Optimal Design

Project for Steven McCary

Modified All Terrain Vehicle
Automatic Doorknob Opener

By:
Joseph Yi
Judy Kachittavong
Savio Chris
Team # 22

Client Contact:
June McCary
88 Mansfield City Road
Storrs, CT – 06268
Phone Number: (860) 604 5755
1. Optimal Design Project

1.1 Introduction

The objective of this project is to design and create a vehicle for our client that has been diagnosed with a condition called cerebral palsy. Its negative effects on motor control and bodily movements in addition to other symptoms mark this condition. Due to the inhibitions engendered by this condition Steven, the client, has much difficulty enjoying his battery powered quad or any standard all terrain vehicle. To improve his level of enjoyment a modified vehicle will be designed that accommodates his needs brought about by this condition. With no reliable use of his limbs, a joystick control that incorporates the actions of accelerating, breaking and lateral steering all into one easy to use device will be implemented. In addition to the client’s dearth of dependable motor control the client must also be positioned in the best way for the most comfort and to optimize the motor control he does have. A restraint system must also be implemented to ensure safety of the rider and make sure that his waist is always at an angle of about 90°.

The design implements a full roll cage frame into the chassis of the vehicle. It has an elongated chassis to allow for the motor to be placed in the rear. This extended design will also allow for adjustments in seating to be made to accommodate the client. The complete end design objective is a safe and rigid structure with a low center of gravity to minimize possibility of rollover. The roll cage will also be designed in a way that will make entering and exiting the go kart not a difficult task as our client’s motor skills are impaired. Bumpers will be placed all around the vehicle to provide an impact buffer if
collision with another object were to occur. Attached to the chassis will be the suspension system, involving independent front suspension and dependent rear suspension.

The motor used will be an engine of around 10 horsepower to create power for the drivetrain. This will also power an alternator, which will convert the mechanical energy produced by the motor into electrical energy. The energy for all of the electrical components needed for the go-kart will come from a deep cycle lead-acid battery that will be charged by the alternator to ensure that there is always an electrical power that can be supplied to the electrical components housed by this vehicle. The electrical systems for this vehicle will encompass the following: control system, joystick, steering controls and pedals. The method of control will be the joystick control to steer, brake and accelerate. A remote control kill switch will be designed to provide the guardian the means to kill the power to the motor if the need for this arises. A radio receiver will be integrated into the vehicle that will take the transmitted signal outputted by the remote control kill switch and be fed into the microprocessor that will then kill the power to the engine.

The restraints that will be used to ensure the client’s safety will be the Tumble Forms 2 Carrie seat or any other variation of this specifically tailored for children with cerebral palsy. This seat is shown in figure 1. This specially designed seat provides the driver of the vehicle the ability to maximize the movements of his arms so that he may drive the vehicle. The main drawback to this Tumble Forms seat is the price range. The
seat may not be able to be implemented given the budget constraints. If the seat proves too costly to purchase a cheaper bucket seat will be used in tandem with a five point safety harness to restrain the client without compromising mobility of his arms. Whichever seat is used will be attached to the seat plate strongly secured to the chassis of the vehicle.

Also, another goal of this project is to design an automatic doorknob opener (ADO). This device will be used on the client’s bedroom door and bathroom door. The ADO will be controlled by a large red push button or a remote control. Figure 1 shows a picture of a red push button that will resemble the one used in the ADO. Once pressed, the door will automatically open and release the door closed, allowing for Steven to pass through it. The handle of the door will turn and the axel, upon rotating. This axel rotates
and moves that catch that holds the door locked. This will make it easier to go from one room to the other.

Figure 2. Red Push Button.

