The Smart-Kart Operator Manual

Team 9

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**Safety Instructions:**

- The Smart-Kart is for outdoor use only.
- The product can only be used in dry conditions (no rain, snow, mud, puddles, etc).
- Do not use any wet rags or sponges to clean the go-kart. If any part of the vehicle is submerged in water, electrical parts can become damaged.
- Do not store the vehicle in extremely hot environments. This may damage electrical components.
- Do not use the product on roads; this is strictly a product of off-road driving. Avoid public roads, streets, or other public property.
- Never use the product in close proximity to other persons or animals. This may cause harm or injury to them.
- Avoid using the product near small children.
- Avoid impact on to any part of the go-kart including the front bumper. This may damage the ultrasound sensors for smart braking.
- The weight capacity of the two persons riding the go-kart should NOT exceed 350lbs. If the weight should exceed this, injury to persons driving or damage to the go-kart may result. Passengers who do not fit comfortable in the vehicle should not use the Smart-Kart.
- Never fit more than 2 persons on the go-kart
- The client should only use the product if there is a supervisor in the vehicle at all times!
- The supervisor responsible should read the operation manual thoroughly and understand all controls, procedures, safety measures and risks.
- The supervisor is responsible for training and instructing the driver and any other persons that are operating the vehicle if they themselves cannot read the instruction manual.
- Experience and mastery of the controls is essential for proper handling of the Smart-Kart.
- The product should be properly taken care of before and after each use to ensure safety and longevity in the future.
• NO FLAMMABLE PRODUCTS OR OBJECTS SHOULD BE PLACED ON OR NEAR THE GO KART. **THE GO-KART IS GAS POWERED.**
• Frequent checking of all components including oil is required for the safety and longevity of the product.
• The passengers should always be wearing seatbelts/harnesses and helmets when the vehicle is on and/or in motion.
• Protective clothing such as long sleeves, pants and closed toed shoes is essential when operating or working on the Smart-Kart.
• Avoid driving up steep inclines especially when the weight capacity is over 300lbs. This may damage the engine.
• DO NOT touch the engine and surrounding components during of right after use, these parts can get extremely hot.

**Features:**

• Gas powered
• Two modes of control
  o Electric joystick
  o Electric X-box controller
• Kill switch
• Lights
• Two-seater (two passengers)
• Forward or reverse option
• Power controls
  o Power braking
  o Power steering
  o Power drive
• Transmission
• Alternator
• All-terrain tires
• Double A-arm suspension
• Ultrasound sensors for smart braking
Parts and Accessories

- Rack and pinion
- Steering linear potentiometer
- Steering gear motor
- Tie rods
- Front wheels
- Steering system guard
- Bumper with ultrasound sensors
- Lights
- Dashboard
- Foot rests
- Passenger seat with seatbelt
- Client seat with 5-point harness
- Armrest for client
- Control panel
- Joystick
- X-box controller
- Steering steed controller
- Braking speed controller
- Throttle speed controller

- Microcontrollers
- Throttle with throttle actuator
- Braking with braking actuator
- Battery
- Engine
- Gas Tank
- Carburetor
- Transmission
- Forward/reverse lever
- Disk Brakes
- Sprocket and chain reduction system
- Rear wheels
- Roll bar
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1. **Introduction**

1.1 **General Overview**

The Smart-Kart is a modification to an already prefabricated purchased go-kart. These modifications were designed to accommodate the needs of the client, ensure the safety of the client and add innovative components to the vehicle. The all steel chassis includes sheet metal side panes and a roll bar. Mechanical components of the go-kart such as the shifter, parts of the steering system, and gas and brake pedals were removed and replaced with electrical steering system powered by a motor, a linear actuator to pull the throttle, and a linear actuator to operate the hydraulic disk brake system. The roll cage was replaced with a roll bar after chassis extensions were made to comfortably fit two people. The Smart-Kart utilizes a gas powered engine and a 12V-9A deep cycle battery to power the start up and electrical components. An alternator that came equipped with the engine charges up the battery once the engine is in idle or drive. The three main systems (steering, drive, and braking) are all powered electrical. The braking and drive system use linear actuators to operate while the steering uses a rotational motor couples with a linear potentiometer. The engine and electrical components are turned on separately on the dashboard.

