Project Proposal: E-Racer

TEAM 3
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Executive Summary

This project involves the creation of a go-kart for a child with cerebral palsy. The client cannot use standard go-karts as he is not able to use his legs. He is also not able to use his left arm independently, but is able to use his left hand as a “helper hand”. There are several other products which have been designed, and one company which manufactures commercially available go-karts for disabled people. However, these go-karts lack many features which are necessary for a vehicle of this kind. The current project will address these shortcomings through the production of a custom-made go-kart based on the client’s needs and abilities. The primary goal of this project is to keep the client safe, but his ability to enjoy recreational time must also be heavily considered.

1 Introduction

1.1 Background

This project will entail the design and creation of a go-kart for a child with cerebral palsy. The client does not have significant use of his legs—he is able to stand either for a very short period of time or with external support. Additionally, the client’s left hand is not fully functional and operates as more of a “helper” hand, but can grip a steering wheel. However, the client’s right hand is essentially fully functional to the point where the client can play video games. Also, when the client becomes excited, his chin tends to drop towards his chest. While many patients with cerebral palsy have tremors, the client in this case does not.

The client is very good at using his current wheelchair, which uses a joystick control. In addition, the client requires some support for both side of his torso, and this support must be substantial so that it does not loosen over time.

1.2 Purpose of the Project

The goal of this project is to allow the client to use a go-kart which is similar to a standard go-kart, but with some adjustments. The client cannot use the standard go-kart due to its use of foot pedal controls and a steering wheel mechanism, as well as lack of proper restraint and inadequate safety measures. This project will create a go-kart which is custom-made to suit the client’s needs, thus addressing all of these issues. The primary requirement of the go-kart is to keep the client safe, while enabling him to enjoy recreational time with friends under the supervision of a guardian.

1.3 Previous Work Done by Others

1.3.1 Products

There have been a few other products which have attempted to address 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 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.\(^1\)

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.\(^2\)

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.\(^3\)

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 cart 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.\(^4\)

1.3.2 Patent Search Results

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.\(^5\)

2 Project Description

2.1 Objective

This project must achieve the following:
1. Allow the client to use a joystick control until he is comfortable with the go-kart and then switch to a joystick
2. Allow for kart operation by use of only the right hand
3. Provide a proper restraint system
4. Provide numerous safety mechanisms in case:
   a. The client’s chin drops to his chest
   b. The go-kart tips
   c. The client slips out of the restraint system
   d. The client loses control of the go-kart
5. Provide proper support for the client
6. Allow for adjustment as the client grows
7. Allow for ease of entry into the go-kart

In order to achieve these goals, the following designs will be implemented:
1. Create a mechanism which will allow the client to choose whether he wants to use a
   steering wheel or a joystick
2. Create a joystick which incorporates all controls into a single mechanism on the right
   side and create a steering wheel which (a) can be used with one hand and (b)
   incorporates gas and brakes into the steering wheel unit
3. Design a 5-point safety belt which can be adjusted as the client grows
4. Incorporate mechanical and electrical safety measures
   a. Design a mechanism which activates a kill switch if the head drops below a
      certain level (if the client cannot activate his own kill switch) or create a
      helmet which will only allow for left to right motion (not up and down)
   b. Create a roll cage around the go-kart if it does not already have one
   c. Create a system on the sides of the go-kart in case the client slides sideways
      out of the restraint system (will have to be a door mechanism on one side so
      the client can enter and exit)
   d. There will be a kill switch in the go-kart as well as a remote kill switch; there
      may also be secondary control by a remote non-driver, similar to that used in
      the original E-Racer
5. Design a seat which will be comfortable for the client as well as provide the proper
   support, particularly for his left side
6. The restraint system will be designed to be adjustable as the client grows
7. The chair could have a swivel mechanism which would allow it to turn 90 degrees so
   the client can be placed in the seat; there will have to be a lock which secures the seat
   in its original forward-facing position

There are many innovations associated with this new design, including the ability to
switch between steering wheel and joystick control. The vehicle will also have several safety
features not present on other products, including side restraints and an emergency stop procedure
that is activated by multiple events. In comparison to currently available products, the E-Racer
will be unique in its ability to provide adjustments to accommodate user growth. Additionally,
where existing product designs do not have a good method for entry into the go-kart, the current
E-Racer will allow for rapid and easy entry of the user. Most importantly, this go-kart will be
tailor-made to the client’s unique needs, including consideration of his tendency to bring his chin
down to his chest, his lack of tremors, and the extensive support required by his left side.
2.2 Methods

An electric go kart will be purchased from Minimoto (Jeep Dune Buggy). This go-kart will be modified to accommodate the requirements specified by the client. Major modifications will be done on the following systems: restraint system, control system, braking system.