The ADO will be screwed and hinged to the door using screws and the device will be encased in a wooden case, with dimensions of 15 x 7 x 2 ¾ inches. This case will be divided into two compartments, battery and mechanical parts. Compartment 1 will contain a circuit that includes a 12-volt rechargeable battery that will power the device, a remote control transceiver, two relays, two limit switches and DC 12 volt Micro Motor. Compartment 2 will contain the other mechanical parts of the device. Figure 2 shows a similar design of the interior of both compartments.
The device opens by integrating the exchange of a rotational motion into a linear translation of the door latch, where the door latch will be pulled back and the motor will turn the threaded rod on which a bar is mounted. This bar will move forward and backward as the rod spins to pull the latch open and closed. A piece of aluminum will be attached to the latch apparatus for the bar to hold onto and pull the latch back. Each end of the rod that is mounted to the case will help achieve a smooth rotational motion.

Once again, the device will operate by a push of a button or a remote control. When the remote control or push button is triggered, it will send an electrical signal to the motor and will provide enough force to retract the catch inside the door. This will force
the door ajar, which can be easily pushed open by the client. The circuit is required to achieve the desired rotation of the motor. Once it is activated, the motor will begin to rotate. When the latch is fully open, the bar goes along the threaded rod and hits a limit switch. This triggers a relay to switch the direction of the motor and close the latch. When the bar returns to its original position, another limit switch is pushed, causing the other relay to turn off the circuit.

1.2 Subunits

**Go-Kart**

This section discusses the functions of the go-kart by describing the several different components that will be necessary to assemble the go-kart.

**Mechanical Systems**

**Chassis**

Buying a ready-made chassis, although expensive, saves time and money on purchasing raw materials and welding and assembling a chassis from scratch. In addition, welding and assembling a chassis without any previous experience or expertise could expand the horizons for unwanted and costly errors thereby increasing the expenditure. Furthermore, purchasing the chassis as part of a chassis kit has the added benefit of providing a good chunk of the other accessories and components required for the go-kart, such as the wheels, tires, brakes and cables.
The chassis kit also comes with a 2-seat model. The client’s mother currently has to stand beside or behind the quad and run alongside it while the client tries to ride it. With the 2-seat model, the client’s mother can sit in the go-kart with the client while he rides it so as to prevent any accidents and to help the client guide the go-kart appropriately. This will also allow the parent to help the client learn how to use the basic controls to drive the go-kart. Furthermore the parent of the client will be provided with a remote control to manipulate the go-kart from afar if they wish to do so.

**Wheels & Tires**

The wheels and tires that come with the chassis kit will be used for the go-kart. The assembly of the wheels will be done so according to the methods necessary and provided with the kit.

**Seats**

The seat provided with the chassis kit is like a bench and does not meet the necessary specifications of providing a safety restraint for the client. Therefore, the provided seat will not be used. Instead, two seats will be implemented - one for the driver and one for the passenger. The driver seat will be designed with a safety restraint system for the client, as he will be the driver of this go-kart. The seat implemented for the driver, i.e. the client, will either be a modification of a Tumble Forms 2 Carrie Seat if it is affordable with our given budget, or an upright seat that provides supports for the head, neck and trunk with a 5-point harness, foot rests, leg straps.
The passenger seat will be a regular bucket seat with very minimal restraints in the case that the passenger desires to be restrained in their seat.

**Harness**

A 5-point safety harness will be implemented on the driver seat. This harness will provide safety for the client as well as comfort along with the other supports in the seat that will help hold the client in the optimal seating position while riding the go-kart without being a hindrance to the client’s ability to control the go-kart.

**Steering**

Since the client lacks the necessary motor skills to use foot pedals or steering wheels, the steering system for the go-kart will be implemented with the use of a joystick that controls the acceleration, deceleration and left and right movements of the go-kart. Pushing the joystick forward would accelerate the go-kart to a specific speed level. Pulling the joystick back would initiate a reversing mechanism in the go-kart. Pushing the joystick to the left or right would cause the go-kart to turn left of right respectively.

**Motor**

A Briggs and Stratton Intek 900 Series motor with 250 cc will be used for the go-kart. The motor will put out a maximum RPM of 3800 at about 20V.

**Speed Controller**

The drive motor needs a speed controller that gauges the input voltage and ultimately limits the maximum speed the go-kart can reach. This is necessary so as to maintain the speed of the go-kart at a reasonably safe level so that the client doesn’t meet
with any unfortunate accidents caused by lack of control on the speed. The speed control will be designed for a joystick input, as that is the steering mechanism that will be implemented.