As mentioned earlier, the Smart-Kart is a two-seater vehicle. The driver’s seat is a multi-component seat that was disassembled from an electric wheelchair. It consists of the following parts: seat cushion, trunk support, head and neck support, footrest, and an armrest. The passenger seat is a regular car seat equipped with a regular backseat seatbelt. For seats have an adjustable reclining mechanisms. The driver seat has an installed five-point harness with latch and link quick release mechanism that unbucks all five points with one pull.

The steering system uses the rack and pinion system that is directly connected to the wheels through the tie-rods than came equipped on the go-kart. It is powered by a Dayton 1L469 gear motor, which controls the motion of the rack and pinion via an input signal from the speed controller. To monitor the position of the rack and pinion the Celesco CLWG Series linear
potentiometer was mounted parallel to the rack and pinion as a feedback sensor to the steering system. With this key component, the wheels of the go-kart return back to the initial position (straight) when the joystick is released. Additionally, it ensures that the steering motor does not continue to rotate once the rack and pinion has reached its two physical limits to the left and right. A sprocket and chain reduction system was installed between the motor and pinion to decrease the steering response rate, since the motor rotates faster than necessary. The steering system is shown in figure 1.

Figure 1: Steering system including: motor, linear potentiometer, chain and sprocket reduction.

The braking system utilizes the hydraulic disk brakes that were already present on the purchased go-kart. The hydraulic brake cable is controlled via a robust linear actuator, which extends pushing down on the cable thus initiating the mechanical application of the disc brakes on the back tires. Additionally ultrasound sensors, which are mounted to front bumper, detect objects in front of the go-kart and automatically signal for braking.
The engine that came with the purchased go-kart was a 110cc 4-stroke single cylinder engine (figure 3). The output power of the engine is controlled in a closed feedback system. A linear actuator (figure 4) will be connected to the throttle thus pulling the throttle when the actuator retracts. This throttle, attached to the rotary valve, regulated the amount of gas entering the engine for combustion.
There are two options for controlling the go-kart: the joystick, which is mounted on the left side of the driver seat and an X-box controller on the passenger seat (figure 5. There is an additional kill switch mounted on the go-kart dashboard. This kills all power to the go-kart for emergency stops. A lever on the passenger's right side allows for the reverse of the go-kart.

1.2 Operating the Smart-Kart
It is essential that this go-kart be never used without the attentive supervision of an adult. Additionally, the Smart-Kart should not be used in wet conditions including: rainy, snowy, or muddy conditions. If the vehicle is used in wet environments, serious damage to the vehicle will result and therefore possible injury to the users. It is also recommended that frequent maintenance checks be conducted before the use of the go-kart.

Before starting the go-kart, make sure that the gas tank has a sufficient amount of gas in it. If the go-kart has not been in use for a long period of time, a full tank of gas is usually recommended. Before turning on the engine via the key on the dashboard, turn on the electrical components using the leftmost switch. Using the joystick and/or controller initiate braking and observe that the braking actuator extends upon command. If the actuator does not extend maintenance is required, DO NOT use the go-kart in this condition. After turning the key and starting the engine, observe whether the drive train of the vehicle is in the forward or the reverse direction using the lever to the right of the passenger seat. IT’S IMPORTANT TO BE AWARE OF THE FORWARD AND REVERSE DIRECTION, TO AVOID INJURY. Check that the transmission and braking have sufficient oil levels and that all of the system components that are exposed to the environment are clean and ridden of mud. If any doubt about the safety if the vehicle arises refer to the maintenance issue before riding in the vehicle.

Is it important that the supervisors of the go-kart familiarize themselves with all system controls before handling of the go-kart. Previous experience is highly recommended.

The client and the supervisor should both be seated in the Smart-Kart before turning on the engine and supporting systems. Both persons should be properly buckled in and comfortable in their seats. The passenger should be buckled by the waste seatbelt while the drive is buckled in via the five-point harness as shown in figure 6. Helmets are highly recommended while operating or riding in the go-kart. Once both passengers are properly seated and buckled, the supervisor should turn the key, which is mounted on the dashboard, to the right. If the engine fails to catch and stay in idle, keep the choke (figure 7) pulled out as you turn on the engine. Allow the choke to be
pulled out until the engine catches. The choke simply allows more gas flow to the engine. This is often necessary if the engine has not been turned on for a significant amount of time. After the engine is on and in idle, the supervisor can now switch the systems switch on, this will give power to the steering, throttle, and braking (including ultrasound sensors for smart braking if the US switch is turned on). The supervisor will then have to check whether the go-kart is in forward or reverse using the handle bar to the right and before the passenger seat (on the outside of the go-kart as shown in figure 9).

