kart travels out of reach from the wireless remote. A five point harness will be added to the go-kart to insure that the client is securely positioned in the seat during travel. Additionally, there will be foot straps to ensure that the client’s feet are secure. While the seat sliders come with a locking mechanism and will attach the seat to the go-kart itself, this design includes a secondary locking system so that the level of stress imposed on the seat swivel mechanism is not too great. Finally, this design incorporates the need to restrict the client’s head movement slightly so that he does not drop his head and lose sight of the road. This will be accomplished by a polymer strap which will be attached to the head rest and secured to the top center of the client’s helmet.

The client’s parents wanted the go-kart to be electric. The Jeep Minimoto Dune Buggy is an electric go-kart which is affordable and appears to be easily modified.

2.1.1.1 Seat
The seat of the E-racer will consist of three major components: the body, the swivel mechanism, and the restraint system. It is necessary that the integration of these components into the stock-kart results in a safe, supportive, and convenient seating system. The seat body will provide the necessary lateral support, comfort, and whiplash protection. The swivel mechanism of the seat will allow for easy entry of the client. Finally, the restraint system will ensure that the user is safely secured in the vehicle.

2.1.1.1.1 Seat Body

It is essential that the seat of the E-racer be safe and supportive for the client in order to maximize user enjoyment and comfort. Although the Minimoto Jeepster comes with an existing seat, it has been determined that this stock seat will not provide the necessary padding and lateral support that the client requires. A solution to this problem is to replace the stock seat with an aftermarket model. Automobile racing seats effectively provide the needed lateral support, however there are two major problems with these units: cost and size. Recaro and Sparco are manufacturers that produce hi-back racing seats that have excellent lateral support; however, these seats can cost in excess of $1700, making them impractical for the e-racer design. Additionally, it is unlikely that the Minimoto go-kart will be able to accommodate the size of an automobile seat. The Tillett T7 racing seat fulfills the requirement of having a supportive seat that is compact enough to fit within the stock go-kart. At a price of approximately $300, this seat will fit within the budget of the project and will meet the needs of the client. The T7 is a deep seat and has highly bolstered sides that will provide excellent lateral support for the user—far better support than was present in the stock seat. Additionally, this seat’s padding will prove to be much more comfortable for the user than the hard plastic stock seat. The only negative aspect of the T7 is the lack of head support for the client. While this is a drawback of the product, it is possible to incorporate a headrest into the back of the seat. Headrests can be purchased from aftermarket go-kart parts retailers for approximately $10. The use of a head restraint such as this is necessary to reduce the risk of whiplash from the motions of the moving kart.

2.1.1.1.2 Swivel Mechanism

The seat swivel mechanism of the E-racer will provide the user with a rapid, easy method to enter the vehicle. The goal of the seat swivel is to allow the user to sit on the seat when it is extended and at a 90 degree angle to the vehicle, to buckle into the five point harness (that will be discussed in the following section), and to swivel and lock into the operating position with the help of a guardian. The motion of the seat will be achieved through the use of two seat sliders and one swivel mechanism. The online retailer Desert Karts sells the seat adjuster slider. The use of two of these seat sliders will effectively allow the final seat swivel device to slide the seat forward from under the roll bar and also extend out at a 90 degree angle from the kart.

A final aspect of the swivel mechanism to take into consideration is the security of the system. While the slider mechanisms specified above lock into place, it may be necessary to provide an additional safeguard to ensure that the chair is firmly secured to the kart. This will be accomplished through a simple system where two metal plates attached to the back of the seat will align with two metal plates secured to the kart’s frame. A metal rod will slide through a hole in each of the plates and will be secured with a cotter pin.
2.1.1.3 Restraint System

The restraint system of the E-racer will consist of three main parts: the five-point harness, the foot restraints, and the head restraint system. The goal of the restraint system is to keep the operator firmly secured to the seat and provide support during kart operation. However, this security and support must be comfortable for the user since the kart may be operated for an extended period of time.

A five-point harness is the standard of competitive automobile racing and provides the user with a firm, comfortable fit. This harness is superior to two and three-point belt designs due to the fact that it uses two shoulder belts, a lap belt, and a belt that attaches between the legs. As a result of this design, the user’s entire torso is well restrained. RCI manufactures the “RCI Universal 5-Point Harness,” which retails for approximately $140. The adjustability of this harness will allow the user to have a good, firm fit that will be comfortable during the operation of the kart. While it is typically required that a seat belt is attached to the frame or sub-frame of a vehicle, doing so will not be possible in the E-racer since the user will be buckled into the seat when it is extended and at a 90 degree angle to the kart for easy entry. As a result, it will be essential that the harness is firmly fastened to the seat.

Foot straps will make up the second aspect of the restraint system. Since the client is unable to use his feet for fine motor control the feet will not be used in the operation of the kart. As a result his feet can be fastened to the kart for added security. These straps will be made of nylon and will be similar to those used in the five-point harness. The straps will be secured through the use of Velcro.

The head restraint system is the final safety measure that will be implemented in the restraint system. Since the client often puts his head down when he gets excited it is necessary to prevent this from happening in order to reduce the risk of injury due to loss of control. The goal of the head restraint system is to allow the client to freely rotate his head in order to see obstacles that may be in the path of the vehicle. This is accomplished through attaching a plastic band to the top center of the client’s helmet. The head restraint system will make use of a metal circular button on the top of the client’s helmet that will fit into a cutout on a plastic band. The band would attach to the headrest of the chair. As a result of this device the user would be able to rotate his head within one plane, yet would not be able to look down. If the client grows out of the habit of dropping his head when he gets excited this device would not have to be used.

2.1.2 Acceleration

The client will have the option of using either a joystick or a hand pedal behind the steering wheel to accelerate the cart. The mode of operation will be chosen before the cart is moving. The mode will be selected using a simple switch on the kart’s main control panel. Only one mode will be used at any given time. In other words, while one mode is being used, the other one will be deactivated. The switching mechanism will be described in a later section.

2.1.2.1 Joystick Mode Acceleration

The same model joystick that controls the client’s wheel chair will be used to control the go-kart. The QTRONIX Remote Joystick puts out two different voltage signals. One signal
corresponds to the horizontal position of the joystick. This signal will be used for steering. The other signal corresponds to the vertical position of the joystick. This signal will be used for acceleration and braking. A voltage between 2.5V and 5V from the vertical signal (moving the joystick forward) will accelerate the kart while a voltage between 2.5V and 0V (pulling back on the joystick) will apply the braking system (described in the next section). The variable output voltage will allow the user to have some control over the rate at which the vehicle is accelerated. The voltage from this joystick will be sent to a microprocessor. The microprocessor will calculate the percentage that the joystick is moved from the horizontal midline. This percentage will be used as the %duty cycle for a pulse width modulation program. The pulse width modulation program will output an AC signal that can be modeled by an average DC voltage. As the joystick is moved forward, the %duty cycle calculated by the microprocessor increases and thus the average DC voltage will increase. As a result, the motor (used for acceleration) will increase in rotational speed and the cart will move faster.

2.1.1.2.2 Wheel Mode Acceleration

The left hand pedal (located behind the steering wheel) will be used for acceleration. For safety reasons, the users more dominant hand (right) will be used for braking. When the left hand pedal is pulled inwards, toward the driver, a cable connected to a linear position transducer will be pulled. The linear position transducer out puts a voltage based on the distance that the cable is pulled. The output voltage from the linear transducer will be sent to a PIC microprocessor (separate from the one used for the joystick). This microprocessor will calculate the percent that the handbrake is pulled back. This percentage will be used for the %duty cycle of a PWM signal (same idea as used for the joystick control).

2.1.1.3 Braking

2.1.1.3.1 Braking in Joystick Mode

In joystick mode, pulling back on the joystick will cause the vertical voltage signal to drop below 2.5V. As done for acceleration, the percent that the joystick is moved from the horizontal midline will be used to create an AC signal with the same %duty cycle. The signal will be sent to an AC linear actuator that will apply the brakes. As the %duty increases, the average DC voltage increases, and the linear actuator shortens. When the linear actuator shortens, more pressure is applied to the disk brakes via a caliper resulting in deceleration.

2.1.1.3.2. Braking in Wheel Mode

In wheel mode, the right wheel pedal will control the braking. Another linear position transducer will output a voltage to the “wheel mode” microprocessor based on the distance that the pedal is pulled in towards the user. Again, the percent of maximum pull will be calculated and used for the generation of an AC signal. This AC signal will be sent to the linear actuator as done for the joystick braking control.

2.1.1.4 Steering System
2.1.1.4.1 Joystick Steering

The client will have the option of using either a joystick or a wheel to steer the kart. As previously stated, the mode of operation will be chosen before the cart is moving. The horizontal signal from the QTRONIX joystick will be used for the steering if the joystick mode is selected. A voltage between 2.5V and 5V will turn the kart right while a voltage between 2.5V and 0V will move the kart to the left. The variable output voltage will allow the user to have some control over the rate at which the vehicle is turned. The voltage from this joystick will be sent to a microprocessor. The microprocessor will calculate the percentage that the joystick is moved from the midline. This percentage will be used by a software pulse width modulation (PWM) to create an AC signal that can be sent to an AC motor. The PWM will use the calculated percentage as the %duty cycle for the AC output. As a result, the AC motor will rotate at the same percentage of the maximum speed of the motor. The AC motor will turn the wheels until the maximum turning angle is reached or until the joystick is returned to the midline.

2.1.1.4.2 Wheel Steering

The Minimoto Jeep Dune Buggy comes equipped with a fully functional steering wheel. This wheel functions mechanically and not power assisted. Our client’s medical condition limits his strengths and he would not be able to mechanically turn the tires using the steering wheel. Therefore, the steering wheel will remain on the vehicle; however, it will be disconnected from the mechanical steering mechanism. Instead, the shaft coming off of the steering wheel will be directly connected to a hollow shaft potentiometric angle sensor from Novotechnik. The user will only be able to rotate the wheel 135° in either direction. The output from the angle sensor will be sent to the microprocessor. The microprocessor will then calculate the percent that the wheel is rotated in one direction. This percent will be used as the %duty cycle for PWM calculations. The calculated PWM signal will be sent to an AC motor (the same motor as used by the joystick) which will turn the wheels on the kart. The implementation of the AC motor used to turn the wheels will be designed when we receive the go kart. Currently, we cannot obtain enough information about the kart to fully understand the steering system. Thus, we cannot know how we will modify the as received steering system.

2.1.1.4.3 Switching Mechanism

As previously stated, the driver will have to select the mode of operation before the kart is in motion. All functions of the joystick will be handled by one PIC microprocessor (PIC 1). Also, all functions of the steering wheel (including the hand pedals for acceleration and braking) will be handled by a separate PIC microprocessor (PIC 2). Four single pole double throw switches will be needed to effectively choose a desired mode of operation (joystick or wheel). However, for simplicity, these four switches will be integrated into one simple switch. Four transistors will be used in conjunction with one single pole double throw switch to accomplish the four switching tasks.

2.1.1.5 Remote Kill Switch
One of the safety measures that will be incorporated into the E-racer design will be a remote control switch which will be used by the client’s guardian. This device will allow the guardian to stop the operation of the vehicle by pressing a button on a remote that is similar in appearance to a key fob. This will be mounted directly to the go-kart’s power supply and to the linear actuator. Devices such as this are commonly found on children’s all terrain vehicles. The kill switch is designed for use in an Eton ATV. We plan to modify this part for use in the E-racer.

2.1.2 Design II

Objective

The second alternative design is very different from the first alternative design in many ways. An entirely new stock go-kart was chosen that uses a gasoline powered engine rather than an electric motor which was used in the first design. In the first design, a switch on the vehicle allowed the user to change between joystick and steering wheel controls, while in the second design all controls are implemented through the use of a handheld game controller. In terms of safety considerations the second design has a three point harness and a neck brace to prevent the client from dropping his head, while the first design used a five-point harness and polymer strap attached to the helmet restrict head movement. The final difference between the designs is the seat. In the first design the seat was a modified aftermarket go-kart seat that used two sliders and a swivel to rotate ninety degrees and slide outward for loading. The second design is able to accomplish a similar motion though the use of a less complex rotating arm system. Additionally, the seat will be custom-made for the client through the use of injection-molding, and will provide the necessary support and comfort that the client requires.

2.1.2.1 Go-Kart

The go-kart used in this design will be a gas-powered go-kart designed for children. This go-kart is the GK-202 Mini Go-Kart, featuring a 90cc, 4-stroke, air-cooled engine.

The driver controls on this go-kart include an on-board engine kill switch, and an ignition key start. The go-kart has a full suspension for a smoother ride and rear disc brakes. The disc brakes are extra large for faster stopping. Additionally, rack and pinion steering allows for nearly effortless steering for any age.

The go-kart runs on unleaded gasoline and has a 2-liter tank. The muffler has a chrome cover to control the noise produced by the engine, making this go-kart suitable for use in a quiet neighborhood setting. The go-kart has a very low center of gravity, making it very safe, particularly in the event that the go-kart is in a situation where it is at risk of tipping. Finally, the weight capacity of the go-kart is 220 pounds, making this more than suitable for the client.

2.1.2.2 Seat

2.1.2.2.1 Seat Body

The seat will be injection molded to allow for maximum customization to the client. The seat will be designed to suit the client’s needs as far as size and support. Injection molding
involves making a mold out of a malleable metal, such as aluminum, and then injecting a material (generally a polymer) into the mold.

The filler for the mold in this case will be a mixture of polyethylene and polypropylene. Polypropylene is used because it is lightweight, has a high tensile strength, is impact resistant, has a good compressive strength, retains stiffness and flexibility, is non-toxic and is easily fabricated. Polyethylene will also be used due to the fact that it is lightweight, has a high impact strength, and has a wide range of flexibilities depending on the density of the polyethylene used.

2.1.2.2.2 Seat Swivel

The seat swivel mechanism of the E-racer will provide the user with a rapid, easy method to enter the vehicle. The goal of the seat swivel is to allow the user to sit on the seat when it is extended and at a 90 degree angle to the vehicle, to buckle into the three point harness (that will be discussed in the following section), and to swivel and lock into the operating position with the help of a guardian. The process of moving the seat into the loading position is shown below in Fig. 5.

