E-Racer
Alternative Design 3

University of Connecticut
Biomedical Engineering
Senior Design 1

Sponsors:
National Science Foundation (NSF)
Dr. John Enderle

Client:
Mason McClement

Client Contact:
Gregg and Laura McClement
Calgary, AB, Canada

Team 3:
Kevin Arpin, Michael Marquis, Allison Meisner, Travis Ward
1. Alternative Design 3

1.1 Overview

The proposed design is that of a go-kart which will satisfy the needs of a young boy with cerebral palsy who would like to enjoy recreational time with his peers. 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. Other designs currently exist, but they fail to satisfy many of the needs of this particular client as well as those of people with disabilities in general. The goal of this device is to provide a go-kart which will be safe, affordable, enjoyable and suitable for the client.

The client is an eight year old boy from Alberta, Canada. His name is Mason Clement. He was a premature baby born at 25 weeks and he spent the first 55 days of his life on a ventilator. A ventilator is a mechanical machine used in hospitals to force air into and out of a patient and mimic their breathing. 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 on everyday activities without the assistance of an aid.

The projected design is called the E-Racer. This project was conducted once before by a biomedical engineering senior design team at the University of Connecticut in 2001. The client’s parents saw articles for the design on-line and decided to have one made for their son. The E-racer is proposed to be an electric go-kart designed for a child with cerebral palsy. The go-kart must be drastically modified to accommodate the client because he has no control over leg movement, very limited control of his left arm, and his head often falls to his chest when he gets excited. This means that the steering wheel, accelerator, and brake 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 several other safety measures.

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. 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.

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 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 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 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.

1.2 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. 1) featuring a 90cc, 4-stroke, aircooled engine.

Figure 1: GK-202 mini go-kart with 90cc, 4-stroke engine.

The go-kart is quiet and neighborhood friendly. This model is intended for children up to eight years old, but this restriction is made due to the amount of space for the child’s leg, and the client’s legs are shorter than most children’s due to the effects of cerebral palsy. The transmission on this go-kart is semi-automatic and has gears for reverse, neutral, first gear and second gear, but has no clutch which simplifies the operation. 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.

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.

1.3 Electric Motor

There are many considerations that engineers must make before choosing a proper engine to install in a vehicle. The engine must first run on the desired fuel whether it is gasoline, diesel, hydrogen, electricity, or any other alternative fuel available on the market. Once a proper engine type has been chosen, engineers must also consider how powerful of an engine to get based on the size and weight of the vehicle, conditions the vehicle will be driving in, the weight of the driver and passenger(s), and how aggressively the engine will be operated. Another important consideration involves proper engine power being matched to the vehicle. A weak engine cannot be placed on a heavy vehicle, because it will struggle to run while using too much fuel and drastically reduce the life span of the engine. If the engine is too strong for the vehicle, it will not be consuming fuel efficiently. A smaller engine could conserve fuel while powering the same vehicle similarly. It takes testing and experience to choose a proper engine for a vehicle.

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 chosen for this design will be replaced by an electric one. The Jeep Minimoto electric engine produces 800 Watts, which is equivalent to 1.07 Horsepower. The GK-202 Mini Go-Kart comes with a 90cc gasoline powered engine which is rated to produce around 3 Horsepower, and can travel up to 25 MPH, which is faster than the client’s parents wanted. This means that an engine with less than 3 Horsepower will need to be chosen to assist with slowing down the go-kart.

An electric motor from Rotomag Motors and Controls PVT, LTD will be used. 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.

One other calculation is used to compare the various electric motors, namely efficiency, shown below. This equation was used as a basis to calculate efficiency by simply rearranging the values and plugging in the known values about the V-Series motor, it is found to have 79.7% efficiency. This was actually one of the highest efficiencies found for small low horsepower electric motors. The benefit of having a motor with a high efficiency is the longevity of the battery life, which is a concern with electric motors in general.

\[
HP = \frac{V \times I \times \text{Eff}}{746}
\]
The GK-202 Mini Go-Kart comes with a large gasoline engine that uses a chain and sprocket technology to propel the go-kart. In other words, the crankshaft comes out of the engine horizontally compared to a vertical crankshaft design on a lawn mower. A sprocket is slid onto the crankshaft and held in place with a small metal piece called a key shown below in Fig. 3. A chain is then wrapped around the sprocket on the crankshaft and a sprocket on the rear axle. This same technology will be used with the electric motor to move the go-kart.