Figure 6: Five-point harness of driver seat
Figure 7: Choke cable

Figure 8: Dashboard with labeled components.

- Power to all Electrical components
- Power to ultrasound sensors
- Controller Option: Joystick or X-box controlled
- Engine ignition key
When the passenger is to operate the vehicle the controller option switch on the dashboard (figure 8) should be switch to the “C” (controller) position. When the driver side is operating the vehicle this switch should be on the “J” (joystick) position. The supervisor should always be prepared to take over operation by switching this switch. They should also be ready to hit the kill, which is positioned to right of the controller option on the dashboard, switch at any time. To use the joystick, only the left hand is necessary. To put the go-kart in drive simply press the joystick arm in the forward direction, pressing the joystick to the right will turn right and to the left will turn left. Pressing the joystick back will apply braking. To use the X-box controller, hold the controller with both hands. NOT ALL THE CONTROLL BUTTONS AND JOYSTICKS ON THE CONTROLLER HAVE FUNCTIONS. The functioning joystick on the x-box controller is the upper left stick, this functions the same as the joystick on the driver side except for the braking. The braking on the X-box controller is the top right trigger button as shown in figure 10. The reverse function is controlled the same as the forward function on both the joystick and the X-box controller once the forward/reverse lever is changed. Braking will work the same way regardless of forward or reverse.
Figure 10: X-box controller with the functioning controls labeled.

The steering will turn to a certain point/limit after which the wheels will not turn to that direction any longer due to limits in the turning radius. When the steering control is released, the wheels will move back to their original positions (straight).

The kill switch on the dashboard just left of the ignition key should only be used in emergency situations. Consistent use of the kill switch will begin to damage the go-kart.

While using the go-kart, all-terrain landscapes are acceptable. The go-kart’s all-terrain tires and suspension was designed to overcome rough terrain. However, it is important that muddy and wet conditions are avoided as this could damage the electrical components of the vehicle. If the go-kart is used on all-terrain it is important to frequently check tire pressure to avoid vehicle damage and user injury. Additionally, if the go-kart is constantly used on rough terrain, it is critical that nuts and bolts are checked and tightened if loose.
After go-kart use is complete, several steps should be taken to properly shut down the vehicle that future use is safe. Make sure that the lever switched to the forward position for future use. After turning on the go-kart do not leave the key in the ignition. Also, the system power switch should be turned off. Once power is shut down, hit the kill switch button just to ensure all power is off. Only after this power off procedure is complete, can the passenger and driver unbuckle their harnesses and belts and take off helmets if worn. Clean any mud or dirt that may have gotten on the go-kart to avoid damage to parts and corrosion. Store the vehicle in a dry place with little humidity. To be safe, cover the go-kart with a waterproof tarp to ensure that no moisture reaches electrical components. If all of these precautions are taken, the Smart-Kart will increase in longevity and injuries will be avoided.

2. Maintenance

2.1 Mechanical Maintenance

2.1.1 Chassis

In order to sustain the proper functioning of the go-kart is it essential that the integrity of the chassis is maintained. Be aware of any mud or debris that may have stuck to the go-kart during use or storage. The chassis should be frequently cleaned without wetting and damaging any of the electrical components. Also be aware of any lose welds or serious bends or breaks in the chassis. Do not use the device until a professional fixes these. Also be aware of any lose mounts on the go-kart than support the electrical components.

2.1.2 Braking

Make sure that the braking actuator is mounted and stationary on the back of the vehicle. If the actuator or braking cable is loose tighten all the bolts that are used to mount the components. Before driving the vehicle turn the system power on, on the dashboard, and test that the braking actuator retracts when braking is applied with BOTH controllers. Also test that smart braking is on. Turn the ultrasound system on and stand in front of the go-
kart. This should retract the braking actuator thus applying the brakes. Every once in a while the discs should be checked on the wheels.

