The S-90 Go-Kart Operator’s Manual

By

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Sean Stenglein. NSF Projects.

Ashford, CT. 860-429-105
Important Safety Instructions

General Warnings

• TO REDUCE THE RISK OF INJURY, ADULT SUPERVISION IS REQUIRED. NEVER USE IN ROADWAYS, NEAR MOTOR VEHICLES, ON OR NEAR STEEP INCLINES OR STEPS, SWIMMING POOLS OR OTHER BODIES OF WATER. ALWAYS WEAR SHOES AND NEVER ALLOW MORE THAN 1 RIDER.
• This product is meant for outdoor use and on private property only.
• Never ride the S-90 on public streets, alleys or other public roads or thoroughfares.
• It must never be ridden in any area that could potentially do harm to humans, animals or property.
• Never ride around the vicinity of small children who may enter your path.
• The S-90 is intended for riders over the age of seven and under 250 pounds. Any rider who does not comfortably fit in the vehicle and/or cannot comfortably use the controls should not ride the S-90.
• This vehicle is a serious machine and should be treated with respect when riding it, working on it, or simply being near it.
• The decision to allow a rider to ride the S-90 must be done with the permission of a directly supervising adult. The directly supervising adult must read and follow all of the contents of the owner’s manual before making this decision.
• The rider must have previous experience in riding electric powered vehicles before attempting to ride the S-90. It is the responsibility of the supervising adult to ensure the rider has the qualification, ability and training before allowing them to attempt to ride the vehicle.
• The S-90 is never to be ridden indoors. Indoor flooring and carpets can be damaged from abrasive contact with the tires.
• The S-90 is designed to run on off-road surfaces. Grass, packed dirt, and moderate off-road terrain are ideal riding surfaces.
• The rider of the S-90 should always wear protective footwear. Open-toed shoes should never be allowed. Keep shoe laces and pant legs away and clear of the wheels.
• The rider must wear a safety helmet, elbow and kneepads to avoid injury if falling.
• Failure to wear a standard approved helmet may result in serious personal injury or death. It is also highly recommended to wear eye protection while riding.
• The S-90 is not designed to pull or tow anything behind it as it may result in serious injury or death as it may result in serious damage to the motor or internal parts.
• The S-90 cannot be used on wet surfaces or in wet weather. Never immerse any part of the S-90 in water. Moisture can damage the motor, switches and drive components.
• The S-90 should never be ridden in mud, water, ice or snow. It is not designed to be ridden in streets or on paved surfaces either. Avoid riding on extreme inclines, declines, rocky surfaces, curbs or jumps.
Parts and Accessories

- Steering gear motor
- Rack and pinion
- Connecting gears (for steering)
- Rack and pinion pillow block

- Tie rods

- Front wheels
- Front tires
- Front fenders
- Suspension arms
- Shock absorbers
- Front bumper
• Steering wheel

• Steering column

• Battery
• Battery bracket
• Foot rest

• Gas pedal
- Brake Pedal
- Ignition
- Right front panel
• Left front panel

• Head lights

• Seat actuator
• Seat switch
• Seat mounting bracket
• Bucket seat
• 5-point racing harness
- Carrie seat
- Roll bar
- Side panels

- Electronics housing
- Wireless receiver
- Wireless killswitch receiver
- Steering speed controller
- Braking speed controller
- PCB
- Hinge pin

- Coil over springs
- Rear axel
- Disc brake rotor
- Disc brake calipers
- Transmission carriage

- Drive Sprocket
- Drive chain
- Chain tensioner
• Drive belt
• Torque converter driven
• Torque converter driver

• Engine
- Rear fenders
- Rear wheels
- Rear tires
- Brake motor
- Brake linkage
- Braking feedback transducer
- Throttle cable
- Throttle servo
- Speed transducer actuator
- Steering wheel height adjuster
• Jack shaft

• Axle bearing

• Grease fittings
- Steering feedback potentiometer

- Steering wheel potentiometer
• Gas pedal potentiometer

• Brake pedal potentiometer

• Joystick
• Wireless remote

• Wireless killswitch
• Hard killswitch
• Soft killswitch

• Engine Relays

• Ground points
• Wire Conduits

• Spring clamps
Features

- Electronic steering wheel and pedal
- Joystick
- Wireless remote
- Speedometer
- Transmission
- Electric throttle
- Electric brake
- Power seat
- Killswitches
- Electric start gas engine
- Universal seat modules
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1 Introduction

1.1 General Overview
The go-kart for this project has been built from the ground up to maximize the efficient use of space, and to ensure that the needs of the client were met. The frame consists of a steel open roll cage design with independent front suspension and semi-independent rear suspension. A 10 horsepower gas motor provides power for the drive, and also runs a 7 amp alternator. All systems on the go-kart are actuated using electric motors. The electric motors interface to the mechanical systems to control them without the operator having to apply force directly. The power for all of the electrical components essential to the go-kart comes from a deep cycle car battery. This battery in turn is charged by the alternator to ensure that there is always electrical power being supplied to the system. The battery supplies the electric motors and the electronic control components.