The gasoline powered engine is mounted to a piece of sheet metal with mounting holes predrilled, similarly to that shown in Fig. 4. The accelerator wire, kill switch wire, and any excess wiring will be disconnected from the engine and it will be unchained, unbolted, and taken off the go-kart. The much smaller electric engine will go in the same location as the gasoline engine. The exact location of the holes on the engine plate already installed on the go-kart are not known, so new holes may need to be drilled to line up with the holes on the base of the V-Series motor shown above in Fig. 1. The same sprocket used on the gasoline engine will be removed and slid onto the electric motor crankshaft along with the key to hold it in place. The chain will then be wrapped back around the sprocket on the rear axle and the sprocket on the new electric motor.
The GK-202 Mini Go-Kart comes with a 12 Volt battery to enable an electric start for the go-kart. The engine also has a 2/5 alternator that recharges the battery while the engine is on, negating the necessity of plugging the battery into the wall to recharge it each time the go-kart is started. The V-Series electric motor requires a 36 V battery. 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. 4. Figure 5 below shows a concept of connecting batteries in series and the resultant voltage created.
The three batteries will be placed in an enclosure to protect them from dust, dirt, and water while the go-kart is driven outside. Since the electric engine is much smaller and lighter than the gasoline engine it is replacing on the go-kart, there will be sufficient room for the batteries’ enclosure to fit next to the electric motor and behind the seat. There will be positive and negative terminals sticking out of the enclosure easily accessible to charge the batteries and also connect them up to the differential amplifier to run the go-kart. A 36 V charger from Japlar will be supplied with the go-kart for quick and easy charging of the batteries. An image of this charger is shown below in Fig. 6.

![Figure 6: Japlar 36 Volt Battery Changer](image)

### 1.4 Controls Systems

The user has expressed his ability to play video games. With this in mind, the kart will be controlled using an analog joystick similar to those found on most video game controllers. 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. A voltage between 0V and 2.5V from the vertical signal (moving the joystick forward) will accelerate the kart while a voltage between 0V and -2.5V (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 or decelerated. The vertical signal will first be sent as an analog input to pin 2 (Port A – configured for input) of the microprocessor (PIC 16F874A). The microprocessor will compare this input voltage to 0V. If the voltage is greater than 0V (acceleration), the signal will be output to the acceleration control system (as described below) via pin 33 (Port B - configured for output). If the voltage is less than 0V, the PIC will perform pulse width modulation functions and output an AC signal to the braking system via pin 34 (Port B).

#### 1.4.1 Acceleration
The acceleration feedback system can be described by the block diagram found in Fig. 7.

![Figure 7: Feedback control for acceleration.](image)

The set speed control will come from the voltage from pin 33. 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.

![Figure 8: DigiKey unity gain difference amplifier.](image)

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.

$$V_{out} = V_+ - V_{in}$$

(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.

1.4.2. 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. 9). 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. 9).

![Figure 9: Braking system using a linear actuator.](image)

1.4.3 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.

### 1.4.4. Summary of PIC Connections

Figure 10 is a summary of all the different signals being input and output to and from the 
 PIC.

![PIC Connections Diagram](image)

**Figure 10:** Summary of PIC inputs/outputs.

### 1.5 Seat

#### 1.5.1 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. 11.
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. 12.

Figure 12: 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. Since the Accuride 9301 series slides are built for heavy-duty applications they will be able to easily
provide this support. According to the manufacturer’s specifications, the slides are able to support a load of 275 lbs (1223.2 N) per pair. It will also be important that the slides are compact enough that they can be mounted on the underside of the seat but can also extend far enough that the seat will be fully extended from the vehicle. The Accuride slides are manufactured with this requirement in mind. As shown in Fig. 13 below, these heavy-duty slides are very compact when retracted, yet can extend very far.

![Figure 13: Heavy-duty slide extended and retracted.](image)

This product is also very desirable in that many different size slides are available. As a result it will be very easy to select a slide length that will closely match the width of the seat. Additional features of Accuride slides are multiple mounting holes; smooth, quiet operation; and a bumper for smooth closure.

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. 14.
Accuride manufactures mounts which function in the same manner as L brackets. These mounts are shown below in Fig. 15.

To determine if the seat slider mechanism will be able to support the weight of the user and the chair, it will be important to perform an analysis of the forces present in the system when the user is seated in the device. A simple free body diagram of the forces at the slides is shown below in Fig. 16.
From this diagram, an equation of the sum of the forces acting on the slide 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 slide will attach to the kart at four points, the reaction force at each of the attachment points \( (N_A) \) will be:

\[ N_A = \frac{W_T}{4} \]

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. When the seat is in the operating position, the forces in the slide are shown in Fig. 17.