2.1.3 Steering

Before driving the vehicle, the steering system should also be tested to make sure its properly working. Check all the connections on the linear potentiometer and make sure the mounting components of the linear potentiometer are tight and stationary. Be sure to check that the gear motor is tightly secured to the floor of the chassis. After driving on rough terrain these bolts can sometimes loosen a bit. Make sure that the wheels are straight when in neutral (not turning). If not, adjust their straight position before driving by manually maneuvering the tie rods. Also be sure that the sprocket and chain system is secured and the two sprockets are in the same plane to avoid damage or loosening of the chain. Be aware of the Plexiglas shield in front of the steering system. This shield should be tight to avoid debris of feet getting in the way of the steering system.

2.1.4 Gas

Before each use, make sure there is enough gas in the gas tank located behind the driver seat. Also be sure that the bolts holding down the gas tank are secure and the gas tank lid is tightened. After long storage the engine often will require a full tank of gas to start. With use, this will be seen less and less often. Regular gas from any gas station can be used to run this engine.

2.1.5 Engine

The engine can sometimes be hard to start if it has been unused for an extended period of time. If the engine does not start easily, pull the choke out and keep it out while starting and until the engine stay idle, this allows more gas to flow to the engine. In some cases the idle screw may become displaced. Tightening and loosening the screw ever so slightly is all it takes to start the engine. This screw is very sensitive so it is important to not turn it in either direction too much. Figure 11 shows the idle screw on the back of the go-kart near the carburetor and engine. In extreme cases carburetors can become
clogged eliminating the pathway for gas to flow into the engine. In this case, it is important that you take the carburetor to a profession to get it taken apart and cleaned. Figure 12 is a figure of the carburetor, which came equipped with the go-kart.

**Figure 11:** The idle screw, adjustable with a screwdriver.

**Figure 12:** The carburetor that came equipped with the engine.

### 2.1.6 Battery

If the go-kart fails to start and electrical components do not start then it is likely that battery is dead. In this case the battery needs to be recharged or replaced. This is not common unless the power system is left on, discharging
the power from the battery without the recharging of it via the alternator. The alternator only charges up the battery when the engine is running. Also check that the straps and mount of the battery is tightened and secure. The dismounting of the battery during vehicle operation is very dangerous for the user.

2.1.7 Control panel

Make sure that the control panel located behind the driver seat is secure, clean and wires are not hanging out of the go-kart. Make sure that the microcontrollers are mounted securely to the panel, as rough terrain can often loosen bolts and screws. Also make sure that the Plexiglas shield is secure and undamaged.

2.1.8 Seats

Before operating the vehicle, make sure that the seats are securely bolted to the chassis and the armrest of the driver seat is secured properly. At this time it is essential to also check the bolts on the chassis that hold the harness in place are secured. Although tighten the wing nut that secures the reclining mechanism of the driver seat. This wing nut is directly behind the Plexiglas of the driver seat.

2.1.9 Footrest

Check that the footrest is secured to the floor of the chassis. This will ensure that the client’s feet are secure in one position while he is operating the go-kart. When the footrest is not in use retract it so it is not in the way.

2.1.10 Front bumper

Avoid any damage to the bumper, as this structure is not meant to withstand high impact. Any impact to the bumper will also cause damage to the ultrasound sensors that initiate smart braking.
2.1.11 Tires

Make sure that the tires are all filled with air before each use. If there is a tire that is deflated, be aware to see if it has a hole or is loose from the hub. Make sure all bolts on the wheels are always tight. If the tires are too worn out over time, it is recommended that they be replaced as soon as possible. When replacing keep in mind the size difference between the back and the front tires.

2.1.12 Oil and brake fluid

Make sure to check the oil before every other use. When oil is low it is recommended that it be changed immediately. If ignored, serious damage to the engine may result. It is also important to add brake fluid to the hydraulic brake system when it is low. The brake fluid container is bolted to the back of the chassis behind the roll bar (figure 13)

Figure 13: The brake fluid container.

2.2 Electrical

2.2.1 Battery
Make sure that all connections on the battery are secure and have good electrical contact. It is important to keep the cover on the battery on after inspecting it so that no dirt or debris gets near the leads. It is also important to keep all wires away from the leads to avoid shorting the circuit. All wires should have insulation around them. If there is exposed bare wire make sure to insulate it with electrical tape or have the wire replaced.