Three possible methods of control are available on a user-selectable basis. The main method of control is the joystick that controls steering, throttle, and braking using a two axis system. The second control system is based on remote control. A radio controller designed for model aircraft is controlled by a guardian. A radio receiver on the go-kart takes the transmitted signal and feeds it to the microprocessor. The final method of control is a steering wheel and pedals that allows the vehicle to be operated like a normal car or go-kart. These inputs are connected to the microprocessor instead of mechanical attachment. Embedded software takes away the need for complex analog circuits that would otherwise make up a control system like this. The software for the go-kart has two main purposes: to provide control over all of the systems necessary to operate the go-kart, and to recognize when the go-kart is not functioning properly and to shut it down safely. To accomplish these two tasks the software is comprised of two infinite loops. The primary loop services all of the normal routines that must be controlled, and check to make sure everything is operating properly. The emergency loop is activated by the primary loop and will function to safely shut down the go-kart and keep it shut down.

1.2 Making the S-90 Operational
It is recommended that the S-90 is not operated during any precipitation or in extremely wet environments to the various electrical components. Never pull start the engine.

In order to safely operate the S-90 go-kart, two persons must be present at all times. Before operation, check the oil, gas, and battery levels. If the levels are low, see maintenance section of operators manual. Prior to operation of the S-90 go-kart, have a rider seated in the bucket seat with the 5-point safety harness (Figure 5) buckled and helmet on. Have the supervisor turn the engine to full choke for cold start, for hot start no choke is necessary (Figure 1) as indicated by the engine. Have the supervisor turn the key to the ignition position (Figure 4). Have the supervisor and the rider verify that the control mode is SWP, one light on the speedometer is lit, and the verification system has one light lit. Verify that the steering, throttle, and brake are operational in SWP mode. Verify that the joystick or dummy plug is plugged in (Figure 3). If wireless control mode is desired ensure that the wireless remote control is switched to the ON position before selecting wireless mode. Also, ensure that the right vertical trim is
centered and the right horizontal trim is fully to the right (Figure 2). If joystick mode is desired, verify that the joystick is plugged in and oriented with the plug facing the rider. Additionally, the joystick should be strapped to the leg of the rider. Select desired mode by pressing the control mode button and reading the corresponding indicators (Figure 7). Once desired mode has been selected, test steering, throttle, and brake using the corresponding controller. If at any time during this initialization, devices fail to respond properly turn key to off position and see troubleshooting section. If all tests are successful, turn and hold key to start position until the engine catches and release key. For cold start
release choke incrementally over the course of a minute. The S-90 is now ready to drive.

Figure 3: Joystick with plug

Figure 4: Front dashboard with correct startup lights
Figure 5: Seat with 5-point harness

Figure 6: Left front dash panel
1.3 How to use the S-90

*If this is the first time driving the S-90, make sure there is plenty of space and take time to become familiar with the response of the controls.*

1.3.1 Steering wheel and pedals

In this mode, the steering wheel controls the direction of the wheels, the gas pedal controls the throttle, and the brake pedal controls the brake. Take time to become familiar with how each component responds to input. To increase speed, press the gas pedal. To slow down, or stop, press the brake pedal. Never press the gas and brake pedals at the same time. To steer, turn the wheel in the desired direction. Steering is somewhat different from a traditional car. Avoid large movements of the steering wheel at high speeds.