Figure 5: Overview of seat swivel mechanism.
The swivel chair mechanism for the E-racer will rotate only at the mounting point and will be fixed at the seat’s point of attachment.

A final aspect of the swivel mechanism to take into consideration is the security of the system. Since seat rotation is accomplished through a joint at the point of attachment, it will be important to ensure that the seat does not swing back and forth both in the operating position and in the loading position. To prevent this motion a metal rod will pass through a hole in the swivel arm and through one of two metal plates that is fixed to a stationary upright bar. Securing the seat in the loading position will make use of one of the plates while securing the seat in the operating position will make use of the other. The rod will be secured with a cotter pin, making the removal and installation of the pin a very simple process. An overhead view of the process is shown in Fig. 6.

Figure 6: Swivel lock.

2.1.2.3 Safety

The harness used for this design will be a three point harness. The harness is two inches wide and attaches behind the neck and at each hip. Figure 7 shows the harness which will be used.
Figure 7: Three point harness.

This harness is made out of military grade nylon webbing, and includes pressure reducing waist pads, which would be advantageous in the event that the go-kart stops abruptly. The restraint system comes equipped with a push button release and can be attached to the go-kart with either a bolt in or snap in system.

To address the issue of the client’s chin dropping to his neck when excited, this design will feature a neck brace commonly used in motocross and go-kart racing. The brace, from Leatt, is generally used to prevent injury in the event of a collision, but can also be used to support the client’s head. Figure 8 below shows the brace. The brace is made by injection molding and is made of glass reinforced nylon or carbon fiber and Kevlar neck brace (the materials depend on which model is used). The neck brace is designed to prevent hyperflexion (extreme forward head movement), hyperextension (extreme rearward head movement), lateral hyperflexion (extreme sideways head movement), axial loading (compression of the spinal column due to the effect of force on the helmet), and posterior hypertranslation (rearward movement of the head/helmet on the neck). The neck brace can prevent potential injuries against potential injuries by slowly bringing the head to a controlled stop. The design of the brace prevents the head and helmet from projecting over the brace, therefore preventing a fulcrum action. This will prevent injury in case the client needs to come to a rapid stop. Clearly, the neck brace will perform the required functions and also offer additional safety features.

Figure 8: Leatt neck brace.
2.1.2.4 Controls

2.1.2.4.1 Handheld Controller

The client enjoys, and is fully capable, of playing Play Station 2 (video game console) using a normal PS2 controller. With this in mind, the modified go kart will be controlled by a controller that is similar to the PS2 controller. The Logitech Rumble Pad 2 was chosen for the control and is shown below in Fig. 9.

![Figure 9: Ten button computer game pad.](image)

The controller is a complicated one in the sense that it is designed to interface with either Windows or Mac. This communication is necessary for computer games to be able to find and work with the controller. Our application of this controller does not require this advanced communication and as such we will modify the controller for this relatively simple go-kart application. We will connect each of the buttons to its own digital input port on a microcontroller. Port C will be used for these inputs (see Fig. 10 - pins 15-18 and 23-26). The microcontroller (PIC 16F874A) will use these digital signals as interrupt signals.
This schematic describes the process by which the buttons will communicate with the PIC (button 1 used here as an example. When the button is not pressed, the PIC will see 5V at the corresponding pin of Port C (logic high). When the button is pressed, the 5V is grounded and the PIC will see 0V (logic low). All buttons on the controller will function in this fashion. Figures 11 and 12 describe the configuration of the controls.
Button number 2 will be used for acceleration. Acceleration on the unmodified go-kart was accomplished through a cable that is pulled when the gas pedal is pressed down. When this happens, more gas and air mixture is allowed into the cylinder allowing the engine to work faster and move the go-kart faster (in the same fashion as an automobile, which also uses an internal combustion engine). In the modified go-kart, the opening and closing of the throttle will be controlled by an AC linear actuator. When the acceleration button is depressed, a logic high will be sent to one of the pins in Port C of the microcontroller. The microcontroller will then send out an AC signal to the linear actuator. When first applied, the duty cycle of the AC signal will be
relatively small, resulting in slow acceleration. The kart’s acceleration will increase as the duty cycle increases with time. The increasing acceleration will occur until the gas button is released or until the user shifts up a gear (using button 8).

Pressing the shift up button will cause a logic high to be sent to the microcontroller. The microcontroller will then output a DC voltage with a to a DC linear actuator. This DC voltage will be applied for the exact amount of time it takes to move the shifter into proper position. These times will be calculated by trial and error and will be programmed into the microprocessor.

The unmodified go-kart comes with slots that hold the shifter in the proper position. These slots will be removed to allow for the shifting to be accomplished in a linear motion. The shifter will be held in place by the linear actuator. The user can shift down a gear using button 7. Shifting down from first gear will put the kart in neutral. Shifting down another gear with put the kart in reverse.

Braking will be accomplished the same way that acceleration is accomplished. The only difference is that the user will brake with button 1 instead of button 2 (acceleration). The brake will be applied with increasing force as the brake button is held for a longer period of time. For safety concerns, however, the user must be able to stop the kart immediately in case of an emergency. Therefore, an emergency brake can be applied using button 6 (Fig. 12). When and if this button is pressed, the microprocessor will apply the brakes fully until the emergency is reset (using reset button on controller). Additionally, in the case that button 2 (acceleration) and button 1 (braking) are depressed at the same time, the microcontroller will be programmed such that braking will be the overriding signal.

The left analog joystick will be used for steering and the right stick will be electrically disconnected. Also, for simplicity, the thumb pad (see Fig. 11) will also be electrically deactivated. The physical stick and pad will remain in place for aesthetic purposes only. The analog signal coming from the left joystick will be sent directly to the PIC for steering purposes (pin 0 of Port A – pin 2). This analog joystick puts out a 0-5V signal based on the horizontal position of the joystick. A voltage between 2.5V and 5V will turn the kart right while a voltage between 2.5V and 0V will move the kart to the left. The variable output voltage will allow the user to have some control over the rate at which the vehicle is turned. The voltage from this joystick will be sent to a microprocessor. The microprocessor will calculate the percentage that the joystick is moved from the vertical midline. This percentage will be used as the %duty cycle for a pulse width modulation program. The pulse width modulation program will output an AC signal that can be modeled by an average DC voltage. As the joystick is moved right, for example, the %duty cycle calculated by the microprocessor increases and thus the average DC voltage will increase (Equation 1).

\[
\text{Average DC} = (\% \text{ Duty cycle}) \times (\text{Peak AC voltage}) \quad \text{Equation 1}
\]

As a result, the AC motor will rotate, and thus turn the wheels at a rate that is proportional to the movement of the joystick. The AC motor will turn the wheels until the maximum turning angle is reached or until the joystick is returned to the midline.

The steering mechanism described here is almost exactly identical to the first alternative design. The major control difference pertains to the acceleration and braking methods.

2.1.2.5 Remote Kill Switch
One of the major safety measures that will be incorporated into the E-racer design is a remote kill switch that will allow the user’s guardian to stop the vehicle at any time with the push of a button. One product is 3Built’s Remote Engine Shut-off system (Model # RES12VU). According to the manufacturer’s website, the Remote Engine Shut-off system is built to cut a vehicle’s ignition system at the push of a button and is operational up to a distance of 250 ft. (76.3 m). 3Built’s product uses a small, two-button controller which sends a signal to a receiver on the vehicle. When the receiver gets the signal from the remote it either activates or releases a relay that functions in a similar manner to the factory off/run switch. An overview of the operation of the device and its integration into the ignition system is shown in the manufacturer’s installation instructions.

As applied to the E-racer, pressing the lock button on the remote would activate the relay in the receiver, which would in turn disable the vehicle’s ignition system. Pressing the unlock button would release the relay, allowing the vehicle to be restarted. However, it is important to note that this device does not restart the vehicle. As a result, when the ignition system is disabled the user’s guardian would have to make sure that the remote kill switch is in the unlocked position and then manually restart the vehicle. Figure 13 below shows a flow chart of the kill switch activation.

![Flow chart of kill switch activation](image)

*Figure 13: Flow chart of kill switch activation.*

The kit includes the RES Receiver, the RES Remote Control, wire connections, a quick disconnect, zip ties, and instructions. The 3Built Remote Engine Shut-off system RES6VU-B sells for a retail price of $69.99 and is available through the manufacturer’s website.
2.1.3 Design III

Objective

The third design involves purchasing a gas powered go kart and converting it to electric. There are not many viable electric go karts on the market today. However, for this application, the client has requested an electric powered kart. Therefore, a gas powered kart with an attractive overall mechanical design will be used. The motor will be removed and replaced with a comparable electric motor.

This design is advantageous because there is more flexibility in the selection of the base kart and more flexibility in the selection of the electric motor. This design, however, is more costly because a fully functional gas powered engine will be wasted and replaced with an expensive electric motor. Also, the added step of mounting the electric motor will challenging and time consuming.

This kart will be controlled by a joystick. The seat on the go-kart will be modified so that it is comfortable for client and so that it allows for easy entry by sliding out. This mechanism will increase the client’s ease of entering and exiting the go-kart. A kill switch will be added to the electric motor in order to completely cut off power to the battery in case of an emergency. This kill switch can be activated by a button on the go-kart and by a wireless remote that the client’s mother will be holding while the go-kart is in use. A four point harness will be added to the go-kart to insure that the client is securely positioned in the seat during travel. Finally, this design incorporates the need to restrict the client’s head movement slightly so that he does not drop his head and lose sight of the road. This will be by a magnetic proximity sensor and a magnet attached to the client’s helmet.

2.1.3.1 Go-Kart

The go-kart used in this design will be a gas-powered go-kart designed for children. This go-kart is the GK-202 Mini Go-Kart, (shown below in Fig. 14) featuring a 90cc, 4-stroke, aircooled engine.

![Figure 14: GK-202 mini go-kart with 90cc, 4-stroke engine.](image-url)
This go-kart is very attractive due to several safety features, easy of use (especially for small children) and simple controls, which will be easy to modify as detailed below. This design requires that the go-kart be changed rather drastically; the engine and transmission in the go-kart shown above will be removed and an electric motor will be used instead. The control system will also be changed dramatically.

2.1.3.2 Electric Motor

One of the requests from the client’s parents was to use an electric motor on the go-kart. Since there are a limited number of electric go-karts on the market, (including the Jeep Minimoto used in Alternative Design 1), the gasoline powered engine on the GK-202 Mini Go-Kart will be replaced by an electric one to create an electric powered go-kart. An electric motor from Rotomag Motors and Controls PVT, LTD will be used (similar horsepower to electric motor on jeep minimoto). The motor features a high current carrying capacity and can produce large starting torques necessary to start moving a heavy go-kart and rider. This motor also has automatic fan cooling during continuous running along with sufficient protection from dust. A V-Series motor shown below in Fig. 2 will be used. This motor produces 2 Horsepower (1490 Watts), almost double the power from the Jeep Minimoto electric engine. The increased horsepower is needed to compensate for the difference in weight of the two carts. The Jeep Minimoto weighs 110lbs and the GK-202 Mini Go-Kart weighs 172lbs. The V-Series Motor can handle up to 36 Volts and 52 Amps. The much smaller electric engine will go in the same location as the gasoline engine.

36V is required by the electric motor. Since 36 V batteries aren’t produced regularly, three 12 V batteries will be connected in series to produce 36 V. A 12 V battery is the same kind used in cars and shown below in Fig. 15. Figure 16 below shows a concept of connecting batteries in series and the resultant voltage created.

![Optima 12 Volt Battery](image)

Figure 15: Optima 12 Volt Battery

![Three 12 Volt Batteries in Series, Creating 36 Volts](image)

Figure 16: Three 12 Volt Batteries in Series, Creating 36 Volts
The three batteries will be placed in an enclosure to protect them from dust, dirt, and water while the go-kart is driven outside. A 36 V charger from Japlar will be supplied with the go-kart for quick and easy charging of the batteries.

2.1.3.3 Controls Systems

A similar model joystick that controls the client’s wheel chair will be used to control the go-kart. A QTRONIX Joystick will be used that is similar in style but slightly different in electrical function to the joystick on the client’s wheel chair. The joystick to be used for this design puts out two different voltage signals. One signal corresponds to the horizontal position of the joystick. This signal will be used for steering. The other signal corresponds to the vertical position of the joystick. This signal will be used for acceleration and braking. The variable output voltage will allow the user to have some control over the rate at which the vehicle is accelerated or decelerated.

2.1.3.3.1 Acceleration

The acceleration feedback system can be described by the block diagram found in Fig. 17.

![Figure 17: Feedback control for acceleration.](image)

The set speed control will come from the voltage from a PIC microprocessor. It will be set to 0V unless the joystick is moved forward. When the joystick is pushed forward, a positive voltage will be sent to the positive input of a unity gain difference amplifier (Fig. 8, DigiKey INA117). A tachometer (DC generator) will output a voltage (0-2.5V) based on the speed of the motor. At maximum speed, 2.5V will be output. When the motor is not moving, 0V will be output. The DC voltage from this tachometer will be sent to the negative input of the difference amplifier.

When the joystick is first pushed forward, a positive voltage will be compared to 0V from the tachometer. As a result, the difference amp (DA) will output a voltage based on the following Equation 1.

\[ V_{\text{out}} = V_+ - V_{\text{in}} \]  

(Equation 1)

This voltage will then be proportionally amplified based on the 36V range of the DC motor. The DC generator (tachometer) will output a voltage that increases proportionally with
the increasing speed. As the tachometer voltage increases it will eventually reach the same value as the set voltage ($V_+$. When this happens, the DA will output 0V to the amplifier (the motor is up to the correct speed). However, since the motor is no longer powered by the amplifier, the speed will begin to decrease. The tachometer output voltage will fall accordingly and there will again be a difference between the two input voltages of the difference amplifier. This will produce an output from the difference amplifier and dc amplifier which will power the motor and correct the drop in speed.

2.1.3.3.2 Braking

If the vertical signal sent to the PIC is less than 0V, the PIC will use the negative voltage for PWM calculations. The percent that the joystick is moved from the horizontal midline will be used to create an AC signal with the same %duty cycle. The signal will be sent to a DC linear actuator that will apply the brakes via a cable (Fig. 18). As the %duty increases, the average DC voltage to the actuator increases, and the actuator’s arm shortens. The average DC voltage sent to the actuator is determined by Equation 2.

$$\text{Average DC} = (%\text{Duty Cycle}) \times (\text{Max AC Voltage}) \quad \text{Equation 2}$$

When the linear actuator shortens, more pressure is applied to the disk brakes via a caliper resulting in deceleration (Fig. 18).