2.2.2 Control Panel

The control panel located behind the driver seat is the housing for most of the electrical components (especially the more sensitive ones). It is surrounded by Plexiglas to avoid damage. However IT IS NOT WATERPROOF and it is critical that not moisture is exposed to the control panel. It is also important to check all wires on the control panel to make sure no bare wires are touching. If there are bare wires that are touching, make sure the power is turned off before you insulate them with electrical tape or separate and secure them. If any adjustments are necessary, consult the troubleshooting section or contact a professional.

2.2.3 Controllers

The controllers do not required any separate battery, they are powered by the vehicle’s battery. It is important that the controllers are kept clean and that the silicone tubing insulates their wires. Keep the X-box controlled inside the go-kart at all times. This controller is not stationary like the joystick so it is important to make sure it is close by and inside during operation.

2.2.4 Wires

All wires are to be kept insulated so that no bare wires are exposed and that no wires are in the way of any mechanical components such as the tires, axles, suspension, etc. If a wire become loose it is important to seek professional help. ONLY persons with experience should rewire any electronic components. When moving any wires out of the way make sure that the power to the go-kart is turned off.
2.3 Environmental

To ensure longevity of the go-kart, the vehicle should be used and stored in the proper environment. There should not be any moisture near the go-kart, as this would damage the electrical components. It is also important to run the go-kart in the open air and store it in a warm-to-cool environment. Extensive exposure to heat may damage the electric components. It is also recommended that the vehicle is not run for an extended period of time or is given rest between driving sessions as the engine can get extremely hot. If the engine continues to stay on, the extensive heat can damage the electrical components on the control panel. Lastly, use a waterproof tarp to cover the go-kart while it is in storage and transportation.

3. Technical Description

The Smart-Kart is a complete unit that is made up of several subunits that work together. Each subunit pictured and described in detail in the following section. The final prototype is seen in figure 14.
3.1 Chassis

The two-seater chassis dimensions are 81 x 44 x 25 inches (l x w x h), where 44 inches is the width of the driving cabin. Sheet metal side panels keep legs and feet inside the go-kart. The two-seater allows the client to ride with a friend of parent.

3.2 Seats

The original side bench that came equipped with the go-kart was taken out and a two individual seat system was installed (figure 15). This allowed the client to have a specific seat that provides extra trunk and neck support. Both seats come equipped with a reclining mechanism. The passenger seat has a regular seat belt while the driver seat utilizes a five-point latch and link quick release harness. This ensures that the passengers are safe while operating the vehicle. The specialized driver seat came from a disassembled wheelchair.
The neck, trunk, seat, and foot supports all came separate and are assembled on a mounting plate that is bolted down to the floor of the go-kart. An armrest is to the left of the driver seat. This allows the client to control the go-kart with his strong hand. Extra cushion in the trunk was added to fit the client more snugly.

![Image](image.jpg)

**Figure 15:** The passenger seat (left) and client seat (right).

### 3.3 Engine and Supporting Components

The engine for this go-kart is a 110cc 4-stroke single cylinder included with an alternator. The engine comes complete with automatic transmission via the chain system and a speed governor. The speed governor can be adjusted to 15-20 mph. This provides the client with the desired speed while increasing the safety of the vehicle. The rotary valve (choke open the rotary valve)) regulates the amount of fuel being consumed. The carburetor component is where the fuel and air mix before delivering it to the engine.

### 3.4 Electrical System

The electrical system operates with a 12V DC, 85 Ah battery designed for devices used in marine applications. This battery sits on the back of the go-
kart on the opposite side of the gas tank. All three speed controllers (i.e. steering, throttle, and braking), the front dashboard "system" switch, and the microcontroller circuit must access both terminals of the battery. This battery powers all electrical systems within the go-kart including the speed controllers, microcontrollers, all dashboard controls, headlights, kill switch, and ignition. The 12V, 7A alternator is directly connected to the battery terminals and constantly charges the battery while the go-kart is running. The integrity of this connection must be maintained in order to maintain a proper voltage across the battery terminals. The battery is conveniently housed in a battery box to avoid shorts, protect performance in bad weather conditions, and provide a suitable mount for the rather heavy structure (~38.5 lbs.)