1.3.2 Wireless Control

Never turn the wireless remote off while the S-90 is in wireless control mode. The supervisor should never be more than 50 feet away from the vehicle. The wireless remote is used to control steering, throttle and braking when in wireless control mode. All controls are operated by the right joystick (figure 8). The direction of the wheels is controlled by movement of the horizontal axis on the right joystick. The vertical axis controls both the throttle and the brake. At center position on the vertical axis the throttle is set to idle and the brake is off. To increase throttle, press up on the vertical axis. The level of throttle is proportional to how far up the joystick is pushed. To activate the brake, pull down on the vertical axis.
1.3.3 Joystick Control
Using the joystick, steering is controlled by movement along the horizontal axis and is proportional to
the amount the joystick is moved. The vertical axis controls both throttle and brake. The throttle is
controlled by pressing the joystick up along the vertical axis and is proportional to the amount the
joystick is moved. Similarly, braking is achieved by pulling down on the vertical axis and is proportional
to the amount the joystick is moved.

1.3.4 Software Killswitch
Note: all killswitches (software, hardware, remote) will work regardless of the control mode selected.
Under normal circumstances the go-kart should be brought to a halt using the desired control mode and
shut off using the key.

There are four killswitches directly connected to the vehicle. The main killswitch is software based and
is positioned to the left of the rider’s head. To activate the killswitch routine, the rider should press and
release the killswitch button with their head. The software killswitch will releases the throttle, activate
the brake, and shut off the engine. Successful activation of the software killswitch can be confirmed by
the speedometer lights flashing. Note: activation of the software killswitch does not preclude steering
capabilities.

1.3.5 Hardware Killswitches
There are three hardware killswitches on the S-90:

(1) Is located to the right of the driver’s head. This is activated by pressing the button with the
driver’s head. The button will remain depressed if activated properly. Twist killswitch to
reset.
(2) Is located on the left front panel (Figure 9). This switch is pressed down to activate. Put switch in the up position to reset.

(3) Is the key. The key is turned to the OFF position to activate this killswitch.

These three killswitches will shut off the engine, but will not activate the brakes and should only be if the software killswitch fails to work.

1.3.6 Remote killswitches
Two remote killswitches are available on the S-90. Both can be activated using the killswitch remote control provided. The hardware remote killswitch is activated by pressing the red button labeled ON and the software remote killswitch is activated by subsequently pressing the red button labeled OFF.

Any killswitch activation will require the S-90 to be turned off and reset using the key. After a killswitch is activated go through the start up procedures listed in section 1.2 before operating the S-90 again.

1.3.7 Proper shutdown of the S-90
To properly shutdown the S-90, first bring the vehicle to a controlled stop using the desired control method. Either the rider or supervisor can turn the key to the OFF position. This will shut off both the engine and the software. Note that the S-90 does not have a parking brake so be sure to block the wheels when leaving the S-90 on an uneven surface.

Note: Electronic systems can be used to steer the vehicle when pushing it.

Note: Try to avoid pushing the vehicle in reverse. If the vehicle is pushed in reverse, ensure that the chain tensioner is not catching on the drive chain. If the chain tensioner does become caught on the drive chain, turn the lead screw on the transmission trolley to tension the chain.
2. Maintenance

2.1 Engine
Please refer to the Tecumseh Power LH318XA Operator’s Manual for all information about engine maintenance regarding the S-90.

2.2 Transmission
Always check that the set screws in the pillow blocks located on the jack shaft as well as on the sprocket and shaft collar are tightened before each running of the S-90. Next check the drive chain tension. If the chain is loose, turn the lead screw on the transmission trolley until the chain is firm to the touch and the chain tension makes only a minimal deflection in the drive chain. Check the belt located on the torque converter to ensure that it has not worn through in any locations. If there is any steel showing in the belt, this part must be replaced.

2.3 Brake
Before each run check that the screw holding the transducer for the brake is positioned vertically. Note that any bend in this part will result in improper braking function. Ensure that the sheet metal bracket is not bent or pried up, as this indicates improper braking function. Check the clear bubble on top of the brake piston to see if there is fluid in the braking line. Ensure that all of the bolts for the brake linkage are tight, including the screw holding the aluminum block to the braking motor. Retighten these bolts if they become loose. Make sure that the disc brake is clean and free of mud, rust, or other debris. Visually inspect that there are brake pads left in the brake caliper. If these need to be change, note that the axel must first be removed to access the brake pads.

2.4 Lubrication
Yearly, give one pump of grease to the two rear suspension grease fittings, the two pillow blocks on the jack shaft, and to the pillow block for the rack and pinion. Put oil on the hinge pin at the ends and in the two gaps. Spray a light weight oil (WD-40 or similar) on the tie rod ends.

Every month, put oil on all sixteen joints for the front suspension arms.