![Figure 17: Forces on slide in operating position.](image)

where $L$ is the length of the track and $W_T/2$ is the total weight applied to a single slide. 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:

$$
F_A = \frac{W_T}{2} - \frac{W_T}{4} = \frac{W_T}{4}
$$

Thus, it can be seen that the forces at the points of attachment on a single slide are equal to the total weight of the seat and rider divided by four.
When the seat moves sideways into the loading position as shown in Fig. 7, the forces in the seat slide are shown in Fig. 18.

Figure 18: Forces on slide in the loading position.

where points A and B are the points of attachment. Since the slides will provide full extension, the point at which the load will be applied to the slider will be located half the length of the slider past attachment point A, as shown above in Fig. 18. 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:

\[ F_A = \frac{W_T}{2} - F_B = \frac{W_T}{2} + \frac{W_T}{4} = \frac{3W_T}{4} \]

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:
Additionally, it can be assumed that the length of the track \((L)\) is 50.8 cm (20 in.) and that the chair moves sideways a distance of 50.8 cm (20 in.).

\[
L = 50.8\, \text{cm} = .508\, \text{m}
\]

\[
\frac{L}{2} = 25.4\, \text{cm} = .254\, \text{m}
\]

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

\[
F_A = \frac{3(294.3\, \text{N})}{4} = 220.73\, \text{N}
\]

\[
F_B = \frac{-294.3\, \text{N}}{4} = -73.58\, \text{N}
\]

From this analysis, it can be estimated that when the chair slides sideways 50.8 cm, each of the attachments closest to the seat will carry 220.73 N of force while each of the outboard points of attachments will be in tension and will undergo an upward force of 73.58 N. In this way, the use of statics may be used to solve for the forces present in the system to ensure that the slide mechanism can withstand such forces.

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. This device is shown below in Fig. 19.

![Quick-release locking pin](image)

**Figure 19: Quick-release locking pin.**
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.

1.5.2 Seat Body

The seat used in this design will be a bucket seat designed for children. The bucket seat is shown in Fig. 20.

![Figure 20: 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.

1.5.3 Seat Safety

1.5.3.1 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.

1.5.3.2 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 as shown in Fig. 21. A strip was used instead of a single magnet so that the client can turn his head without activating the safety mechanism.

Figure 21: Magnet strip placement on the back of the helmet.

A magnetic proximity sensor determines whether a magnet is in the vicinity of the sensor. Magnetic proximity sensors are made of reed contacts whose thin plates are trapped in a glass bulb with an inert gas. The plates are easily influenced by magnetic fields that create magnetic induction. Magnetic attraction makes thin plates flex and touch each other causing an electrical contact. 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.

Figure 22 below shows how the required distance between magnet and sensor will be calculated. The maximum forward flexion of the neck has been determined to be approximately 45°. However, at this point, the person would be looking all the way down, and the situation would already be hazardous. A safe level of forward flexion would be approximately 20°. To calculate the range of the sensor required by this degree of flexion, the distance between sensor and where the line tangent to the client’s head meets the vertical line on which the sensor lies must be known. Once this distance is known, the desired range of the sensor is calculated below.

\[ a = \tan(\theta) \cdot d \]
\[ a = \tan(20^\circ) \cdot d \]
\[ a = 0.36397d \]
Figure 122: Determination of distance between sensor and magnet.

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.

1.5.3.3 Arm Rest

This design includes a joystick which must be mounted in a location convenient for the client. As can be seen in Fig. 16, 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. An appropriate armrest is shown in Fig. 23 below.
1.6 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. 24 is designed for use in an Eton ATV. We plan to modify this part for use in the E-racer.
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.

2.1 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. The budget for this project is $2000. Several components have been added since the first design, bringing the total for this design close to $2000. As a result, this design is not as feasible as the others which have been presented.

2.2 Environmental

This go-kart will be electrically powered, so the go-kart itself will be 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.

2.3 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).

2.4 Manufacturability

Once the go-kart is designed 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.

2.5 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.

2.6 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.

3. 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 insulted 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.

4. 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.

4.1 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.

4.2 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.

4.3 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 by 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.

4.4 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.

5. 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 new 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 design and 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 single joystick mechanism. 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.

6. References