The microcontroller circuit utilizes a LM7805 5V 1A voltage regulator to step-down the battery voltage and maintain a constant voltage to power the microcontrollers. This is essential because the microcontrollers are the only components making direct calculations to be sure to reliably convert all inputs to the proper mechanical outputs. The voltage regulator and corresponding terminals are shown in figure 16.

![Figure 16: LM7805 5V 1A voltage regulator](image)

3.5 Dashboard Controls
The dashboard is located on the front of the go-kart and is pictured in figure 17. The dashboard must be properly maintained to ensure proper behavior of the go-kart, based on the user’s expectations. NOTE: The horn is not attached.

![Figure 17: Modified dashboard controls](image)

**System**

The system switch is designed to control the power to the microcontroller circuit and speed controllers. This switch may be toggled upward to turn these components on and toggled downward to turn them off. It is not recommended to ever turn the system switch off while the go-kart is running. All controls (steering, braking, throttle, smart braking) are dependent upon the power to the microcontroller circuit as well as the speed controllers. It is recommended to turn this switch on before turning the ignition and starting the vehicle.
Ultrasound (US)

The US switch controls the smart braking functionality. This switch may be toggled upward to turn the functionality on or downward to turn it off. When on, the go-kart will sense objects in front of the vehicle and apply the brakes while releasing the throttle to avoid destructive collisions. Depending on the user operating the joystick and controller, it is only recommended to use this functionality while the joystick is activated.

If the vehicle has been stopped and the user would like to steer around the object and continue driving, the US switch must be toggled to off until the object has been cleared of the front of the vehicle. The switch may be turned on once the object has been cleared, and the smart braking functionality will once again be activated.

Joystick/Controller (J/C)

The J/C switch may be toggled to the appropriate polarity to determine which control method is activated. When the switch is toggled upward, the joystick on the driver’s side is activated for all driving functionalities. When the switch is turned downward toward the “C,” the XBOX controller located on the passenger side is activated for driving. It is not recommended to toggle this switch while the go-kart is in motion.

Headlights

The headlight switch is the green button located directly to the right of the horn button. This button turns the front headlights on and off. The ignition key must be turned clockwise until it locks in place to actually use the headlights.

Kill switch

The kill switch is located directly to the left of the ignition key slot. This button directly grounds the motor, which completely deactivates the motor. It is recommended to use this functionality when the go-kart has lost control or is excessively accelerating in an undesirable manner. In order to kill the
power to the motor, the button must simply be pushed and the motor will be shut off. This button works while the go-kart is moving as well as when it is stationary. When driving has been completed and the go-kart is going to be stored, this button must be pushed to eliminate the motor power.

**Ignition**

The key ignition controls the starting of the motor. The key must be turned clockwise until sufficient pressure is felt against motion. The choke must be pulled when turning the key in order to properly start the motor. When the motor seems to be operating properly in idle, the clockwise pressure may be released and the user may let go of the key. The user may now use the control methods in order to drive the go-kart in all applications. However, the user should make sure the system switch is turned on before proceeding.

### 3.6 User Input Methods

**Controller**

Both control methods and all feedback position monitors also use the 5V output from the voltage regulator. The 5V is transmitted from the microcontroller circuit to the device, where the corresponding potentiometer signal is transmitted back to the circuit. The XBOX controller interior is shown in figure 18. This consists of a fabricated circuit with many elements that are unnecessary. For example, many processors located within draw excessive current for this application. Therefore, the joystick and right trigger potentiometers are accessed directly and connected with 5V across the two reference pins. Depending on the device, the wiper signal used in analog-to-digital conversion (ADC) in the microcontroller module operates approximately between 0 and 5V.
The peripheral circuitry located on the fabricated board is not used; only the wires accessing the left joystick and right trigger are used in the software generated. The wiring is protected by nylon tubing for aesthetics, noise reduction, and protection from heat and jagged objects present on the go-kart. As the wires reach the vicinity of the microcontroller circuit, the nylon tubing is terminated and the wires are soldered to the corresponding pin, which is wired to the correct microcontroller pin. The tubing housing the controller wiring should never be significantly bent or twisted because this can cause undesirable resistance changes corresponding to artifact.

The XBOX controller is intended to be used by the passenger and must be activated by the J/C switch on the dashboard. The left joystick is used for steering as follows: toggling the joystick to the left will translate to a left turn and vice versa. In order to activate the throttle, the left joystick must be pushed upward to the desired position. The braking is applied by pressing the right trigger to the desired position of braking. As the right trigger is released, the braking system is released, accordingly. Figure 19 illustrates the locations of the buttons described.