![Figure 18: Braking system using a linear actuator.](image)

2.1.3.3.3 Steering

Steering will be accomplished using a similar mechanism as described for the acceleration. The horizontal signal from the joystick ranges from -2.5V to 2.5V (0V being centered). This signal will be sent to the positive terminal of the differential amplifier. The output of this differential amplifier will be sent to a DC motor that will move the rack of the rack and pinion steering. A linear position transducer will be attached to the rack to know where the rack is relative to the center position. The position transducer will output a voltage (based on position, 0-5V) to pin 3 of the PIC. The PIC will shift the voltage appropriately so as to output 0V when the rack is centered. The shifted signal will be output via pin 35 of the PIC and sent to
the negative terminal of a differential amplifier. The DA control system will function the same as described for acceleration. The DA will output a voltage that is equal to the position voltage (from the linear position transducer) subtracted from the set position voltage from the joystick. As this difference approaches zero, the DC motor turning the kart will slow down and hold the desired position until the joystick is moved again.

2.1.3.4 Seat

2.1.3.4.1 Entry Mechanism

The seat slider mechanism of the E-racer will provide the user with a rapid, easy method to enter the vehicle. The goal of the seat slider is to allow the user to sit on the seat when it is fully extended from the vehicle, to buckle into the four point harness (that will be discussed in the following section), and to lock into the operating position with the help of a guardian. The process of moving the seat into the loading position is shown below in Fig. 19.

![Diagram of seat slider mechanism]

Figure 19: Overview of seat slider mechanism.

The motion of the seat slider device will be achieved through the use of a pair of heavy-duty, full extension slides. The slides will likely be modified from stock slides that are used for heavy drawers. There are many manufacturers for these devices. One such manufacturer is a company
by the name of Accuride. This company produces heavy-duty, full extension slides, specifically the 9301 series slides shown below in Fig. 20.

![Heavy-duty, full extension slide.](image)

*Figure 20: Heavy-duty, full extension slide.*

This model slide appears to satisfy the requirements that are present in this application. Primarily, it will be important that the slides are able to support a considerable amount of weight—the weight of the occupant as well as the weight of all seating components.

In order to use the heavy-duty slides in the e-racer, it will be necessary to provide the proper support. Since the sliders must be mounted in a vertical position it will be necessary to use heavy-duty L brackets when securing the sliders to the seat and to the frame of the vehicle. A side view of the seat depicting the attachment of the slides to the seat and the vehicle frame is shown below in Fig. 21.

![Side-view of slide attachment](image)

*Figure 21: Side-view of slide attachment*

A final aspect of the slide mechanism to take into consideration is the security of the system. Since the slides selected for this design are intended for use with heavy drawers, they
are designed to remain still once they are fully retracted or extended. However, since the e-racer will be moving at turning at considerable speeds it will be necessary to provide a mechanism to ensure that the seat remains in the operating position when the kart is in use. In order to provide this needed security, a hole will be drilled through the seat mounting bracket, the slide, and the frame mounting bracket on each of the two slides while the chair is in the operating position. These holes will accommodate metal pins that will be inserted once the rider has entered the vehicle and the seat has returned to the operating position. The pins used for this application will likely be quick-release locking pins.

The quick-release locking pin is desirable due to its simplicity—no cotter pin is needed so secure the device. Rather the locking mechanism is contained within the pin itself. In order to release the pin, the user will be able to simply press the button at the end of the device and pull. The pin can then be removed from the hole allowing the chair to extend to the loading position.

2.1.3.4.2 Seat Body

The seat used in this design will be a bucket seat designed for children. The bucket seat is shown in Fig. 22.

![Figure 22: Children’s bucket seat.](image)

This seat is advantageous for several reasons. It has a vinyl covering and a significant amount of padding, which will be both comfortable and supportive for the client. The seat also has considerable lateral support, which is particularly important in light of the fact that the client has poor lateral muscle control. This seat is designed to be used with a four point harness, which will be described below. Additionally, this chair comes with a high back, which is useful for two reasons. First, it will prevent whiplash in the event of a collision. Second, it will be used as a mounting spot for the magnetic proximity sensor described below.

2.1.3.4.3 Seat Safety
2.1.3.4.3.1 Four-point Harness

This go-kart will feature a four-point harness restraint system. The four-point harness will be from Corbeau and is a two-inch wide harness made of military grade nylon webbing. The harness also comes equipped with pressure reducing weight pads for a more comfortable ride. This harness also has a push button release system for fast disengagement of the harness.

2.1.3.4.3.2 Magnetic Proximity Sensor

The client that this go-kart is designed for has a tendency to drop his chin to his neck when excited. This requires the creation of a system which will allow for side to side motion but restrict forward motion of the head. This design will incorporate a magnetic proximity sensor, which will be mounted on the top of the bucket seat described above. Additionally, a magnetic strip will be attached to the back of the client’s helmet. A strip was used instead of a single magnet so that the client can turn his head without activating the safety mechanism. A magnetic proximity sensor determines whether a magnet is in the vicinity of the sensor. The output from this sensor would be used to activate the kill switch when necessary.

Magnetic proximity sensors can operate over a variety of ranges. Some require the magnet to be very close for the switch to remain closed, but others can function over a much greater range. It is important to select a sensor which is sensitive enough to activate the kill switch when the client’s head drops, but not so sensitive that the kill switch is activated every time the client is bumped slightly. In the case of this design, the range of the sensor will need to be on the order of a few inches.

2.1.3.4.3.3 Arm Rest

This design includes a joystick which must be mounted in a location convenient for the client. The seat that will be used for this design does not have armrests. Therefore, one will be attached to the side of the seat. The armrest must be wide enough to accommodate the joystick but must not interfere with the client’s enjoyment of the go-kart.

2.1.3.5 Remote Kill Switch

One of the safety measures that will be incorporated into the E-racer design will be a remote control switch which will be used by the client’s guardian. This device will allow the guardian to stop the operation of the vehicle by pressing a button on a remote that is similar in appearance to a key fob. This will be mounted directly to the go-kart’s power supply and to the linear actuator. Devices such as this are commonly found on children’s all terrain vehicles. The kill switch pictured below in Fig. 23 is designed for use in an Eton ATV. We plan to modify this part for use in the E-racer.
2.2 Optimal Design

2.2.1 Objective

This design will include the addition of a joystick to the existing go-kart. The client can control his motorized wheelchair very well and the goal is to mimic this design for the go-kart. Pushing the joystick forward will accelerate the go-kart accordingly through measured changes in voltage. Pulling the joystick backwards will apply the brake accordingly through measured changes in voltage. Pushing the joystick from left to right will also vary voltages recorded through rotary potentiometers in the joystick and turn the go-kart’s front wheels from left to right respectively.

In addition, the go-kart will have a steering wheel which will allow the client to control the go-kart in a way similar to the controls found on a traditional go-kart. This was one of the desires of the client. The steering wheel and joystick will function independently and will offer the client flexibility in his control options based on his confidence in his ability to drive the go-kart.

The system will also allow the client to have good control of the go-kart as soon as he receives the device; there will be no adjustment period as the joystick control will mimic the control he uses on his wheelchair.

Many other changes will be made to the original stock go-kart. The original seat on the go-kart will be modified so that it can rotate 90° to one side and slide outward. This mechanism will increase the client’s ease of entering and exiting the go-kart on his own. In addition to the kill switch built into the go-kart which can be used by the rider if need be, a remote kill switch will be added to the electric motor in order to completely cut off power from the battery. This kill switch can be activated by a button on the go-kart, a wireless remote that the client’s mother will be holding while the go-kart is in use, and also if the go-kart travels out of reach from the wireless remote. A five-point harness will be added to the go-kart to ensure that the client is securely positioned in the seat during travel. Additionally, there will be foot straps to ensure that the client’s feet are secure. While the seat sliders come with a locking mechanism and will attach the seat to the go-kart itself, this design includes a secondary locking system so that the level of stress imposed on the seat swivel mechanism is not too great. Finally, this design incorporates the need to restrict the client’s head movement slightly so that he does not drop his head and lose
sight of the road. This will be accomplished by a neck brace which will be worn on the client’s neck.

2.2.2 Subunits

2.2.2.1 Go-Kart

As mentioned, the Jeep Minimoto Dune Buggy will be modified in this design. This model was chosen for several reasons. The primary reason for selecting this go-kart is that the client’s parents requested that the go-kart be electric. Also, since the go-kart is electric, it will be safer for the client to operate, will not require as much maintenance as a gas-powered go-kart might, and will be much more environmentally friendly. Figure 24 shows the Jeep Minimoto Dune Buggy.

![Figure 24: Jeep Minimoto Dune Buggy](image)

The Jeep Minimoto Dune Buggy has an 800 Watt motor and a 36-volt lead acid rechargeable battery (the battery charger is included). Although the client will presumably not require this, the go-kart features a high torque motor for off road terrain. The go-kart also comes equipped with dual disk brakes and dual shocks. Disk brakes are shown below in Fig. 25. Disk brakes function by forcing brake fluid into a caliper where it presses against a piston. The piston then squeezes two brake pads against the disk, which is attached to the wheel, forcing it to slow down or stop. This model also has a power cut off button on the go-kart itself, which is a very desirable safety feature. The go-kart has forward and reverse modes and has an adjustable roll bar for added safety.
The maximum speed that the go-kart can travel is eighteen miles per hour, which is ideal since it is faster than the client’s current wheelchair, but not so fast as to be unsafe. The go-kart can accelerate from zero to ten miles per hour in approximately 2.3 seconds when carrying a 120-lb load, which is considerably larger than the client. This acceleration is expected with an electric motor, which does not have the same pick-up as a gas-powered engine. The weight of the vehicle is 110 lbs, making it feasible to transport it in a large enough vehicle, but certainly not something that could be done conveniently. The maximum passenger weight is 200 lbs and the maximum passenger height is five feet, ten inches. Both of these measurements are considerably larger than the client, indicating that the client could use the go-kart for many years despite his projected growth.

The go-kart can travel ten miles on one charge, and the battery generally lasts about forty minutes. The battery recharges to 80% in three hours, and is fully recharged in eight hours, making this model ideal for the desired use.

Perhaps the most significant feature of this particular go-kart is that it is electric, meaning that it contains an electric motor. The two main types of go-karts are gas and electric. Electric go-karts are not as popular since they are newer and tend to be less powerful than gas-powered go-karts. Since electric go-karts are generally less powerful, they are generally intended for lighter passengers (i.e. children), which is ideal for this design. Also, powerful electric motors are available and result in go-karts with similar horsepower to gas-powered karts. Electric go-karts offer several advantages over gas-powered go-karts, such as less maintenance, no emissions, no use of gasoline (which introduces safety hazards), and a large amount of low-end torque, which results in greater acceleration from a stopped position.

A working knowledge of the mechanism behind electric motors is essential to designing and implementing the proposed design. Figure 26 shows a DC electric motor and an AC electric motor.
Electric motors work on the basis that an electric current will experience a force when placed in a magnetic field, as shown in Fig. 27. If the current carrying wire is bent into a loop, the two sides of the loop that are at right angles to the magnetic field will experience forces in opposite directions, as seen in Fig. 28.

Figure 26: A DC electric motor and an AC electric motor.

Figure 27: Force on a current in a magnetic field.

Figure 28: Current carried in a bent wire in a magnetic field experiencing opposing forces.
The pair of forces leads to a turning influence (torque) which rotates the coil, as seen in Fig. 29. This turning mechanism is how the motor converts electric energy into mechanical energy. Practical motors have several loops on an armature to provide a more uniform torque and the magnetic field is produced by an electromagnet arrangement call the field coils, shown in Fig. 30.

![Image of forces creating torque](image1)

**Figure 29: Opposing forces creating a torque on the coil.**

![Image of motor with loops](image2)

**Figure 30: A practical motor with several loops.**

The other proposed designs included using a gas-powered go-kart or using a gas-powered go-kart in which the engine was replaced with an electric motor. The electric go-kart was chosen for the optimal design for several reasons. First, the client’s family said they preferred to have an electric go-kart as opposed to a gas-powered vehicle. The converted gas-powered go-kart design was not used as it was not economically feasible. The go-kart in this case would have cost approximately $1800 and to buy an electric motor with the desired power (approximately 800 W) would have cost over a thousand dollars, putting the project far over budget before many parts (seat, controls systems, etc) were even considered. As a result of the client’s wishes and budgetary constraints, the electric go-kart was chosen for the optimal design.

### 2.2.2.2 Seat

The seat of the E-racer will consist of three major components: the body, the swivel mechanism, and the restraint system. It is necessary that the integration of these components into the stock-kart results in a safe, supportive, and convenient seating system. The seat body will provide the necessary lateral support, comfort, and whiplash protection. The swivel mechanism
of the seat will allow for easy entry of the client. Finally, the five-point restraint system will ensure that the user is safely secured in the vehicle.

2.2.2.2.1 Seat Body

The seat which came with the go-kart will not be used because it is flimsy and does not offer the lateral support required by the client. The seat is shown in Fig. 31 below.

![Figure 31: Existing seat on go-kart.](image)

The seat used in this design will be a bucket seat designed for children. The bucket seat is shown in Fig. 32.

![Figure 32: Children’s bucket seat.](image)

This seat is advantageous for several reasons. It has a vinyl covering and a significant amount of padding, which will be both comfortable and supportive for the client. The seat also has considerable lateral support, which is particularly important in light of the fact that the client has
poor lateral muscle control. This seat is designed to be used with a four point harness, which will be described below. Additionally, this chair comes with a high back, which is useful since it will prevent whiplash in the event of a collision.

This seat, unlike the seat designs proposed in the other two designs, is a seat designed for racing. Go-kart seats can be broken into two general categories: reclining seats and fixed back seats. Reclining seats, which seemed unnecessary and were not used in this design, are further broken into two categories: those with no lateral support (Fig. 33) and winged seats (Fig. 34). Also, some seats come with holes for a restraint harness, while others do not. Since this design incorporated a five-point harness, it seemed that a seat with holes for a restraint system should be used.