Additionally, an external potentiometer will be mounted on the speed controller to allow the client to manually set the top speed. The purpose of this is to allow the client for increased speeds, as he grows older if his parents feel that he has the ability to control the go-kart at higher speeds. Similarly, if the parents feel that the client needs an even lesser speed limit, and then they can adjust that as well.

**Brakes**

Usually a standard go-kart possesses a brake cable that attaches the brake pedal to the brake calipers. Pressing down on the brake pedal pulls the brake cable which causes the brake calipers to press down on the brake rotor which then slows down the go-kart.

Due to the client’s inability to use a brake pedal as a result of his insufficient motor skills in his legs, a brake “pedal” will be implemented in the form of a button on the dashboard next to the joystick controls for steering. This button will work exactly as a brake pedal does, only it will be pressed down on with the hand rather than the foot. The client has a very clear ability to press buttons with his hands and can therefore easily activate the braking mechanism by pressing down on the brake button with his hand.

**Electrical Systems**

**Battery**
Deep cycle batteries will be used to run the go-kart. Flooded lead acid batteries will be the kind of batteries used due to their long life and cheapest cost per amp hour.

**Electric Control Box**

A secured control box will contain all the electrical components such as the speed controller, some wiring, and also the receiver for the remote control. Wood or plastic will be used to create the box and it will be secured to the chassis of the go-kart. The purpose of this electrical control box is to secure the components from those using the go-kart, particularly the client. Furthermore, electrical conduits will be used to insulate all other wiring as well and the conduits will be secured to the chassis, so as to prevent any harm to the client or other users of the go-kart.

**Control Systems**

**Remote Control**

A remote control will be designed to allow the parent of the client or other guardian to have control over the go-kart from afar in the case that the client isn’t able to control the go-kart properly himself. The remote control will have a maximum range of 1500 feet. It will use a very similar joystick control to that of the one implemented on the go-kart dashboard for the client. The remote control will be designed in such a manner to allow the parent or guardian a higher level of control on the go-kart than the client’s control mechanism. This is important because it further ensures the safety of the client while still allowing him to control the go-kart by himself to a certain extent. The remote control will run on D cell batteries.
For the remote control to control the go-kart a receiver will be implemented for the go-kart. The receiver will receive signal inputs from the remote control but also from the dashboard controls. The receiver will be programmed to control the steering, braking, and speed control systems. The receiver will be secured in the control box.

**Kill-Switch**

For safety purposes, the remote control will contain a kill-switch in order to shut down all the receiver outputs and thereby stop all movement of the go-kart. This is necessary in the case of a possible foreseen accident or problem upon which the parent of the client will have to implement immediate control in order to prevent the accident from occurring.

**Automatic Doorknob Opener**

This section will describe the number of smaller part that come together to make this device work. Each of these subunits has been designed so that it will accomplish its takes and also integrate into the complete system. The following sections contain details of the design for each subunit and describe how they work.

**Mechanical System**

**Outer Case**

The outer case will be made of plywood. The dimensions of the will be 15 x 7 x 2 ¾ inches. The purpose of this casing is to hold all the electrical and mechanical components inside securely. It will be implemented on the door using screws and hinges.
The purpose of these hinges is to allow access to the parts, which can only be accessed while the doorknob is off. Inside the case, it will hold two compartments that will house the batteries on one side and the mechanical parts on the other, such as the wiring.

**Electrical System**

**Battery**

The battery used in this device will be a 12-volt rechargeable battery. The type of battery used will be a rechargeable ion lithium battery, which will at least last up to 1000 openings. Then, using an AC adapter can charge it and left plugged it to charged for 3 hours.

**Motor**

The motor used in this device will be a DC 12V Micro Motor.