**Joystick**

The joystick utilizes the 5V source from the voltage regulator to power its dual-axis design. The voltage is applied across the two reference terminals, which are internally connected to the other axis’ reference terminals. The potentiometer wiper signal of each axis is outputted back to the microcontroller for ADC and processing. The yellow wire corresponds to the horizontal axis, while the green wire corresponds to the vertical axis. The red wire is connected to 5V, and the blue wire is connected to ground.
The joystick is pictured in figure 20. It is located on the left armrest of the driver’s seat. The joystick consists of the most basic potentiometer parts present in a PC gaming joystick. It is housed in a black project box and bolted directly to the armrest attached to the driver’s seat. This is designed to be used by the client while sitting in the driver’s seat.
3.7 Circuitry

The go-kart control system involves some electrical signal for all mechanical movements to drive. In order to consolidate the electronics into one organized location, a PCB was created and the corresponding inputs were soldered to the board. This board was then mounted to the top of a black project box and bolted directly to the chassis. All three speed controllers were also mounted to this plate. The PCB, which was created and ordered using the program ExpressPCB, is shown in figure 21. It takes several inputs, delivers them to the microcontroller for ADC, and delivers the corresponding signal to the speed controllers. Figure 22 shows the final implemented circuit bolted on the back panel of the chassis. The final circuit is encased in Fiberglas to protect wires and shield heat from entering the circuit.

Figure 21: PCB design
3.8 Output Methods and Speed Controllers

Steering
The steering is controlled by the output of a Victor 883 speed controller to a rugged gear motor connected to the pinion of the steering system. The speed controller is directly wired to the gear motor, and the wire is housed in nylon tubing for aesthetics and noise reduction. As the joystick or controller are moved in the left and right directions, the microcontroller outputs the proper pulse width modulation (PWM) signal to the speed controller, which outputs the proper DC voltage from -12V to +12V. The microcontroller tracks the position of the joystick and controller and compares them to the steering position monitor. The steering monitor is the novoTechnik LWG 75 and is shown above the gear motor in figure 23. As the motion of the rack steers the wheels, it also linearly displaces the steering monitor, which changes the resistance seen across the wiper. This position monitor also operates between 0 and 5V.

Figure 22: Microcontrollers wired and mounted on PCB using 40-pin DIP sockets.
Braking

Braking is controlled by a linear actuator located on the back side of the go-kart. The electrical energy supplied by the corresponding speed controller drives the linear actuator into the braking cylinder, where it uses brake fluid to compress the hydraulic disc brakes. As the right trigger on the controller is pressed or the joystick is pulled backward, the microcontroller signals the linear actuator to extend and compress the braking cylinder, thereby resisting wheel motion. This braking actuator operates at 12V DC, which is the output of the speed controller.

The linear actuator also contains a built-in 10kΩ feedback potentiometer so that it is easy to track the position with the microcontroller code and stop the motion of the actuator when a certain threshold has been reached. Similar to the other feedback potentiometers, the braking linear actuator feedback uses the 5V signal from the voltage regulator as a reference. The braking linear actuator system is pictured in figure 24.
**Figure 24:** Braking linear actuator system

**Throttle**

Throttle is controlled by a linear actuator located on the back-side of the go-kart. The electrical energy supplied by the corresponding speed controller drives the linear actuator connected to a wire connected to the rotary valve, which regulates the amount of gas entering the engine. As the wire is pulled, more gas enters the engine so that the go-kart may consume fuel and move. As the joystick or controller left joystick is pushed upward, the microcontroller signals the linear actuator to retract and open the rotary valve, thereby increasing gas consumption. This throttle actuator operates at 12V DC, which is the output of the speed controller. The linear actuator also contains a built-in 10kΩ feedback potentiometer so that it is easy to track the position with the microcontroller code and stop the motion of the actuator when a certain threshold has been reached. Similar to the other feedback potentiometers, the throttle linear actuator feedback uses the 5V signal from the voltage regulator as a reference. The throttle linear actuator system is pictured in figure 25.
Two ultrasound sensors are mounted just behind the front bumper on rugged aluminum plates. The voltage regulator powers the sensors at 5V. When the dashboard ultrasound sensor is toggled to on, the sensors deliver a signal to the microcontroller, where the microcontroller will send the appropriate braking and throttle commands based on how close the nearest object is. The sensors have a range from 3 cm to 21.2 ft, but the analog output voltage is used to easily customize the range. The sensor system is pictured in figure 26.