![Figure 33: Reclining seat with no lateral support.](image)

![Figure 34: Reclining seat with lateral support.](image)

Non-reclining seats can also be broken into two categories: those with lateral support and those without. An example of a fixed back seat without lateral support is shown in Fig. 35, and one with lateral support is shown in Fig. 36.
Since the client tends to lean to the side, the seat used in this design had winged support. Also, lateral support makes it more difficult for the rider to slide out the side, making the go-kart safer. As can be seen in the pictures above, fixed back seats provide more lateral support in the hip area since the seat is continuous, rather than being two connected parts, as in the reclining seats. This added support is beneficial to the client, providing a further reason to use a fixed back seat.

The seat must also have an armrest to accommodate the joystick that will be added to the go-kart. The armrest must be wide enough to fit the joystick, but not so wide that it impedes the client while he is driving. The armrest will be attached to the floor of the go-kart on the right side of the seat so that the seat can slide out to the left in order for the client to enter. This will be made by purchasing a two-by-four piece of lumber and cutting it to about a foot long. A piece of thick foam will be placed on top of the wood, followed by a piece of vinyl fabric which will be stapled into the wood. The armrest will be mounted on a system of two T-slotted aluminum supports joined by another T-slotted aluminum piece. The actual armrest will be mounted on the aluminum piece joining the two bases, as shown in Fig. 37. The ends of the two aluminum side supports will be bolted into the floor of the go-kart next to the seat.
Figure 37: Attachment of joystick mount, armrest and joystick to go-kart.

Figure 38 below shows the aluminum pieces which will comprise the joystick mount.

Figure 38: Aluminum supports for joystick.

The other two designs considered for the seat were the bucket seat and attached head rest, and the injection molded seat. The racing seat was chosen because of its lateral support, generous cushioning, built-in head rest and ease of attachment of a restraint system. Also, this seat is affordable ($120) and has a durable vinyl cover. The seat with the attached head rest was not
chosen as the sum of the cost of the parts and the added labor to combine the parts made it not a feasible option. The injection molded seat, while a good idea in theory as it would allow for the seat to be custom made, is not feasible since injection molding is generally only used for mass production and the added cost and effort resulted in this design not being viable. The numerous benefits of the racing seat make it the obvious choice over the other proposed designs for the go-kart seat.

2.2.2.2 Swivel Mechanism

The seat swivel mechanism of the E-racer will provide the user with a rapid, easy method to enter the vehicle. The goal of the seat swivel is to allow the user to sit on the seat when it is extended and at a 90 degree angle to the vehicle, to buckle into the five point harness (that will be discussed in the following section), and to swivel and lock into the operating position with the help of a guardian. Since the client’s condition makes fine movement difficult, this entry mechanism will provide the user with a simple method to enter the vehicle and will enhance his overall enjoyment when using the E-Racer. The process of moving the seat into the loading position is shown below in Fig. 39.

![Figure 39: Seat swivel overview.](image)

The motion of the seat will be achieved through the use of two seat sliders and one swivel mechanism. This configuration is that same as the system that was presented in Alternative Design 1. This method of achieving the desired seat movement was selected since it did the best
job at satisfying the requirements of the client while minimizing interference with existing components in the go-kart.

One of the designs that was explored involved the use of a rotating arm that would operate in a similar manner to a lecture hall chair. The main problem with this design was the lack of available parts on the market that would be necessary to manufacture such a system. While it is likely that the swivel arm could have been custom-made in the machine shop, doing so would have required a considerable amount of labor. Since the act of incorporating stock parts into the go-kart will require a great deal of labor, adding more labor in the construction of custom parts is simply not feasible. Additionally, while the optimal design for the seat swivel will allow the seat to move forward as far as possible without interfering with the vehicle controls and then to rotate 90 degrees, the swing arm design assumed that the controls would be far enough away from the arc of the moving chair to prevent interference. Since this assumption could lead to considerable complications in the construction of the vehicle, the rotating arm will not be used in the entry mechanism for the E-racer.

The final design that was explored involved the use of two heavy-duty sliders to fully extend the chair out from the side of the kart. Although this design is desirable due to its simplicity and ease of use for the client, it is likely that this entry method would present many obstacles when installed in the stock go-kart. The main concern with the use of this design in the go-kart is that the kart’s fenders and roll cage would interfere with the motion of the chair. Since specific vehicle dimensions will not be available until the product arrives, it is difficult to know whether the use of the heavy duty sliders is a viable option. If there is major interference with these components, considerable alterations to the structure of the kart would have to be made. These modifications could significantly compromise the integrity of the vehicle and therefore such modifications will be avoided. Additionally, since the chair would be fully extended from the vehicle in the loading position, there would be a risk that the kart could tip to the side if the occupant is too heavy. This device is being constructed specifically for a young boy weighing approximately twenty-two kilograms which will likely be small in comparison to the final weight of the vehicle. As a result it is doubtful that the kart would tip when the client enters the vehicle. However, if another, heavier individual were to use the kart, the chances of injury would increase. With safety being the primary concern in the construction and use of the E-racer, it has been determined that the entry mechanism from the first alternative design is simply a better choice.

When compared to the two designs discussed above, it is clear that the seat swivel mechanism presented in Alternative Design 1 is the best choice for use in the E-Racer project. The seat swivel mechanism will be constructed through the use of stock parts that are available for purchase from online retailers. The mechanism will be installed in the vehicle without drastic alterations to the frame and roll-cage of the kart. Finally, the seat swivel mechanism will provide the client with a safe, easy way to enter the vehicle, without risk of the vehicle tipping to the side. The seat swivel device will be constructed and installed in the vehicle as described below.

The seat slider that will be used in the seat swivel mechanism will allow for the linear movement of the seat as it moves forward from under the roll cage and also when it extends out from the vehicle. While there are many seat sliders available on the market for automobiles, the device used in the E-Racer is unique in that is must be small enough to both fit in a small vehicle and also accommodate a small racing seat. Since the E-Racer will be powered by an electric motor it will be crucial to maximize the amount of time that the vehicle can operate on a single charge, and as a result it is important that the seat sliders be relatively lightweight in order to
minimize overall vehicle weight. Additionally, since two seat sliders must be used in the fabrication of the seat swivel mechanism, cost is a major factor that must be taken into consideration. The online retailer Desert Karts sells the seat adjuster slider shown below in Fig. 40.

![Seat adjuster slider](image.png)

**Figure 40: Seat adjuster slider.**

At a cost of $25 per pair, the seat adjuster slider is an affordable and effective device that will be used in the fabrication of the seat swivel mechanism. The seat adjuster sliders will be a good choice for use in the seat swivel mechanism due to their low profile and their ability to slide and lock in place with the use of a hand lever. This device is similar to those found in automotive applications, where the front seats of a vehicle can be adjusted fore and aft to accommodate drivers of various heights. When applied to the E-Racer, the seat adjuster slider will be used to move the seat forward and out from the side of the kart as is shown below in Fig. 41 and Fig. 42 respectively.
Chair slides toward front of kart, away from roll cage

**Figure 41: Seat swivel mechanism in forward motion.**
The seat adjuster slider mechanism is superior to other designs since they allow for fine control of the amount of forward seat travel. This ability to carefully manipulate the motion of the seat will be highly beneficial when the device is installed in the Minimoto go-kart, where interference with controls will be a major consideration. The use of the seat adjuster slider in the construction of the seat swivel mechanism will provide the user with a simple, convenient way to enter the vehicle.

The swivel that will be used in the seat swivel mechanism will allow for the rotational movement of the seat as it spins 90 degrees, as shown below in Fig. 43.
Since the swivel will have to support the weight of the occupant, the seat, and one seat slider, it is important that the device can support a considerable amount of weight while still being able to rotate smoothly and easily. Additionally, it will be important to ensure that the seat is not raised considerably due to the presence of the seat swivel mechanism, and as a result the swivel that is purchased must be low-profile. The swivel chosen for the design will be a 12 in. heavy-duty lazy susan with a load rating of 1000 lb (4448 N). This specific model is an excellent choice for use in the E-Racer due to its robust, low-profile construction and high load rating. This device can be purchased from the online retailer Rockler for under $10 and will allow for the rotation required by the seat swivel mechanism. The heavy-duty lazy susan is shown below in Fig. 44.
By combining the motion of the sliders and the swivel into one finished device, seat swivel mechanism will effectively allow the final seat to slide forward from under the roll bar and also extend out at a 90 degree angle from the kart. Also, since the sliders and the lazy susan are low-profile the seat should not be raised considerably.

Since the seat swivel will make use of the seat sliders in a way that is slightly different than their intended application it will be important to perform an analysis of the forces present in the system when the user is seated in the extended in the chair. A simple free body diagram of the forces at the sliders is shown below in Fig. 45.
From this diagram, an equation of the sum of the forces acting on the slider can be determined:

$$\sum F = 0: (m_r + m_s)g - N = 0$$

where $m_r$ is the mass of the rider, $m_s$ is the mass of the seat, $g$ is gravitational acceleration, and $N$ is the reaction force. From this equation the following relationship can be derived:

$$N = (m_r + m_s)g$$

For the rest of this explanation:

$$W_T = (m_r + m_s)g$$

where $W_T$ is the total weight of the rider and all of the seat components. As a result,

$$N = W_T$$

and assuming that the slider will attach to the kart at four points, the reaction force at each of the attachment points ($N_A$) will be:
when the seat is in the operating position.

An analysis of the forces present at each of the attachment points can now be made. For this analysis, the assumption will be made that the weight of the rider is evenly distributed over the seat. The following analysis will focus on one of the two tracks that will allow the seat to slide forward from under the roll bar. When the seat is in the operating position, the forces in the track are as follows:

![Diagram of forces on track in operating position](image)

*Figure 46: Forces on track in operating position.*

where $L$ is the length of the track and $W_T/2$ is the total weight applied to a single track. Summing the moments about point $A$:

$$\sum M_A = 0: -\left(\frac{L}{2}\right)\left(\frac{W_T}{2}\right) + (L)(F_B) = 0$$

Thus:

$$F_B = \frac{W_T}{4}$$

Summing forces in the $y$-direction:

$$\sum F_y = 0: \frac{W_T}{2} - F_A - F_B = 0$$
yielding:

\[ F_A = \frac{W_T}{2} - F_B = \frac{W_T}{2} - \frac{W_T}{4} = \frac{W_T}{4} \]

Thus, it can be seen that the forces at the points of attachment on a single track are equal to the total weight of the seat and rider divided by four.

When the seat moves forward into the second position as shown in Fig. 41, the forces in the seat track are as follows:

\[
\begin{align*}
\sum M_A &= -x \left( \frac{W_T}{2} \right) + (L)F_B = 0 \\
F_B &= \frac{xW_T}{2L} \\
\sum F_Y &= 0: \frac{W_T}{2} - F_A - F_B = 0
\end{align*}
\]

yielding:
Now that the force equations have been derived it is possible to apply some real-world values in order to approximate the forces that will be present at each of the four attachment points. The mass of the client is 22 kg and it is unlikely that the mass of the components that make up the chair will be any more than 8 kg. Thus the total can weight can be calculated:

\[
W_T = (30kg)(9.81m/s^2) = 294.3\text{N}.
\]

Additionally, it can be assumed that the length of the track \((L)\) is 40 cm and that the chair moves forward a distance of 10 cm.

\[
x = \frac{40\text{cm}}{2} - 10\text{cm} = 10\text{cm} = .1\text{m} \\
L = 40\text{cm} = .4\text{m}
\]

To find the values of \(F_A\) and \(F_B\), the values can be plugged into the force equations:

\[
F_A = \frac{294.3\text{N}}{2} \left(1 - \frac{.1\text{m}}{.4\text{m}}\right) = 110.36\text{N} \\
F_B = \frac{(.1\text{m})(294.3\text{N})}{2(.4\text{m})} = 36.8\text{N}
\]

From this analysis, it can be estimated that when the chair slides forward 10 cm, each of the front attachments will carry approximately 110 N of force while the rear two attachments will each carry approximately 37 N of force.

An identical analysis can be performed for the other slider track, while this track will not have to support the weight of the swivel mechanism and a slider unit. It is important to note that the front left support will carry the greatest amount of weight when the cumulative effect of the seat motion is taken into consideration. In this way, the use of statics may be used to solve for the forces present in the system to ensure that the swivel mechanism can withstand such forces.

A final aspect of the swivel mechanism to take into consideration is the security of the system. While the slider mechanisms specified above lock into place, the swivel used in the seat swivel mechanism rotates freely making it necessary to provide an additional safeguard to ensure that the chair is firmly secured to the kart. This will be accomplished through a simple system that will temporarily and securely fasten the seat to the frame of the vehicle during operation. The fastening system will make use of two metal plates that will be attached to the back of the seat and two metal plates that will be secured to the kart’s frame. When the seat is in the loading position, the two plates on the seat will align with two plates on the kart’s frame. A metal rod will slide through a hole in each of the plates and will be secured with a hairpin-style cotter pin. This system is shown below in Fig. 48.
Since this lock mechanism is specific to the E-racer, it will be necessary to design and construct the device from stock materials in the machine shop. The seat and the frame of the vehicle will need to be examined in order to determine the optimal mounting location of the metal plates. Once this is done the plates and the rod can be fabricated and mounted. In order to allow for the proper operation of the cotter pin, a hole will be drilled through the non-flanged end of the metal rod. The straight portion of the pin will be inserted into the hole, forcing the pin to temporarily deform and apply pressure to the curved surface of the metal rod. As a result this pressure, the pin will be effectively be locked into place, thus preventing the removal of the metal rod from the plates. Various pins of the hairpin style are shown below in Fig. 49.
Figure 49: Hairpin-style cotter pin.

Figure 50 shows the use of the hairpin-style cotter pin to hold the metal rod in place.
The hairpin-style cotter pin will be effective in this application since it is designed to be strong, secure, and economical, while not undergoing permanent deformation in its use. As a result, this type of cotter pin can be reused, which is required by the application in the E-racer since the seat swivel mechanism will be secured and released hundreds of times over the life of the vehicle.

The construction and implementation of the seat lock is the final step in the construction of the seat swivel mechanism. An overview of the procedure for operating the seat swivel mechanism, including the incorporation of the seat lock, is shown below in Fig. 51.