Restraint System:

The driver of this go-kart has limited control of his body due to his medical condition. The restraints on a typical go-kart will not sufficiently secure the driver during operation and/or in the event of an accident. The driver will need assistance entering the go-kart and properly applying the designed restraints. To make this process as quick and easy for both the driver and the assistant, the driver’s seat will be on a swivel track. This track will allow the seat to turn to the left and protrude out the left side of the go-kart for entry (Figure 1). Once the driver is seated, a four point restraint will secure the trunk section (Figure 2). The seat will then return to the operating position (Figure 1) and will automatically lock into place. A secondary lock will also be applied for safety purposes. The driver’s legs can then be secured using two straps applied to the driver’s lower leg (Figure 2)

Figure 1 – Moveable Chair for Easy Access Loading
The client requested a go-kart with two types of control systems (joystick and wheel). Only one type of control system can be used while operating the kart. This control system can be changed when the kart is not in motion. There will be a plastic cover that will lock over the switch when the cart is in motion to prevent changing modes during operation (Figure 3). When more specifications are received the switching mechanism will be designed.

The first type of control system will use a joystick that operates in a similar manner to the client’s electric wheel chair (Quickie Z500). Pushing the joystick forward will cause the go-kart to accelerate whereas pulling back will engage the braking system (Figure 3). The driver’s right hand is fully functional and has relatively good fine motor control. Therefore, a variable control joystick will be used. In other words, the speed of the go-kart will be commensurate to the angle that the joystick is pushed forward. The joystick that will be used has a range of 0-5V. The joystick will output a voltage of 2.5V when centered. Pushing the joystick forward will produce
a voltage from 2.5V-5V (based on the angle made with the vertical axis). The voltage produced will go through a series of comparator circuits that will switch on an appropriate relay, placing a new resistor into the circuit that will drive the electric motor. As the resistance is decreased, the electric motor will increase in speed. Similar comparator circuits will be used for the braking system so as to produce different levels of braking. If the driver would like to go into the reverse mode, he can stop the car, flip a switch on the control box, and then push the joystick forward (Figure 3). The reverse control will have a top speed of 5mph. The reverse switch will have a cover that will be unlocked only when the kart is not moving.

The joystick will also be used to steer to go kart. A linear actuator, controlled by the joystick, will mechanically steer the kart. For safety purposes, the turning radius of the kart will be adjustable with a mechanical selector. The design of this selector will be determined when we obtain specifics regarding the braking and steering systems from the go-kart manufacturer. The
turning radius will be increased as the driver becomes accustomed to the operation of the kart, thus making the vehicle more maneuverable.

The other control system will use a steering wheel and hand paddles located behind the wheel (similar to shifter paddles found in sports cars). The left hand paddle will cause the kart to accelerate while the right hand paddle will be used for braking. This configuration was chosen so as to have the brake paddle on the driver’s stronger side (right side). The acceleration and braking controls will be similar to the joystick control in the sense that they will operate with variable control. Thus, distinct levels of acceleration and braking strength will be applied based on the distance that the pedals are pulled towards the steering wheel.