2.5 Steering
Before each run, visually inspect that the rack and pinion gear and the steering motor gear are properly meshed. Every other run, ensure that the set screws for both gears and for the pillow block are tight. Visually inspect that the tie rods are not damaged, bent, or rusted. Monthly ensure that the steering feedback potentiometer is properly positioned and firmly bolted at both points. The steering feedback potentiometer can be accessed by removing the vehicle’s battery.

2.6 Rear Suspension
Ensure that the rear suspension clamps have not shifted and make sure that the steer spring restraints are intact.

2.7 Frame
Check frame for chipped paint and dents. Repaint as needed to prevent rust. Take extra time to check the front bumper and skid plate as they encounter the most wear.
2.8 Tire
Check that 4-6 psi is in each tire. If the knobs are completely worn off the tires, it is highly recommended that the tires be replaced. Rotating the tires is not recommended.

2.9 Storage
Store the S-90 indoors in a well ventilated, dry environment when possible. Due to the electrical components reliable operation of the S-90 cannot be guaranteed if stored outdoors or in a damp environment.

2.10 Battery
Check battery level before each run. If the S-90 battery level is ¼ or below, the battery should be charged before operating. The battery can be charged by either using a 12V battery charger or by traditional jumping methods (not recommended). If the battery is leaking, proper disposal of the battery is required immediately.

2.11 Changing the seat
For the bucket seat line up the six bolts with the mounting holes and tighten with the supplied lock nuts using a ½ inch wrench. For the Carrie Seat, using the two supplied bolts attach the bottom bracket to the permanently mounted bracket on the seat. Line up the bolts of the bottom mounting bracket with the mounting holes and bolt down with the supplied lock nuts using a ½ inch wrench.

2.12 Steering wheel and column
Never lubricate the steering column. If the steering column becomes too loose gently tap the edge of the steering column with a hammer and reinsert the steering wheel onto the steering column. Repeat until desired stiffness is achieved.

3. Technical Description
The final S-90 prototype consists of a number of smaller subsystems and each of them will be reviewed in the following sections. This review will consist of in depth descriptions and pictures along with mention of deviation from the original optimal design (Figure 10).
3.1 Software Control
For the software control, the go-kart is operated using embedded C code on PIC16 microcontrollers. Three microcontrollers ended up being used in the final design (Figure 11). This is an increase from the two that were proposed in the original optimal design report. The extra microcontroller allowed for additional interrupt and input/output pins to be used that would have otherwise not been available. The microcontrollers take input information from peripheral sensors such as user inputs and system feedback and interpret the data to create output signals. These signals are then routed to the proper speed controllers or electric motors to drive and control the go-kart. The software control operates on a two loop system. The first main loop constantly runs and is tasked with converting input information to output information for normal operation of the go-kart. The secondary loop is an emergency shutdown loop that can be triggered by either a head switch or by the remote kill switch. The emergency loop is tasked with executing a pre-programmed routine to modify all important outputs to stop the go-kart, cut the engine and allow for safe steering. The software control selection software was implemented perfectly from the optimal design, allowing the user to cycle through all three modes of control. Additionally, all three modes of control can be used to safely operate the vehicle.
3.2 Steering System

The steering system did not stray far from the optimal design with only minor changes to the way the steering wheel raised/lowered and minor changes to the way the rack and pinion output shaft was reinforced. The steering wheel is connected to a potentiometer used as a voltage divider transducer by a notched belt. The transducer raises and lowers with the actual steering wheel. The steering gear motor is attached to the chassis by welded bolts and additional screws for fine tuning (Figure 12). The rack and pinion is bolted to tabs welded to the chassis and a stabilizer bar has been welded to the tie rod ends at the ends of the rack and pinion. The stabilizer bar is necessary for keeping the steering linkage rigid. The tie rods were fabricated from bolts welded to steel pipes and go from the rack and pinion to the from wheel hubs. The suspension is designed to be minimally effected by changes in the suspension, but a small amount of deflection in the wheel angle can be noted when the suspension is fully engaged. Under normal load the front wheels are calibrated to be about 1-2 degrees toe-in. This is useful for making aggressive turns in off-road conditions.