---

**Figure 50: Operation of hairpin-style cotter pin.**

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The construction and implementation of the seat lock is the final step in the construction of the seat swivel mechanism. An overview of the procedure for operating the seat swivel mechanism, including the incorporation of the seat lock, is shown below in Fig. 51.
Figure 51: Seat swivel mechanism procedure for operation.
2.2.2.3 Remote Kill Switch

One of the major safety measures that will be incorporated into the E-racer design is a remote kill switch that will allow the user’s guardian to stop the vehicle at any time with the push of a button. Many of these devices are available on the market since they are commonly used in children’s all terrain vehicles. One such product is 3Built’s Remote Engine Shut-off system (Model # RES12VU) shown below in Fig.52.

![Remote engine shut-off system](image)

According to the manufacturer’s website, the Remote Engine Shut-off system is built to cut a vehicle’s ignition system at the push of a button and is operational up to a distance of 250 ft. (76.3 m). This system “can be installed on virtually any motorcycle, ATV, snow-mobile, go-cart, generator, rhino, rock crawler, truck or car,” although the vehicle’s wiring diagram may be necessary during the installation process. 3Built’s product uses a small, two-button controller which sends a signal to a receiver on the vehicle. When the receiver gets the signal from the remote it either activates or releases a relay that functions in a similar manner to the factory off/run switch. When applied to the E-Racer, this system will use the relay to cut off power to the electric motor. An overview of the operation of the device and its integration into an ignition system is shown in the manufacturer’s installation instructions and is duplicated below in Fig. 53.
In the E-racer, pressing the lock button on the remote will activate the relay in the receiver, which will in turn disable the vehicle’s electric motor. Pressing the unlock button would release the relay, allowing the vehicle to operate on electric power. Figure 54 below shows a flow chart of the kill switch activation.
The kit includes the RES Receiver, the RES Remote Control, wire connections, a quick disconnect, zip ties, and instructions. The 3Built Remote Engine Shut-off system RES6VU-B sells for a retail price of $69.99 and is available through the manufacturer’s website.

In order to incorporate the remote kill switch into the E-racer, the wiring diagram of the Minimoto Jeepster will have to be acquired, or the electrical system of the vehicle will have to be examined in order to gain a better understanding of its operation. Once this is accomplished, the REI receiver of the remote kill switch will be tied into the circuitry of the vehicle, and will basically work as a switch to apply or remove power to the electric motor.

Other designs explored the use of a remote kill switch intended for use in an Eton ATV. While this device functioned similarly to the 3Built Remote Engine Shut-off system, 3Built provides superior instructions and customer support which may be critical when the device is incorporated in the E-Racer design. For that reason the 3Built unit will be used in the construction of the E-Racer.

### 2.2.2.4 Restraint System

The restraint system of the E-racer will consist of three main parts: the five-point harness, the foot restraints, and the head restraint system. The goal of the restraint system is to keep the operator firmly secured to the seat and provide support during kart operation. However, this security and support must be comfortable for the user since the kart may be operated for an extended period of time.
A five-point harness is the standard of competitive automobile racing and provides the user with a firm, comfortable fit. This harness is superior to two, three, and four-point belt designs due to the fact that it uses two shoulder belts, a lap belt, and a belt that attaches between the legs. As a result of this design, the user’s entire torso is well restrained. RCI manufactures the “RCI Universal 5-Point Harness,” which retails for approximately $140. This harness is shown below in Fig. 55.

![Fig. 55: RCI Universal 5-Point Harness.](image)

The adjustability of this harness will allow the user to have a good, firm fit that will be comfortable during the operation of the kart. While it is typically required that a seat belt is attached to the frame or sub-frame of a vehicle, doing so will not be possible in the E-racer since the user will be buckled into the seat when it is extended and at a 90 degree angle to the kart for easy entry. As a result, it will be essential that the harness is firmly fastened to the seat.

The five-point harness was chosen over the three- and four-point harnesses for the obvious reason of the added safety afforded by the five-point harness. All three harnesses are made out of similar material, but the five-point harness offers additional safety for only slightly more money. Therefore, the five-point harness was chosen as a result of safety and budgetary considerations.

Foot straps will make up the second aspect of the restraint system. Since the client is unable to use his feet for fine motor control the feet will not be used in the operation of the kart. As a result his feet can be fastened to the kart for added security. These straps will be made of nylon that has a 1000-lb breaking strength, which is more than sufficient for the client. The ends of the nylon will be bolted to the floor of the go-kart and then threaded through a plastic buckle shown in Fig. 56. This buckle will allow for adjustment of the straps as the client grows.
Figure 56: Plastic buckle used with nylon strap to secure client’s feet to the floor of the go-kart.

Figure 57 shows the five-point harness and foot straps as they will be used to secure the client.

Figure 57: Five-point harness and foot straps.
A standard seat belt such as those found in cars would keep the client against the seat if the go-kart stopped, but would not prevent the client from sliding out underneath the belt. The five-point harness prevents this, keeps the client against the seat if the go-kart rapidly comes to a stop, and prevents him from sliding out the side of the seat. Therefore, the five-point harness satisfies many safety needs and is a very beneficial addition to the go-kart.

To address the issue of the client’s chin dropping to his neck when excited, this design will feature a neck brace commonly used in motocross and go-kart racing. The brace will be the EVS RC3 Neck Support, shown in Fig. 58 below. The brace is intended to prevent injury in the case of a collision, but will also be used to prevent the client’s head from dropping. If the foam on the front part of the brace is not stiff enough to prevent downward motion of the head, more foam can easily (and cheaply) be added. This neck brace is easily removable and allows for side to side motion, but will prevent to much forward flexion.

![Figure 58: EVS RC3 Neck Support.](image)

Figure 59 below shows a side view of the neck brace and how the brace will provide the desired support.
Clearly, the client would probably have a more comfortable ride if he did not wear the neck brace. Also, he will probably not be traveling so fast that the neck brace is needed for general riding (the neck brace is generally used for off-road, high speed riding which is unlike the type of riding the client will be doing). Therefore, once the client is used to riding the go-kart and is no longer overwhelmed with excitement when riding, he will probably not need the neck support anymore. The limited use of the neck support is a strong reason to keep financial constraints in mind when purchasing the neck support, and make the EVS RC3 a viable option for this design.

The neck brace was chosen for the optimal design over the other three designs primarily for safety and feasibility reasons. The other three options were the polymer strap, the magnetic proximity sensor and the Leatt neck brace. The polymer strap was slightly less safe than desired because of the fact that if the go-kart stopped suddenly and his restraint was not sufficiently tightened, the client would be pushed forward. When the client’s head moved far enough that the polymer strap was taut, if he still had momentum, he may injure his neck. The magnetic proximity sensor was feasible in theory, but may be too sensitive for the desired application. Also, the electronics behind the sensor are reasonably delicate, so the jostling that would occur if this were implemented in the go-kart may affect the operation of the sensor. The Leatt neck brace was not chosen because although it performed many functions which would lead to added safety, the brace allows for forward flexion of up to 45°. While this is still sufficient to prevent injury in case of a collision, it is not sufficient to prevent the client from looking down. The brace could be modified with the addition of foam to the front of the brace, but at $400, this did not seem to be a wise financial decision. The proposed brace (EVS RC3) may need some modification, but it only costs $36 and is therefore a much more economical choice.
2.2.2.5. Seat Integration

The integration of all the units of the seat into one unit is just as important as deciding which components to purchase. The existing seat in the go-kart will be removed. Figure 60 shows the seat that comes with the go-kart.

![Figure 60: Seat which comes with the go-kart.](image)

Although this seat does come with holes for a five-point harness, it will not be used because it does not have a head rest and offers no lateral support. Also, the front wheel fenders must be modified to be smaller or else removed altogether. Figure 61 shows the wheel fenders on the go-kart.

![Figure 61: Wheel cover and seat on go-kart.](image)

The wheel fenders must be modified or removed so that the sliding entry mechanism will function properly. If the wheel fenders were kept as is, the seat would not be able to slide out. The sliding mechanism described above will be attached to the body of the go-kart using the appropriate hardware (screws, nuts/bolts, etc.). The seat will then be attached to the sliding mechanism by drilling the necessary holes in the bottom of the seat. The five-point harness comes with bolt-in and wrap around mounting hardware, so it will be attached to the seat by drilling the necessary holes and using the supplied hardware.

As mentioned above, the foot straps will be attached by screwing holes in the floor of the go-kart and using nuts and bolts to secure the straps. The neck brace needs no integration and will be an external safety measure not attached to the go-kart.

2.2.2.6 Control System

The client will have the option of using either a joystick or a steering wheel to control the kart. While in steering wheel mode, the operator will use two hand pedals located behind the
steering wheel to accelerate and decelerate the kart. The mode of operation will be chosen before the cart is moving. The mode will be selected using a simple switch on the kart’s main control panel. Only one mode will be used at any given time. In other words, while one mode is being used, the other one will be deactivated. The switching mechanism will be described in a later section.

This control system is better than other suggested designs because it offers the client flexibility as he grows and becomes more comfortable with the kart. We are expecting that the client will be able to use the joystick control as soon as the kart is delivered (because of his previous experience with his joystick controlled wheel chair). The wheel/hand pedal system will take more time and training than the simple joystick mode. Also, another very important aspect to this project is making the go kart as “normal” as possible. We want our client to fit in with his friends and we do not want the design to be extravagantly different from a normal go kart. Our client feels as though he will be most comfortable if he has a steering wheel on his go kart like all his other friends.

2.2.2.6.1 Joystick Mode

An analog joystick from a Playstation 2 controller will be used to control the go kart (Figure 62).

![Analog joystick base from Playstation 2 controller.](image)

This dual axis joystick consists of two 10K potentiometers and a push down switch. The driver will be able to push down on the joystick to kill the kart’s power in case of an emergency (implementation described below). Each of the two potentiometers produce a voltage signal based on the position of the joystick. One signal corresponds to the horizontal position of the joystick. This signal will be used for steering. The other signal corresponds to the vertical position of the joystick. This signal will be used for acceleration and braking. A voltage between 2.5V and 0V from the vertical signal (moving the joystick forward) will accelerate the kart while a voltage between 2.5V and 5V (pulling back on the joystick) will apply the braking system. The variable output voltage will allow the user to have some control over the rate at which the vehicle is accelerated.
The vertical voltage will be sent to pin 2 of a PIC 16F874A microprocessor (Port A configured for input). The PIC will determine if the voltage is less than or greater than 2.5V. If the voltage is less than 2.5V, it will be subtracted from 2.5V and sent to the motor speed control system (via pin 16 of Port C, configured for output). If the voltage is greater than 2.5V, 2.5V will be subtracted and the voltage will be sent to the joystick mode braking system. The comparison performed by the PIC is described in the block diagram shown below in Fig. 64.

**Figure 63: Block Diagram for Joystick Mode Acceleration and Braking**
2.2.2.6.1.1 Joystick Mode Motor Speed Control System

A DC motor speed control kit will be obtained from Karl’s electronics (Figure 65).

This control system uses two timers/oscillators configured for pulse width modulation. A 10K potentiometer is used to control the speed of the motor. A detailed circuit diagram can be found below in Fig. 66.
Figure 65: Circuit diagram for motor speed control.

The motor is always connected to +/- M. “LK1” will not be used in this application because we will be using separate sources for the motor and for V+ in the circuit diagram above (Note 1). “P1” can be adjusted to change the maximum speed allowed. The operator’s supervisor (parents) will be able to change this maximum speed setting.

For this application, the pot “RV1” seen in Figure will not be used. Instead, the vertical pot signal from the analog joystick will be used in place of “RV1”. The vertical pot from the joystick is also a 10K pot and outputs a range of 0-5V. However, since only half of the signal range (2.5V-0V) is being used for acceleration, the signal will need to be amplified by a gain of two before being sent to the motor speed control unit. This amplification will be accomplished using Analog Devices AD823 Operational Amplifier (Figure 67). The microprocessor and the amplification will be inserted at the node circled in red on Fig 66.
This amplifier will be powered with a single supply (+5V). The AD 823 will be used in the circuit as shown below in Figure 68.

\[ R_z \text{ has no effect on the gain of the amplifier. The gain of the circuit is equal to } \frac{R_f}{R_{in}} \text{ and will be made equal to 2 for this application.} \]

**2.2.2.6.1.2 Joystick Mode Braking System**

In joystick mode, pulling back on the joystick will cause the vertical voltage signal to increase above 2.5V. DiffB (Signal minus 2.5V) will be used by the PIC to calculate the percentage that the joystick is moved from the horizontal midline. This percentage will be used...
to create an AC signal with the same %duty cycle. The signal will be sent to a DC linear actuator that will apply the brakes according to Fig. 80 (via pin 16, Port C configured for output). As the %duty increases, the average DC voltage increases, and the linear actuator shortens. When the linear actuator shortens, more pressure is applied to the disk brakes via a caliper resulting in deceleration.

The FA 150 linear actuator from Frigelli Automations will be used for the braking system and is shown below in Fig. 69.

![Linear actuator for braking system.](image)

**Figure 68: Linear actuator for braking system.**

This actuator runs off 12V DC and has a maximum load capacity of 150lbs. The actuator moves at a rate of 0.5inches/sec and extends a maximum distance of 2 inches.
2.2.2.6.1.3 Joystick Steering

Steering will be accomplished using the feedback system described in below in Fig 71.

Figure 69: Linear actuator braking modification design.

Figure 70: Feedback steering system.
The horizontal signal from the joystick ranges from 0-5V (2.5V being centered). This signal (Fig. 71 – “set value”) will be sent to the positive terminal of the differential amplifier (Figure 71). The output of this differential amplifier (Texas Instruments INA117P – Figure 71) will be sent to a DC actuator that will move the rack of the rack and pinion steering.

![Texas Instruments unity gain difference amplifier.](image1)

A linear position transducer, or LPT, (shown below in Fig. 72) will be attached to the rack to determine where the rack is relative to the center position (Fig. 77). This transducer was chosen based on its ability to function properly and accurately independently of external conditions (Celesco CLP series 10 inch linear position transducer).