The driver has a tendency to look down when he gets excited. If the driver does this while the kart is moving, the motor will be killed and the brakes will be automatically applied. This will be detected using a sensor to the driver’s seat. The parents of the driver have also requested a remote kill switch so that they, at any time, can turn off the engine and stop the kart with the push of a button. The parents will also have the option of setting the kart to automatically turn off and stop in the event that it is out of range with the remote kill switch. This option will be selectable on kart using a simple on/off switch (Figure 3). Figure 4 summarizes all the different emergency shut down conditions.
Braking System

The stock go kart has a mechanical braking system. In other words, the hand lever is connected to a caliper via a cable. When the lever is pulled, the cable shortens and the caliper is tightened around a disk. The electrical joystick control cannot produce the mechanical force (joystick mode) to tighten the caliper. Similarly, our client does not have the strength to mechanically tighten a caliper by pulling on a hand lever. A linear actuator will be used to provide the mechanical strength needed to tighten the caliper on the disk. This linear actuator will be controlled by either the joystick or the right hand paddle depending on which control mode is selected. Again, comparator circuits will be used to allow the joystick and the brake paddle to provide variable levels of braking force.

Figure 5 – Braking System Incorporating a Linear Actuator
3 Budget

Budget considerations for the E-Racer are depicted in Figure 6 below. It is likely that the budget will change as designs are revised and other requirements and considerations are realized. However, since the expected total cost for the final product is approximately $1,400—six hundred dollars under the $2,000+ budget, there is still room for additional purchases to be made. Another consideration is the possibility that a different model go-kart may be selected. One of the desirable aspects of the Minimoto model is its relatively low cost in comparison to other go-karts. Since the design revisions will likely entail the use of other go-kart models, the cost of the stock kart will likely be greater than the $800 Minimoto. With the assumption that the final cost of the E-Racer will be exactly $2,000 and that the production vehicle will cost 35% of the prototype cost, the MSRP for the E-Racer would be $700. This is unlikely, simply because the cost of the unmodified kart is greater than this amount. In any case, the E-Racer design will cost the customer thousands less than the Mobility4kids models.

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Figure 6 – Budget
4 Conclusion

In conclusion, this go-kart will accomplish many tasks, including providing the option of switching between joystick and steering wheel, incorporating numerous safety measures, and designing a seat which can provide sufficient support and comfort. The fact that the vehicle will have multiple control systems addresses two main concerns. Primarily, it is important for the user to be able to control the vehicle comfortably as soon as the project is completed. This will be accomplished by using a control system that is similar to the one currently employed in the client’s power wheelchair. Through the use of this control method, the client will be pleased with the ease of use of the vehicle and will immediately be able to safely and comfortably enjoy the product. From this point, the product will provide the client with the ability to operate the vehicle with steering wheel controls—a request that was made so that he may be able to control the vehicle in a similar manner as his peers. While the vehicle will certainly be fun for the client to use, it will also be very safe as a result of the myriad of safety features that will be incorporated into the final product. The most significant safety feature which will be added to the kart is the emergency stop system that can be activated as a result of multiple events. This system will effectively bring the vehicle to a halt when an emergency situation is detected. While this feature will be very beneficial for our client—an eight-year-old with cerebral palsy, it is likely that the implementation of this system in stock go-karts would reduce the risk of injury to all users, and could be a valuable resource for parents wishing to have greater control over the safety of their children. Further, the addition of the five-point harness will provide a much more robust restraint system than is present in the stock go-kart, ensuring that he is firmly, but comfortably secured in the vehicle. Finally, measures to ensure that the client does not look away from the road will further increase the level of safety that will be maintained during the operation of the vehicle. This will involve the incorporation of some type of sensor into the seat of the vehicle. The seat itself will be much more comfortable for the client than current stock models as a result of its ability to maintain sufficient postural support for the client—particularly on his left side.

Many aspects of the project make it unique, including the ability to switch between controls, be adapted as the client grows, allow for easy entry into the go-kart, and provide additional restraints not found in other designs. There is certainly a market for this kind of device, as can be evidenced by the establishment of companies such as Mobility4kids. However, the go-karts made by Mobility4kids have far less than adequate safety measures, are expensive, and only travel up to 7 mph. The E-Racer will effectively have offer all of the benefits of the Mobility4Kids models while providing the user with a safer and more exciting driving experience for thousands less than existing designs. Therefore, it is apparent that a market exists for this type of product, which is not satiated by the currently available options. The E-Racer design will fill this void in the market by providing a safe, affordable, and fun vehicle for people with physical disabilities. As mentioned above, one of the key goals of this project is to allow the client to enjoy virtually independent recreational time in a vehicle similar to those used by his peers. With the implementation of the previously discussed designs, this hope will become a reality for the client.
5 References