**Control System**

**Push Button**

A large red push button will be placed on top of the casing. This will easily allow the button to be wired into the components inside the case. The button will have a circular shape. The button will activate only when the user depresses the button. This will automatically send electrical signals to the motor, which in turn will allow enough force to release the catch.
Remote Control

The remote control will be as small as a car key chain. The remote control system will require a circuit. This circuit will be designed to fulfill the desired rotation of the motor, while the circuit will also include a 12V battery, remote control receiver, two relays, two limit switches and the motor. Once either the remote control or push button is pressed, the circuit will be programmed to activate the motor to start. A rod will hit a limit switch to open a latch, while triggering a relay to switch the direction of the motor to close. Then, the other limit switch will be pushed, to activate the other relay to shut off the circuit.

2. Realistic Constraints

2.1 Engineering Standards

Although, the client has an electric quad with all of its original factory settings, modifications will be used to accommodate the client. The standards for the production of ATV will also be maintained throughout this project to keep it close to the client’s ATV as possible. The required speed limit will be kept the same for the appropriate age, which will be 10-15 mph for ages 9+. [1] The steering system will be applied, along with a joystick device to offer easy steering that best fits the client’s condition and needs. The standards of automatic doorknob opener (ADO) production will also be kept. The required door size will be at least 36” wide, with a minimum width for passage of at least 32”. [2]
2.2 Economic

The most important constraint in designing these devices for the project is the economic constraint. Most models of ATV that are on the market now are very expensive. The most important as well as most pressing constraint is the financial one. There will be a fixed budget within which the design must be limited to. This budget is very important due to the fact that this device requires many high-end electronic components that could be quite expensive and difficult to have swapped with another part as many parts will most likely have to be customized. Currently, a fixed budget has not been confirmed. However, the estimation for the fixed budget, which the design for the ATV must be contained, is approximately $1310. Since the School of Engineering sponsors the budget for this project, a budget very high is unlikely. The availability and costs of materials may or may not be limited, which could affect the overall design. There will be limitations on what can or cannot be used for the designs. The ADO’s fixed budget is approximately $415, however the device will be installed on both the exterior and interior of the client’s bedroom door and the bathroom door. Thus, knowing the budget will help determine what materials can be purchase to modify the electric quad and build an automatic door opener.

2.3 Environmental

The environmental constraint that will affect the design of the ADO is its ability to be installed on other common household doors and public places. While, the ATV should be design to withhold extreme temperatures, such as hot or cold. The ATV should be able
to operate on varying surfaces such as the client’s yard or park. Also, to avoid pollution, the device will use a DC motor rather than a gas motor.

As the vehicle houses a motor that operates using a combustible fuel, environmental constraints are brought about. The engine will be gas operated, resulting the emission of carbon monoxide and other chemicals potentially hazardous to the environment. The deep cycle lead-acid battery that will be used to supply power to any electrical component of the vehicle will contain chemicals that are corrosive as well as dangerous. The vehicle will have to be designed to ensure the most number of miles per gallon. An efficient engine that minimizes gas consumption will be implemented.

Outdoor use of this vehicle also require that the vehicle be designed to resists the forces of whatever environmental factor there may be that could possibly undermine the components of the vehicle. Water and moisture may cause the electrical components in the vehicle to short and malfunction. To avoid this, all electrical components must be waterproofed. All mechanical aspects of the vehicle must be able to withstand varying temperatures and the effects of dirt and dust within its components.

2.4 Sustainability

Sustainability will be another issue in designing both these devices. Each device must be durable through a given time. With the ADO, there are no worries about adjusting any requirements or components that is involved in the device. The device can be removed and installed on other doors, since screws will be used to place on. This
makes it easier to remove. Since the client is 11 years old, and will continue growing, the height of where the device is placed on the door will be reachable for him, regardless how tall he is.

Also, the ATV will accommodate to these changes. To do this, the bucket seat installed on the ATV will be replaceable for a bigger one in later time. Also, the DC motor will be efficient for the client’s weight and even when his weight increases. Another constraint involves determining a cap for the max speed the vehicle will be allowed to achieve. Through obvious reasons, the vehicle cannot be allowed to operate at very high speeds. A speed cap must be put on the vehicle to ensure continued safety of the client. A decision will have to be made to determine the optimal speed to maximize the client’s enjoyment without compromising his safety. The device should also preferably be designed to sustain adequate movement and damage without causing any malfunction with the internal workings of the vehicle.