![Linear position transducer.](image2)

The position transducer has a range of 1K to 11.5Kohm resistance. A proper input voltage will be provided that result in output a voltage range of approximately 0-5V (2.5V at half extension). The signal from this position transducer will be sent to the negative terminal of the DA. The DA will output a voltage that is equal to the position voltage (from the linear position transducer) subtracted from the set position voltage from the joystick. When the joystick is centered, the voltage from the position transducer will be subtracted from 2.5V (from the joystick). Initially, the wheels will be centered and as a result the position transducer will be “centered” and output a voltage of 2.5V. Therefore, no movement will occur. However, as the joystick is moved right,
the “set value” will decrease below 2.5V. As a result, the DA will output a negative difference. This negative voltage will be sent to the DC actuator which will rotate the tires toward the right. As the wheels turn, the difference will approach zero, the DC actuator turning the kart will slow down, and the desired position will be held until the joystick is moved again.

The actuator chosen to move the rack is FA-200-TR-24 from Firgelli Automations, which is shown below in Fig. 73. This track actuator can handle loads up to 200lbs and operates at 24V.

![Figure 73: Track actuator for steering.](image)

2.2.2.6.2 Wheel Mode

The factory installed wheel on the Minimoto go kart will be used for wheel mode operation and is shown below in Fig. 74.
The two hand pedals located behind the wheel on the right and left sides will be modified for braking and acceleration, respectively. The user has better control of his right hand. Therefore, for safety concerns, the right hand pedal will be used for braking.

**2.2.2.6.2.1 Wheel Mode Acceleration**

The left hand pedal (located behind the steering wheel) will be used for acceleration. When the left hand pedal is pulled inwards, toward the driver, a cable connected to a linear position transducer will be pulled (Celesco CLP series 2 inch LPT, see Fig. 72). The output voltage from the LPT will be sent to a PIC microprocessor (pin 33, Port B configured for input). This microprocessor will calculate the percent that the handbrake is pulled back (based on a known voltage level for maximum pull). The same percentage of 5V will be output to the motor speed control circuit at the node circled in red on Fig. 66. This 0-5V signal will be output from pin 19 of the PIC (Port D configured for output).

**2.2.2.6.2.2 Braking in Wheel Mode**

In wheel mode, the right wheel pedal will control the braking. Another linear position transducer (same model as used for acceleration hand pedal) will output a voltage to the microprocessor based on the distance that the pedal is pulled in towards the user. Pin 34 will receive this signal (Port B, configured for input). Again, the percent of maximum pull will be
calculated and used for the generation of a PWM signal. This signal will be sent to the DC linear actuator as done for the joystick braking control (via pin 20 of Port D).

2.2.2.6.2.3. Wheel Steering

The Minimoto Jeep Dune Buggy comes equipped with a fully functional steering wheel (Fig. 74). This wheel functions mechanically and is not power assisted. Our client’s medical condition limits his strengths and he would not be able to mechanically turn the tires using the steering wheel. Therefore, the steering wheel will remain on the vehicle; however, it will be disconnected from the mechanical steering mechanism. Instead, the shaft coming off of the steering wheel will be directly connected to a hollow shaft potentiometric angle sensor from Novotechnik, which is shown below in Fig. 75.

![Hollow shaft angle sensor](image)

*Figure 75: Hollow shaft angle sensor.

The steering wheel will be restricted to the rotations described below in Fig. 76. The user will only be able to rotate the wheel 135° in either direction. The output from the angle sensor will be sent to the microprocessor (pin 35 of Port B).
Figure 76: Wheel rotation limitations.

The microprocessor will then calculate the percent that the wheel is rotated in one direction. This percent will be used as the %duty cycle for PWM calculations. The calculated PWM signal will be sent to the track actuator (previously described) which will turn the wheels on the kart. This signal will be output from pin 21 (Port D). The block diagram in Fig. 77 describes the control of turning using the steering wheel.
2.2.2.6.3 Summary of Voltage Sources

This kart will require three voltage levels. 5V is required for most of the integrated circuit chips (i.e. PIC, AD 823, etc.). The linear actuators require 12V and the linear position transducers will require approximately 10-12V (based on calibrations). All of these voltages will
derive from a 12V rechargeable battery that will be mounted in the rear of the kart. A Texas Instruments UA7805CKCS voltage regulator will be used to down regulate the 12V to the 5V required. A 10K set pot will be used to calibrate the voltage going to the LPT’s.

The 24V required by the track actuator will be derived from the 36V rechargeable battery powering the go kart’s motor. The 36V will be down regulated by a Texas Instruments UA7824CKC voltage regulator.

A replacement 36V battery will be purchased from Dewalt (Model number DC9360). This rechargeable battery pack will be encased in a box that is the same size as the 36V battery pack that came installed in the Minimoto go kart. Therefore, the encased battery will be easily interchanged. Figure 78 below shows the 36V battery that will be purchased from DeWalt.

Figure 78: 36V rechargeable DeWalt battery.

Figure 79 below shows the battery that came with the Minimoto. Again, this is a square battery and a box of similar size will be built to house the DeWalt battery.
2.2.2.6.4 Pin Usage Summary for Microprocessor

A summary of the pin usage on the PIC microprocessor is given below in Fig. 80.
2.2.2.6.5 Switching Mechanism

As previously stated, the driver will have to select the mode of operation before the kart is in motion. All functions of the joystick will be handled by Ports A (inputs) and C (outputs) of the microprocessor. Also, all functions of the steering wheel (including the hand pedals for acceleration and braking) will be handled by Ports B (inputs) and D (outputs). Four single pole double throw switches will be needed to effectively choose a desired mode of operation (joystick or wheel). However, for simplicity, these four switches will be integrated into one simple switch as is shown in Fig. 81. Code written for the PIC will incorporate the signal at pin 21. If pin 21 is high (+5V), the PIC will assume the user has selected joystick mode. If pin 21 is low (0V), the PIC will assume the wheel mode has been selected. Each of the poles on the left hand side of Figure will have a 10k resistor going to ground. Therefore, when the poles are not selected, they are grounded instead of floating.
2.2.2.6.6 Joystick Cover

Since the joysticks which come as part of gaming systems are quite small, the electronic component of the joystick on a video game controller will be used but a larger knob is needed for the client. Therefore, the knob joystick pictured in Fig. 82 will be used.
This joystick comes with the electronic components and the plastic casing. The electronic components will be removed and the casing will be used with a different electronic component. The diagram in Fig. 83 shows that this joystick is made up of many parts which are screwed together, making its disassembly easier.
This joystick was chosen due to the low-profile molded nylon knob which will be easy for the client to use but will not impede his riding if he switches over to steering wheel mode.

2.3 Prototype

The E-Racer prototype relies heavily on mechanical components from the stock Jeep Minimoto Dune Buggy go-kart. Unchanged from this vehicle are the frame, suspension, wheels, tires, bumpers, grill, and some cosmetic trim. Considerable alterations were made to the vehicle’s braking system through the addition of a linear actuator and the required hardware to integrate this device into the system. Alterations were also made to the stock steering rack to accommodate a steering linear actuator along with a linear position transducer. While the
steering wheel supports from the stock kart are used in the final prototype, the mounting points for this device have been modified to allow for adjustment to meet the needs of the client. Finally, the seat and seatbelt from the Jeep Minimoto were removed completely to allow for the installation of a far more supportive, more comfortable seat that makes use of padded side supports to meet the specific needs of the user. Also, the single-strap seatbelt was replaced with a strong, snug-fitting five-point racing harness that will provide a more secure fit during vehicle operation.

2.3.1 Portions of the E-Racer Unchanged from Stock Go-Kart

The main component that is used from the stock Jeep go-kart is the vehicle’s frame. The frame consists of a main frame where the occupant sits, along with two sub-frames: the front suspension sub-frame to which the front wheels and suspension are attached, and the rear sub-frame which houses the vehicle’s motor, main battery, accessory battery, and speed controller. The E-Racer prototype is shown in Fig. 84 below.

![Figure 84: E-Racer prototype.](image)

The stock Jeep frame provided an excellent foundation on which to make modifications to meet the needs of the client.

The suspension from the stock go-kart has also been left intact. As shown below there are two sets of suspension systems. The front suspensions are shown below in Fig. 85, and the rear suspensions are shown in Fig. 86.
The front of the kart has two sets of spring that connect the main frame to the front suspension sub-frame. With the installation of the steering linear actuator, these springs had to be adjusted so that they do not compress considerably. This had to be done to prevent interference with the linear actuator since it was feared that a large bump would allow the suspension sub-frame to hit the linear actuator and damage it. The rear suspension consists of a single spring and connects
the rear sub-frame to the main frame. The adjustment on this suspension component was left unchanged. As a result the rear suspension is still fully functional and will allow the user to have a far more-comfortable ride than is present in other recreational vehicles without such a feature.

The wheels and tires from the stock Jeep Minimoto were not changed at all since we found their design and construction to be very suitable for our use in the E-Racer. Figure 87 below shows a front wheel on the E-Racer.

![Figure 87: Wheel on E-Racer.](image)

The wheels are made to be durable and cosmetically attractive and we felt no need to modify them in any way. Similarly, the tires on the stock vehicle are very good for use in the E-Racer. The tires are pneumatic, meaning that they are filled with air rather than being solid rubber. This is desirable since pneumatic tires deliver a much smoother ride that reduces vibration and is considerably more comfortable for the driver. The existing tires on the Minimoto were also found to be a good size for the prototype and were in excellent condition at the time of delivery. Some research online has shown that replacement tires are still available despite the fact that the vehicle is no longer in production. This ability to get replacement parts will ensure that should a new tire be needed due to damage or wear that the clients will be able to acquire a new one.

The rear bumper and front grill remain on the final prototype since alterations to the stock Minimoto vehicle did not require their removal. Figure 88 below shows the rear crash bumper.
The ability to keep the rear bumper is desirable since it protects some of the electrical components at the rear of the vehicle from being damaged. The bumper is connected to the rear sub-frame through the use of two large bolts and a set of springs that absorb some of the force in a minor impact. This component will allow the user to lightly bump objects surrounding the vehicle without damage to the vehicle’s control system, including the batteries, electric motor, speed controller, and braking system. The grill from the stock Minimoto go-kart remains on the prototype mainly for cosmetic reasons. The front grille is shown in Fig. 89 below.

Originally, the grill was on the Minimoto for that same reason—to make the vehicle more visually appealing. This part in no way functions as a device to handle impact. The steering linear actuator and linear position transducer were installed in the front of the vehicle in such a way as to allow for the re-installation of the grill. As a result the grill remains in the prototype to make the kart more visually appealing and to hide the modifications that have been made to the steering system from onlookers.
Some of the cosmetic trim from the stock Minimoto kart will not be re-used due to interference problems with some of the added parts. However, some of the trim has been re-installed in order to make the vehicle as visually appealing as possible. For example, the rear cover which houses the motor, battery, and speed controller is used without the battery cover intact. Figure 90 below shows the rear battery cover.

![Figure 90: Rear battery cover.](image)

In addition to giving the rear sub-frame a cleaner appearance, the cover will protect some of the wiring and cables from catching on sticks and other items that the vehicle may encounter, and will also cover the motor chain from the outside environment. As was mentioned, the battery cover will not be re-used since the accessory battery sits above the main battery and will prevent its installation. Also, each of the front fenders remains as well as the rear fender on the non-joystick side of the vehicle. Figure 91 shows the front side pod. Figure 92 shows the rear side pod.
2.3.2 Brakes

The braking system for the prototype of the E-Racer consists of both stock components from the Jeep Minimoto, along with considerable modifications to allow for user input. The stock go-kart came with a dual disk brake arrangement, with one disk brake on each of the two rear wheels. The disk brake consists of a rotor which is fixed to the wheel axle and rotates with the wheel, a caliper that squeezes a brake pad into the rotor, thus applying friction to slow the
vehicle, and a brake cable that is responsible for the operation of the caliper. Figure 93 below shows the disc brakes at the rear of the go-kart.

Figure 93: Rear disc brakes.

When the kart was received, the cables were pulled through the operation of hand levers on the steering wheel of the vehicle. Since the E-Racer’s client is not able to generate the amount of force required by the hand lever device, and also because braking had to be functional in two independent control modes, the system to operate the pulling of the cable had to be fabricated. This braking modification consists of a metal plate that is mounted at the edge of the rear-subframe between the rear suspension and the seat.

This plate houses a linear actuator and a series of metal brackets required to hold the braking cables securely in place and also to attach the inner cable to the moving end of the linear actuator. The linear actuator used is manufactured by Firgelli Automations. This device is rated at 35 lbs. of force which is more than is required by the braking system. When the linear actuator receives the required signal from the control system of the vehicle, the moving end of the linear actuator retracts, thus applying force to the brake cables, which in turn squeezes the calipers, slowing the vehicle as needed. Despite the addition of this braking system, no sacrifices for space needed to be made on the vehicle. The braking modifications sit neatly behind the seat and do not interfere with any of the other components on the vehicle. Since the system is so well-hidden its operation should be imperceptible for the user.

2.3.2.1 Brackets

Three brackets were used in the braking system: two to secure the actuator to the plate and one to secure the sheathing to the plate. The brake cables are two wires which are connected to the left and right disc brakes. The wires end in small cylinders and are covered in sheathing. The brake cables are longer than necessary and could not be cut as this would
sacrifice their integrity. Therefore, it was very important to secure the cables so that when the actuator pulled the wires, only the wires moved while the sheathing remained stationary.

Another bracket was made to secure the shaft of the bracket. A third bracket was purchased to secure the stationary end of the actuator. The two brackets used to secure the actuator to the plate are shown below in Fig. 94.

Figure 94: Shaft bracket (top) and fixed end bracket (bottom) for the braking system.

2.3.2.2 Plate

An aluminum plate was made on which to mount the actuator, the associated
brackets, and the cables. Holes were drilled in the frame of the go-kart to attach the plate to. The plate (with the actuator on it) is shown in Fig. 95 below. The plate included three holes to attach to the go-kart frame, three holes for the actuator brackets, and two holes for the sheathing bracket.