Figure 25: Throttle linear actuator system

3.9 Ultrasound Sensors

Figure 26: Ultrasound sensor system
4. **Troubleshooting**

Problem- No power to system  
Possible causes:  
1. Battery is dead  
2. Battery is not properly connected  
3. Problem with alternator  

Possible Solutions  
1. Change/recharge battery  
2. Look over battery wiring  
3. See professional to check alternator  

Problem- engine won't turn on/stay on  
Possible Causes:  
1. Engine not receiving proper gas to air ratio  
2. Carburetor is dirty  

Possible Solutions:  
1. Pull choke when starting the engine  
2. Put more gas into the vehicle  
3. Change gas filter  
4. See professional to clean carburetor  

Problem- Power is on, but no controls are working  
Possible Causes:  
1. System switch is not turned on  
2. The control currently in use is not switched on  
3. Wiring is loose  

Possible Solutions:  
1. Turn on all necessary switched  
2. Seek professional to rewire control panel or change electrical parts  

Problem- Steering is inconstant  
Possible Causes:  
1. Steering input does not have proper voltage  
   a. Everything operates on 5 V
2. Rack and pinion is disconnected
3. Sprocket and chain is not properly connected
4. If engine is not on: low battery
5. Linear potentiometer has been damaged

Possible Solutions:
1. Check that the voltage to the circuit is a constant 5 V
2. Assess the rack and pinion and make changes if needed
3. Assess sprocket/chain system and make changes if needed
4. Assess battery life and replace or recharge

Problem - battery dies quickly
Possible Causes:
1. System is not properly turned off
2. Alternator is broken/not properly charging the battery during operation

Possible Solutions:
1. Follow the proper procedure to turn off system
2. Seek professional to check alternator, replace if necessary

Problem - battery and/or components are moving while driving
Possible Causes:
1. Battery strap is loose
2. Nuts and bolts/ screws are lose

Possible Solutions:
1. Tighten battery strap
2. Tighten all nuts and bolts on system components.

Problem - rattling noises in the back of the go-kart. There will be rattling constantly because of the strong engine, however if anything is out of the norm, it must be checked immediately.
Possible Causes:
1. Control panel is loose
2. Components in the panel are loose (microcontrollers, board, speed controllers)
3. Battery is loose
4. Gas tank is loose
5. Brake and throttle actuator is lose
6. Electrical components for the engine are loose

Possible Solutions:
1. Tighten components in control panel
2. Tighten battery strap
3. Tighten bolts on gas tank
4. Tighten bolts on all mounting components of braking and throttle actuators
5. Strap back any electrical engine components that have become loose

Problem- unusual rattling in the front of the go-kart

Possible Causes:
1. Steering motor is loose
2. Rack and pinion is loose or not connected to motor
3. Rack and pinion is not connected to the tie rods
4. Plexiglas guard is loose
5. Dashboard has become loose

Possible Solutions:
1. Tighten steering motor to the floor of the vehicle
2. Make sure connection of rack and pinion is tight
3. Make sure connection of rack and pinion to the sprocket and chain system is tight
4. Tighten bolts on Plexiglas
5. Tighten screws on dashboard.

Problem- sprocket and chain system is noisy or the chain comes off

Possible Causes:
1. The two sprockets are not in the same plane with each other
2. The chain’s master link has come off
3. The motor is loose and out of plane
4. The steering rod is loose and out of plane

Possible Solutions:
1. Loosen rack and pinion system to adjust the top sprocket until it is in line with bottom sprocket
2. Loosen motor and adjust bottom sprocket until it is in line with the top sprocket
3. Tighten the motor
4. Tighten the steering rod

Problem- Ultrasound smart braking is not working
Possible Causes:
   1. Sensor switch is not one
   2. Sensors are broken
   3. Wiring has loosened
   4. Sensors are loose
Possible Solutions:
   1. Turn US switch on
   2. Replace ultrasound sensors
   3. Seek professional to rewire the sensors
   4. Seek professional to recalibrate the sensor