2.5 Manufacturability

As each device is battery operated, the stock battery provided might not be powerful enough to provide enough energy to compensate for any additional, especially the addition of a bucket seat in the ATV. It may require integrating a more powerful power source and motor to make up for the additional added weight. Another constraint for the ATV may be the sensitivity of the joystick. It may be overly sensitive and respond to every involuntary action that our client makes. The combination of our two
other projects may be financially constraining and may need to exercise a budget plan that best help us reach our goals while staying within our financial constraints.

2.6 Social

One social constraint is to make sure that the noise level from the ATV does not disturb the neighborhood. Also, another constraint is to make sure Steven can have freedom enjoying daily household tasks. Allowing him to explore the outdoors or accessing his bedroom door, he will become more independent and be able to reach new areas, which would help decrease the social gaps caused by his cerebral palsy. By creating these products for Steven, the prime goal is to provide him with an easier access to some aspects of a non-cerebral palsy child’s life that Steven lacks complete access to right now.

2.7 Ethical and Political

Ethical constraints could develop when a product is designed without considering the client, workers, and/or public’s safety and health. Political constraints become another major issue when the client and workers are physically or mentally harmful caused by the manufacturing of the device.

2.8 Health and Safety
Health and safety constraints will be that it needs to provide adequate support for his physical condition. All of the client’s needs will be met and Steven’s safety and best interest will be in focus throughout the project. Safety measures will be taken to make sure that Steven will be safely and comfortably harnessed to his seat and also a reasonable control on the speed limit of the vehicle will be implemented. This will aid Steven’s caretakers as well, by allowing them to give Steven a little more independence while using his vehicle, since their current areas of worry will be addressed. A remote control for the vehicle will be created for the parents to use from a distance, so they may control the vehicle if the need arises. The ADO will allow Steven to comfortably pass through doors without the help of others. It will also reduce Steven’s mother’s worry of him locking himself up in a room and being unable to get himself out.

In addition, safety constraints include making sure that the device doesn’t have any exposed wiring or other such flaws that could cause harm to. Another constraint is the issue of refilling the vehicle with more fuel that it combusts. To meet this constraint, the engine will have to be a fuel efficient one that will minimize the number of times the tank needs to be refilled.

3. Safety Issues

In designing both of these devices, safety is the most important concern. As discussed in the earlier section, safety is a constraint that must be shown some attention.
It is a priority to keep the operator safe from harm at all times whether they are sitting within the vehicle or entering it. All wires of electrical components will be carrying potentially dangerous currents and will be enclosed in rubber coverings and enclosed to shield them from the environment as well as from the operator of the vehicle. All wires will be secured to the chassis of the vehicle so that there are no loose wires that the operator can get tangled in. All wires used will be rated for a particular current magnitude and used properly to prevent any of the wires from overheating and potentially catching on fire. For the mechanical components of the vehicle, the biggest safety concern comes about from any moving parts that the client may be able to get caught in.

To prevent this, all moving parts will be situated in a way that will eliminate any possibility of this. As mentioned earlier, the chassis of the vehicle will be a steel roll cage frame that, in the event of a rollover accident, will prevent the client from becoming crushed under the weight of the overturned vehicle. Bumpers will surround the sides of the vehicle and absorb some of the force given a collision. All components of the vehicle will be secured to the chassis and no parts will become dislodged during operation to prevent injury to the operator. As there is a battery providing a power source to the electrical components, there is a potential chemical hazard if some of the corrosive elements leak out of the battery housing. This is unlikely however, even in the event of a collision. The gasoline used for fuel must be housed in a robust tank that will resist puncture in the event of collision. To keep all of the electrical components as cool as possible to avoid overheating, there will be a cooling system employed. These components will be enclosed but ventilated to prevent accidental contact with heated
components that could potentially cause burn to the client. The exhaust of the vehicle will also be directed away from the operator.