![Figure 95: Plate, actuator, brackets and cable joiner.](image)

### 2.3.2.3 Cable Joiner

A cable joiner was needed to attach the wires from the left and right brake together. This was done to ensure that the left and right brakes were depressed equally. If this were not done, then one of the brakes would be depressed more than the other, leading to unsafe driving conditions. The cable joiner takes advantage of the fact that the ends of the brake wires are small cylinders. Thus, the cable joiner has two round holes for the cylinders and small notches cut out for the wire to sit in. This provides a physical stop for the cylinders so the wires stay in place. The cable joiner is directly attached to the actuator. The cable joiner, attached to the actuator, is shown below in Fig. 96.
2.3.2.4 Actuator

The main feature of the braking system is a linear actuator. A linear actuator has a small motor and converts rotational motion to linear motion by extending and retracting a moving piece. The linear actuator is what pulls the wires to depress the brakes. In order to determine the strength of the actuator, a fishing scale was used to measure the force required to depress the brakes. In order for the brakes to respond faster, a fast-moving actuator was used. The actuator used is shown in Fig. 97 below.

Figure 97: Actuator used in the brake system.
2.3.2.5 Disc Brakes

The E-Racer has disc brakes, which work by depressing brake pads around a rotor when the brake wires are pulled. The disc brakes on the E-Racer are shown in Fig. 98 below.

![Figure 98: Disc brakes on the E-Racer.](image)

2.3.3 Joystick Attachment

The joystick is attached on the right side of the E-Racer since this is Mason’s strong side. Since the bar the joystick box is attached to is at an angle, it was difficult to attach the box. When it was attached, there was a big of wobble in the joystick. To resolve this, an additional support was added to the side of the go-kart. This additional support utilized a small hole in an offshoot of the frame below the joystick box. After this support was added, there was no longer any wobble in the joystick. The joystick box is shown below in Fig. 99.
2.3.4 Seat & Restraint Systems

As was discussed earlier, the seat and seatbelt on the stock Jeep Minimoto go-kart were deemed unacceptable for use in the E-Racer prototype. As a result these devices were discarded and were replaced with new components. The existing seat on the Jeep Minimoto was made of flimsy plastic, was uncomfortable, and simply did not meet the postural needs of the client. With the seat removed it was possible to install an aftermarket seat that was purchased. This seat was then modified to allow for the installation of custom-fabricated side supports. Due to the limitations of the client, strong side supports are necessary. The side supports are able to withstand considerable forces due to the differences from optimal design.

2.3.4.1 Seat

The E-Racer seat offers a lot of cushioning. The side supports which were added to the seat offer the client additional support, particularly since he tends to lean to the side. The seat also serves as points of attachment for the five-point restraint system. The seat is shown in Fig. 100 below. Additionally, the plate shown in Fig. 101 was made to attach the bottom of the seat to the go-kart frame.
Figure 100: E-Racer seat and side supports.

Figure 101: Seat plate for the attachment of the bottom of the seat.
The back of the seat was attached to the frame of the go-kart using the mechanism in Fig. 102 below. The system for attaching the back of the seat consists of two pipe fittings, a small plate, and threaded rods.

2.3.4.2 Restraint

A five point harness was used in the E-Racer for added security for the rider. The over-the-shoulder attachments were made on the back of the seat. The hip attachments were made underneath the seat, and the between the legs attachment was also made under the seat. The restraint is shown in Fig. 103 below.
2.3.4.3 Foot Straps

The E-Racer also has foot straps near the front of the go-kart. These foot straps will be used to keep the rider’s feet in place while driving. Since the driver will not be using his legs, his feet should be secured so that they do not interfere with driving. The foot straps are at the front of the go-kart and are seen in Figure 104 below.

2.3.4.4 Neck Brace

The client has a tendency to drop his neck when he rides so the E-Racer comes with a neck brace. The neck brace is easily removable and prevents excessive forward flexion of the neck. The neck brace is shown in Fig. 105.
2.3.5 Steering System

As was the case with the braking system, the steering system of the E-Racer prototype consists of both stock components from the Jeep Minimoto and a couple of aftermarket products that had to be used for the proper operation of the vehicle. As received, the steering system for the Jeep Minimoto consisted of a steering wheel that was mechanically connected through the use of a long, metal shaft to a series of linkages connecting the two front wheels. Due to the fact that the client for the E-Racer is not able to apply the force necessary for this type of system and also due to the fact that the E-Racer operates on two independent control modes, modifications had to be made to this system. In order to take care of the force necessary to move the steering rack, a linear actuator was installed. The linear actuator used for this application is manufactured by Motion Control Systems of Eatonton, NJ, model # 9234C120-R10. Figure 106 shows the steering actuator.
This linear actuator was connected to the vehicle frame through the use of basic hardware, and was then tied into the existing steering linkage system. A custom bracket is affixed to the vehicle’s floor pan and effectively stabilizes the linear actuator when it moves through its stroke. The moving portion of the linear actuator is connected to a half linkage which applies force to one of the wheels on the kart. This half-linkage had to be shortened for the proper installation of the linear actuator. The linkage that connects the front wheels and keeps them parallel to one another was left unchanged. In order for the proper operation of the control system, a linear position transducer has been installed parallel to the linear actuator. Figure 107 below shows the linear position transducer.

The linear position transducer used for this application is manufactured by Novotechnik of Southborough, MA, model # TEX75. This device is connected to the vehicle frame at one end just above the linear actuator and is connected to the moving end of the linear actuator at the other end. The device moves in conjunction with the linear actuator and is able to keep track of the position of the linear actuator as a result.

Since the steering shaft of the stock steering setup had to be removed, modifications had to be made to the steering wheel to allow for proper operation. With the steering shaft removed, the wheel was free to rotate up and down in front of the driver. To prevent this from happening and also to allow for the installation of a rotary potentiometer required by the control system, a
A small, plastic box was mounted between the bars of the steering wheel support frame. Figure 108 shows this box.

![Figure 108: Potentiometer box.](image)

The box was secured to the support frame through the use of simple hardware including brackets, bolts, and spacers. With the box attached to the support frame the potentiometer could be attached to what remained of the steering shaft from the steering wheel. In addition to the installation of this steering control box, the steering support frame has been modified to allow for adjustment to meet the needs of the operator. In stock form, the steering support frame connected to the main frame of the kart through the use of a welded bracket and common hardware. In prototype form, this steering support frame is adjustable and can be attached to the vehicle main frame at several points. These various attachment points allow for the steering wheel to be raised or lowered depending on the specific desires of the occupant. The steering support frame was further modified so that it is able to fold out from the vehicle to allow for easy occupant loading. In stock form the support frame was permanently fixed to the vehicle, making entry difficult for users. Since the point of attachment to the main frame is adjustable and also detachable, the support frame can effectively fold out from the vehicle and sit flat on the ground ahead of the kart. This feature greatly alleviates the difficulty of entering the vehicle.

### 2.3.6 Electrical Modifications

Very few electrical components from the Jeep Minimoto go-kart remained for use in the prototype. The 36V electric drive motor, along with the chain-driven gears are still used to propel the vehicle. Figure 109 below shows the DC motor.
While we had originally intended to use the stock motor speed controller from the Minimoto, we experienced difficulties with this unit during testing and had to order an aftermarket speed controller. This device then had to be modified for use in the vehicle. Figure 110 below shows the speed controller.

The stock circuit breaker and emergency kill switch remain in the prototype of the E-Racer and still function to break the delivery of power to the electric motor when needed. Figure 111 below shows the emergency stop button. Figure 112 shows the 36 volt circuit breaker and charger.
While we are using the 36 volt battery that is intended for use in the stock Minimoto go-kart the battery that shipped with the stock kart was replaced. Since the vehicle has been out of production for a number of years we were concerned that the battery that shipped with the vehicle would not be able to hold a charge for a considerable period of time. For that reason we ordered a fresh battery for use in the prototype. Figure 113 below shows the two batteries, charging port and circuit breaker for the 12 volt battery and the mode select switch.
We also purchased a 12V accessory battery to power the steering and braking linear actuators along with all of the additional control circuitry.

The E-Racer prototype continues to use the stock battery charger for the vehicle’s 36V battery and also has an additional port and circuit breaker for charging the accessory battery. Figure 114 below shows the 36 volt battery charging port and Fig. 115 shows the 36 volt battery charger.
Control system modifications include the incorporation of a custom-designed control PCB that is housed in a box at the front of the vehicle. This printed circuit board was specifically designed for use in the E-Racer prototype and is able to control the braking, acceleration, and steering of the vehicle in joystick and steering wheel control modes. The schematic for this PCB is shown below in Fig. 116.

The custom-made PCB is used in conjunction with two speed controller modules that were purchased and assembled from the component level. The speed controller is shown in Fig. 117.
The two speed controllers and the PCB are housed in boxes at the front of the E-Racer. These boxes can be seen in Figure 118 below.

2.3.7 Steering Wheel & Shaft

The steering wheel and shaft were slightly modified from their original state. On the wheel, a switch was added to control acceleration and braking while in steering more. The modified steering wheel is shown in Figure 119 below.
To allow easier entry for the client, the steering wheel shaft has been modified so that it can be lifted up for entry. Also, the shaft is on a track so that the exact position can be selected from one of three options, allowing for greater comfort for the rider while driving. This can be seen in Figure 120 below.

2.3.8 Instructions for Use of Device

1. Push down the Emergency Power Shut-Off button before attempting entry into the vehicle. This will prevent accidental acceleration when loading. This button can be seen in Figure 121 below.
2. Check to see the “ON/OFF” switch under the steering wheel is in the “OFF” position. This switch can be seen in Figure 122 below.

3. Step in the vehicle and carefully slide down into the seat.
4. Put on the seat belt and adjust until tight but comfortable low around the driver’s waist. This is seen in Figure 123 below.
5. Secure the rider’s feet using the foot straps at the front of the go-kart. This is seen in Figure 124 below.

6. Have someone outside the E-Racer release the Emergency Power Shut-Off button at the rear by turning clockwise. The button should pop up. This is seen in Figure 125 below.

7. Ensure that the forward/reverse, steering wheel/joystick and training/normal switches are in the desired positions.
8. Flip the “ON/OFF” switch to “ON”.
9. If you have selected joystick mode, begin to accelerate the go-kart by gradually pushing the joystick forward. If you have selected steering wheel mode, begin to accelerate the
go-kart by gently pushing on the “ACC/BRK” button on the steering wheel in the
direction of “ACC”. This is seen in Figure 126 below.

Figure 126: Accelerating in joystick (left) and steering wheel (right) modes.

10. To stop in joystick mode, pull back on the joystick. The harder you pull back, the faster
you will stop. To stop in steering wheel mode, push the “ACC/BRK” button in the
direction of “BRK”. The harder you press, the faster you will stop. This is seen in Figure
127 below.

Figure 127: Braking in joystick (left) and steering wheel (right) modes.

11. To steer in joystick mode, move the joystick to the right to turn right and to the left to
turn left. To steer in steering wheel mode, turn the wheel to the right (to turn right) or to
the left (to turn left).

12. If you need to switch to reverse, come to a COMPLETE STOP first. Then change the
“FWD/REV” switch to the “REV” position. Wait 3-5 seconds before accelerating again.

13. If you want to switch to between training/normal modes, come to a complete stop, and
turn the vehicle off by turning the “ON/OFF” switch to the “OFF” position. Then change
the “TRAINING/NORMAL” switch to the desired setting. Then turn the “ON/OFF”
switch to “ON” and begin accelerating.

14. If you want to switch between joystick/steering wheel modes, come to a complete stop
and turn the vehicle off. Then change the “JOYSTICK/WHEEL” switch to the desired
setting. Then turn the go-kart back on and continue driving.
3. Realistic Constraints

As with any other engineered device, this product must conform to certain standards set forth by various national and international societies and government agencies. These agencies include the International Organization for Standardization (ISO), the Society of Automotive Engineers (SAE), Underwriters Laboratories (UL), American Society for Testing and Materials (ASTM), National Institute of Standards and Technology (NIST), American National Standards Institute (ANSI), the Consumer Product Safety Commission (CPSC) and the Standards Engineering Society (SES). All of these organizations provide for purchase their current standards. These standards include general requirements to be met by any engineered device, including standards of quality and safety which must be satisfied.

3.1 Economic

Economic constraints certainly play a role in the design of this device. Certainly, there are budgetary concerns, but the acceptance of the device into the market after it is produced must also be considered when designing the go-kart. This will be determined by economics. Currently available products that are similar to the proposed device are priced at around $6000. Standard go-karts (those not suitable for disabled people) cost about $1000-$2000, so it would be ideal for the go-kart created to cost approximately the same amount. This would allow for broader market appeal than is present with the currently available product, and therefore would result in increased sales.

3.2 Environmental

This go-kart is electrically powered, so the go-kart itself is non-polluting. However, charging the battery of the go-kart will require an electrical power source, and the production of this electricity does result in some pollution. The environment must be considered in selection of the battery used as well as in the instructions for disposal of the battery should a new battery be needed. Often, batteries contain components which can be damaging to the environment if not disposed of properly. This does constrain the selection of the battery somewhat, but will be mostly dealt with in the operator’s manual.

The environment in which the go-kart will operate does create a constraint on the design since the go-kart will be driven outside and must not be affected by a dusty atmosphere. Also, the go-kart should function over a range of temperatures (roughly 60 degrees Fahrenheit to 90 degrees Fahrenheit can be expected). These factors were considered in the selection of electrical and mechanical components, as well as in the materials selection.

3.3 Sustainability

The go-kart is battery operated so it will need to be charged periodically (probably after each ride, depending on how long the client rides the go-kart for). Length of charging time and battery life when fully charged need to be considered before the go-kart’s sustainability can be fully assessed. Also, the lifetime of the battery will determine how often a new battery needs to be purchased, which is important in determining the sustainability. The sustainability of the go-
kart itself will depend on how the go-kart is driven (type of terrain, frequency of minor collisions, etc).

3.4 Manufacturability

Once the go-kart is design and the prototype produced, it will presumably be easy for a company to manufacture a similar go-kart from the ground up. However, this design will probably be manufactured as a modified go-kart since there will not be a large enough market for the device to be built in a manufacturing facility which produces only this product. In other words, the manufacturing of this product will probably be done by a company which specializes in the modification of standard vehicles.

3.5 Health and Safety

There are numerous constraints imposed on this device by the Consumer Product Safety Commission (CPSC), which has standards for the safety of toys. This go-kart is considered a toy since it is a consumer device that will be used by a young boy. These constraints include electrical, mechanical and thermal considerations.