Safety is a major concern in this project, when the devices are both active and not. For the ADO, it is important for this device to be able to be installed on any household door. Since the ADO will be encased in a wooden box, to avoid any accidents, the case will not protrude out too much for anyone to bump into, with rounded edges. Also, to keep Steven from being locked in or out of his bedroom or bathroom, the device must run on rechargeable batteries at a given amount of time. Since, all components will be contained in the case, it must be well sealed. Each component inside will be isolated from each other and any other possible connection or wiring should be secured.

4. Impact of Engineering Solutions

The potential global impact that would arise from the design and production of this vehicle is minimal as there are some existing models on the market already. There should be little to no impact given the engineering solutions present in this vehicle design. The vehicle is designed surrounding the needs of our specific client. Although in the event that this vehicle is recognized and commercially mass-produced, it could potentially influence economics, society and the environment as well as potentially even global effects. This vehicle’s purpose is to provide a release for any physically hindered person. By creating a product such as this for a market that have a couple of other
products like it may have the potential for lucrative gain for a manufacturer. If this became the case, the product would become more widespread and in turn have a possible effect on society as they may begin to see physically disabled people in a different way. These handicapped individuals would be now seen enjoying the outdoors in a vehicle that many people would enjoy riding, making there differences less apparent. The environmental impact is less favorable. The designed vehicle does operate on combustible, emissions producing fuel which are released into the atmosphere, contributing to the degradation of the ozone as well as acid rain and various other adverse effects on the environment. Changing the engine oil when it needs to be changed also creates an issue for disposing the oil. It must be properly disposed of in a way that minimizes its negative impact on the environment.

Since the goal of this project is to create a device that will allow our client to enjoy outdoor activities and to carry out daily tasks with hopes to make Steven’s life easier. Even though this product is made for only one client, it’s can be very versatile and may be used on any household door. There are many products in the market that are more highly advanced than the design of this ADO we are using. The global impact of the ADO is hard to imagine. However, it could cause awareness of the disability, which could lead better products that could improve of the quality of life for disabled people. It will have a minimal environmental impact, since the product is used indoors. If it was used on the outside doors, then this could have an impact, since it would allow the people to be able to go outdoors. It would bring a new demographic of people to nature and the
outdoors. If mass-produced, there would could be a large market for a low cost ADO, which can bring people who have disabilities closer to a normal stand of living.

5. Life-Long Learning

In order to design and construct this project, there will be many new skills learned. These skills can be carried with the team members with the group after college. Aside from technical and mechanical aspects of this design project, knowledge of the disease, cerebral palsy and how it can negatively effect a patient’s life will be understood and appreciated so that further devices that will ameliorate there way of life and level of happiness will be designed and produced. Since the client of this project was diagnosed with cerebral palsy. Being aware of what and how cerebral palsy is developed would be the first thing learned in this project. It is important to this disability associated with this disorder, because it will become essential when building a specific product for a person who has cerebral palsy. Another learning component would be how to work in teams and build social skills. Group projects can be a difficult task without communication or teamwork because it becomes necessary to divide work efficiently and quickly to meet deadlines. While communicating with the client, it is required to be respect and intelligent interviewing to find out what the client needs and what they don’t need about their current situation.
While designing this vehicle, many new skills have been acquired and knowledge obtained. The electronics system for steering involved will no doubt involve a good deal of learning and understanding of new concepts. It will require obtaining knowledge of programming in embedded C. Additional extensive knowledge of motors, power trains, and shop experience will be required to assemble various components of this vehicle with minimal error and the unnecessary reordering of new parts due to error. As we will be using a PWM with our variable speed motor, thus understanding the basic concept of the PWM signal and knowing exactly how to apply it to the vehicle will have to be learned. At the end of this design project, one of the greatest lifelong learning skill that will be most likely be acquired will be hands on experience with the mechanical aspect of assembly and further knowledge of engines, suspension systems, electronics, and coding.

6. References

<http://www.cpsc.gov/businfo/frnotices/fr06/066703.html>