The electrical standards require that all live electrical components must be securely enclosed. Switches, motors, transformers and the like need to be securely mounted to prevent any non-functional movement and possible damage. Any heating elements must be supported and prevented from making contacts that might produce shock hazards. Products requiring cleaning with a wet cloth must be designed to prevent seepage of water into areas with electrified parts, to prevent corrosion and electrical shock. Electrical plugs must have a finger/thumb grasping area and must have a safety shield to protect fingers from accidentally contacting energized prongs while the toy is being plugged into a wall outlet (this is applicable only to the battery charger, which is the only component that needs to be plugged into a wall outlet).

In addition, there are mechanical constraints imposed by the CPSC which need to be adhered to in the design of this device. Enclosures must be strong and rigid enough to preserve the safety and integrity of the electrical components, even when the toy is subjected to foreseeable abuse. The toy’s potentially hazardous moving parts must be enclosed or guarded to minimize the chance of contact.

Finally, the CPSC has certain requirements for thermal safety which must also be satisfied by this design. The product must not exceed maximum surface temperature requirements, which are determined on the basis of accessibility of a particular surface, its function and the material from which it is made. A surface to which a child cannot gain access is allowed to reach a higher temperature than a knob or other surface which they may come into contact with. Also, the device must undergo rigorous “use and abuse” test procedures for toys as required by the CPSC.

3.6 Social

There are a couple of social constraints which must be kept in mind during the design process. Generally, go-karts cannot be ridden everywhere. Go-karts cannot be driven on main roads, but in some areas can be driven on secondary roads. Go-karts also generally cannot be driven on bike paths and foot trails. The client lives in Canada, so the traffic regulations may be
different; it will certainly be imperative that the client is alerted of the need to look into traffic rules regarding go-karts in their area.

An additional social constraint is related to the appearance of the go-kart. The client wants a go-kart which looks and drives like a “normal” go-kart. It is important for the design to modify the go-kart to suit the client’s needs, but to also keep in mind that the final product should not look too different from a standard go-kart from the outside. This will make the client feel more comfortable and accepted by his peers.

4. Safety Issues

Safety is of utmost importance for this design. Our primary concerns, however, will be focused on the safety of the user. The intended user has cerebral palsy and has limited control of his body. As a result, the driver’s trunk and legs have to be properly secured. A five point harness will be used to support his trunk and foot restraints will be used to secure the drivers legs. Also, the client has a tendency to look down when he gets excited. This presents an obvious problem while the client is in control of the moving kart. Therefore, a neck brace will be implemented to prevent the driver from looking down during operation. The driver will operate the kart under the supervision of his parents. The parent’s have requested a remote kill switch to stop the kart in case of any emergency. The “forward/reverse” switch will be blocked or deactivated while the cart is in motion. In other words, the driver will be able to switch the direction of the kart only when the kart is not in motion. Similarly, the switch that selects the control to be used (wheel or joystick), will be blocked or deactivated while the kart is in motion. Also, once a control is selected, the un-selected control will be electrically deactivated.

Much like any other go-kart, there are many basic safety concerns that will be addressed. First, we must be sure that this kart is environmentally friendly. The electric motor will emit greenhouse gases like a gasoline powered kart. The lead acid battery that comes standard on the Minimoto Jeep Dune Buggy was designed to withstand potential damage from environmental conditions and mechanical damage during operation. This battery will not be modified so as to preserve the integrity of the casing. Similarly, all electronic components and connections will be properly insulated to prevent electrical failure or electric shock to the operator. The Minimoto Jeep Dune Buggy has had reports of the electric motor overheating. The operator will be protected from the motor in case it does overheat at some point during or after operation. All electrical components and wiring will also be thermally insulated from the electric motor.

5. Impact of Engineering Solutions

This design will incorporate solutions to a variety of problems. These engineering solutions will likely have many varied and far-reaching impacts.

5.1 Societal

The go-kart will allow for increased independence and a sense of normalcy for persons with disabilities. This go-kart will help to break down the divide between people with disabilities and those without. Specifically, this device will create a sense of normalcy for the young client,
which is especially important because a person’s self-esteem is so often built or destroyed during childhood.

5.2 Environmental

The innovations presented in this design will essentially have the same environmental impact as existing go-karts. If the product is very well-received on the market the number of go-karts purchased of this type will of course increase which may have environmental effects in terms of the manufacturing of the product since most manufacturing processes are not very environmentally friendly. In addition, there are the environmental issues listed in the constraints above, including electrical power source and battery disposal. However, it is important to keep in mind that this go-kart will be far more environmentally conscious than a gas powered go-kart which releases emissions.

One positive impact of this design in terms of the environment is that it may increase the popularity of electric go-karts over gas-powered ones, resulting in a general shift to more eco-friendly recreational vehicles.

5.3 Economic

This go-kart will be considerably cheaper than any existing product on the market which serves a similar purpose. In addition, this device will be safer than existing ones, due to increased side support on the seat, easy entry for the rider, multiple kill switches, and a very dependable restraint system. This design also offers many features which make it customizable to suit the individual customer’s needs.

The combination of these advantages will presumably result in the device being well-received into the market. In fact, the size of the market will probably become larger than it is now. Since this product is not a necessity, very few people are likely to pay an exorbitant sum for it, such as the $6000 price tag of currently available, similar go-karts. This is especially true since the target market is people with disabilities, and this population probably already has very high medical bills. With the introduction of the design presented here onto the market, the number of customers currently buying other products will likely decrease with migration of that business to the new product. In addition, this design is will probably be successful economically because consumers who previously may not have purchased such a product will probably be likelier to do so. This is a result of the lower price, added safety features, and overall increased enjoyment of the rider.

5.4 Global

The design presented here will have impacts even on the global level. Cerebral palsy affects people of every race, class and nationality. There are hundreds of other debilitating diseases affecting people who would be able to use this device and presumably want to enjoy recreational time the same way as people without disabilities do. This design would allow anyone with use of at least one hand to ride a go-kart.

Although this design was made with a specific client in mind, the desire for independence and enjoyment of recreational time is universal, and this design could be used by many people other than just the client in this particular project.
This product will find a niche in the global market for two main reasons. First, the economic benefits presented above will certainly increase the international market appeal of this design. Additionally, as mentioned previously, the common desire for self-confidence, particularly in a population which often lacks it. Both of these reasons indicate that this design will be successful on the global market. Similar to the case with the American market, the global market is presumably not buying the existing products due to the high price of these go-karts. The design solutions presented here will allow for a broader market, which will include customers around the world.

This design will also have global implications beyond having international appeal based on financial considerations. A more lasting and personally rewarding impact of this design is the possibility of this design fostering bonds between people with similar disabilities who are united by their desire to drive a go-kart despite their disabilities, and who find they are buying the same product. These relationships would develop as a result of the users of this go-kart enjoying time on their go-karts with each other. This may lead to a way for people with disabilities, specifically children, to bond with each other, creating local and global connections with other people who find themselves in similar situations and who enjoy the same things (at least inasmuch as they all enjoy riding go-karts). This design appeals to many groups of people with many different kinds of disabilities and is very adaptable depending on what the user can and cannot do, which will make it applicable in the global setting and may unite consumers based on their shared interests and enjoyment of this go-kart.

6. Lifelong Learning

Lifelong learning is an integral part of almost every experience, and can be found in almost every setting. Many things have been learned and will be learned in the process of the design of this go-kart which will be important even after this project is completed. This newly acquired knowledge is applicable over the entire course of an engineering career. This newly acquired knowledge can be broken down into new material which has been learned and new techniques which have been mastered.

The new material which has been learned includes differences between types of go-karts, the existence of a market for these devices, the numerous standards imposed on this kind of device by external groups, including government organizations and professional societies, the importance of client communication as well as honoring the client’s desire to the greatest degree possible, and finally, the great variety of control mechanisms available.

The go-kart market is extremely varied. Of course, there is the distinction between electric go-karts and gas-powered go-karts. In addition, certain go-karts are only for racing and include many features not found on recreational go-karts such as a very powerful engine and a low center of gravity. Recreational go-karts can vary from nearly racing quality to a bulky design which travels at relatively low speeds. Also, go-karts can have anywhere from one to four seats and have a very wide price range.

Another new piece of information is that a market for this kind of device exists. Obviously, there is a large market for vehicles that are modified to suit the needs of people with disabilities. It was also clear that a market existed for toys suitable for children with disabilities. However, it was surprising that there is a market for recreational vehicles for people with disabilities. Mobility4Kids is an entire company devoted to recreation vehicles for children with disabilities, so clearly a market exists.
It was also surprising that there are so many different groups that have standards which engineering designs and engineered products must be held to. These groups are varied and include international organizations, professional societies and government agencies. Each group has requirements which must be satisfied by every engineered device put onto the market. These standards generally regulate quality and safety of the device.

It has become clear that client communication is essential to creating a successful device and satisfying the client’s wishes are extremely important. When designing this go-kart, the client was contacted several times, including numerous emails and a conference call with the client, his family and his physical therapist. Communication will continue throughout the building process, with more conference calls planned and a possible client visit in the spring.

The last important thing which has been learned so far is that there are many different ways to incorporate several controls into one mechanism. In this design, steering, braking and acceleration are all being incorporated into a steering wheel mechanism, and also all into a joystick. When it was realized that the client really only has good control of his right arm and hand (and limited control of his left) it seemed that it would be difficult to have a control requiring only one fully functional limb. However, there are many ways to accomplish this, so the client’s wishes will be fulfilled with this design.

The techniques which have been learned up to this point include how to work on a team, how to coordinate a group, how to plan a project, how to adhere to deadlines and budgetary constraints, how to prepare and deliver a presentation, and how to thoughtfully and effectively respond to questions regarding the design. The process of designing this device has required that people from different backgrounds work as a coherent unit. This requires figuring out what each member’s strengths are and then delegate the required tasks. The design process always requires organization since one part of the designing a device determining which tasks must be accomplished and the priority of these tasks. Also, there are many deadlines inherent to the design process which must be met, and, of course, budgetary constraints must be considered when designing. One of the requirements for this project was to present a project proposal. As a result of this, the group learned how to give an efficient and persuasive proposal presentation, which will certainly be of use in the future. Finally, this presentation allowed the group to gain experience in answering questions about the design thoughtfully and effectively.

7. Budget

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8. Team Members Contribution to the Project

Allison worked primarily on the brake system, seat and restraint system. She also made the foot straps and attached the joystick. With regard to the braking system, Allison made a mounting plate, ordered one actuator bracket, made another actuator bracket, made a cable joiner, and made a sheathing bracket. Allison made a plate for mounting the bottom of the seat and also designed and made an attachment for the back of the seat. She also attached the restraint system to the seat. Allison measured, made and installed the foot straps. Allison also designed and made the attachment for the joystick. She also wrote a large portion of the owner’s manual.
Michael Marquis worked to complete the installation of the steering linear potentiometer. This involved the fabrication of a custom stabilization bracket and the modification of the existing steering rack linkages. Marquis also worked to find a solution to the steering control problem in acquiring a linear position sensor from Novotechnik. Marquis then mounted this device in the steering system in conjunction with the stock steering components and the steering linear actuator. Marquis worked with Meisner to modify Meisner’s seat attachment solution to allow for a greater seat angle and greater user comfort. Finally, Marquis worked with all of the group members to complete the troubleshooting of various components on the vehicle and contributed to the final preparation of the vehicle. Throughout the semester, Marquis maintained the group’s website through the use of Macromedia Dreamweaver software.

Kevin designed and tested most of the electronics on the go kart. Kevin built a functional protoboard for testing and wrote all code for both microprocessors. Kevin designed hardware needed to supplement the functions of the microprocessor. Kevin also ordered and assembled the bi directional speed control kits to control the steering and braking actuators. Kevin integrated the designed electronics with the electronics that came with the kart and verified the proper operation of the steering system (both modes), acceleration system (both modes), and the braking system (both modes). Finally, Kevin made schematic and designed/ordered PCB.

Travis Ward spent the beginning of the semester verifying the operation of many of the projects that he was responsible for doing on the go-kart. Ward spent a while researching Linear Actuators and found a company to provide a free custom made one to the group. Ward also ordered and mounted a 12 volt battery for the electronics, a circuit breaker, and a charging unit along with a wall charging adapter. He spent a lot of time figuring out a way to implement a relay to automatically switch between charging and run mode when the 12 volt battery was plugged in. Ward also worked with wiring components together and created aluminum pieces to allow the steering column to be adjustable towards or away from the drive to fit a range of drivers.

9. Conclusion

The main goal of this project was to expand the opportunities for a patient with a disease that inhibits fine motor control such as cerebral palsy. Cerebral palsy is a disease that lasts an individuals entire lifetime. It is caused from improper development or damage to the cerebrum and other areas of the brain responsible for motor control. Currently there are no absolute cures to this disease except continuous visits to rehabilitation centers to repeatedly work on improving fine motor control. Patients with cerebral palsy will always lack the enjoyment from the many luxuries that normal people take for granted, so it is an engineer’s job to modify existing devices so that people with disabilities can use them.

The E-Racer is an electric go-kart, modified from the Jeep Minimoto Dune Buggy, for a client with cerebral palsy. The client is an eight year old boy from Alberta, Canada named Mason McClement. His disorder prevents him from having control of his legs, left arm, and, to some extent, his trunk. The client requested this go-kart so he could easily and safely operate alongside his peers.

In order to accommodate his requests, the stock go-kart had to be modified in many ways. First the steering, acceleration, and braking all had to be combined into one joystick. The steering wheel remained on the go-kart to allow potential manual control in the future if the
client improved his motor control. The client can only use one mode of operation (joystick or wheel mode) at a given time. Linear actuators were used to apply the brakes and turn the front wheels of the go-kart, preventing any strenuous work for the client.

Some safety measures that were taken including a neck brace (preventing the client from dropping his head during periods of excitement), a five point harness, and nylon straps to hold the client’s feet in place. Also, a wireless remote kill switch and an easy to push kill switch for the rider were added.

In conclusion, the E-Racer electric go-kart will better the lives of individuals with cerebral palsy and other fine motor control impairments by allowing them to enjoy riding a go-kart with friends and peers.

10. References


120


[38] “Universal Joystick.” Happ Controls. 28 Nov. 2007.
<http://www.happcontrols.com/joysticks/universal_joy.htm>

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