Figure 11: S-90 electronics enclosure
The steering control did not change at all from the original optimal design. The steering control consists of a steering motor and its speed controller. The controller gets its signals from a PIC16 PWM output. The software for the steering control system takes an input from one of the control mode transducers and compares the desired location of the wheels based on the transducer to the actual location of the wheels based on a string-pot feedback transducer. The feedback transducer is anchored to the front plate and has a string that moves with the rack and pinion. If the software determines that the feedback position is different from the desired position of the wheels, the PWM output is changed to trigger the gear motor to move the rack and pinion in the correct direction. When the position of the feedback transducer matches the desired position of the wheels, the gear motor is stopped. This method allows the direction of the wheels to be set on a user defined basis. The system works very well, and the response time of the wheels is comparable to normal analog steering systems.

3.3 Control Systems
All three control methods described in the original optimal design report were created and are working. Each control method carries out the functions of steering, throttle control, and braking, based on user input. The easiest mode of control to use is the joystick (Figure 13). The joystick works on a two axis system where the horizontal axis controls steering and the vertical axis is split between controlling the throttle and controlling the brake. Each axis is a separate potentiometer and the signals from these potentiometers are input into the steering microcontroller for analysis. The second mode of control is by wireless remote control. This system also operates on a similar two axis joystick where the horizontal axis is for steering and the vertical axis is for throttle and brake. The technical implementation of the remote control system is different from the normal joystick however. The remote control system communicates with an onboard receiver which sends PWM signals from the remote control to the microcontroller inputs. The processing of the PWM input has changed since the original optimal design report was written. Originally this input was going to be low pass filtered in order to average the PWM into a readable analog voltage. After testing this, method was determined to be too imprecise to give the driver reasonable control over the vehicle. A new system was devised to interpret PWM signals in
the microcontroller based on the use of interrupts and an on chip timer. The method uses the interrupt port’s ability to detect the rising and falling edge of the PWM signal to time the length of the pulse width itself. Once the length of the pulse width is known by the microcontroller, this length can easily be processed into the appropriate output form by the software. The third and final mode of control is a steering wheel with pedals. This mode of control is intended to allow any user to drive the go-kart as they would a normal vehicle. The steering wheel, the gas pedal, and the brake pedal are each connected to their own potentiometer, which are in turn connected to microcontroller inputs. Each of these control methods can be selected by pressing a button on the left front dashboard. The control modes are cycled through and lights on the dashboard indicate which control method is activated at any point.

3.4 Drive Train
The drive train deviated from the optimal design because the gear box turned out to be defective. As a replacement a jack shaft was constructed, which allows for direct forward transmission (Figure 14). Also, a chain tensioner was added as it was determined that chain slippage was a problem for the optimal design transmission. This realization occurred during prototype testing. The new modification has been tested and eliminates chain slip. The transmission was used to tension the chain and the engine is able to start with a key and has a high oil level shutoff which triggers upon extreme accelerations. Testing has confirmed that the alternator provides ample current to charge the battery during extended use. Furthermore, the engine provides enough torque to move the go-kart up thirty percent grades with 200 pound passengers.
3.5 Throttle

Engine power output is controlled by a throttle linkage which is connected to a servo motor. The servo currently installed replaced the original servo motor which after testing was determined to not provide sufficient torque. Control of the throttle servo changed very little from the original optimal design. The only change to the software controls for the new throttle involved changing the direction of the pulse width modulation signal as it correlated to the user input. In general the throttle servo takes a PWM input from the microcontroller, which is modified based on user inputs from the control modes. The throttle servo is the only device on the go-kart that is connected to a 6V regulator. In order to provide the throttle servo with consistent power at 6V, a heat sink system was developed for the 6V regulator (Figure 15). This development was in response to the testing which confirmed that under heavy use the voltage regulator experienced thermal shutdown. The addition a four cubic inch, square, aluminum heatsink dissipates more than enough heat and allows optimal performance from the servo under all conditions.

3.6 Braking

The mechanical braking system had minimal changes from the original optimal design. The braking system consists of a braking gear motor, a lever arm, a tie rod, a piston, a piston housing, a hydraulic pump, a hydraulic hose, a hydraulic caliper system, and a disc brake rotor (Figure 16). This differs from the old system in that it implements a hydraulic caliper instead of a twist type caliper system. This allows for higher closing forces to be generated on the disc brake rotor, allowing for greater braking...
power. The transducer feedback system from the optimal design did not change. The brake motor is allowed to stall for full braking power to be achieved and it has been determined that this does not overheat the braking speed controller system. In field testing the prototype brake system was shown to not lock up the wheels, but bring the vehicle to a fast, controlled stop. The design also changed from the original optimal design because it was determined that the original lever arm coming off the brake gear motor was too long, reducing the total force seen at the hydraulic piston. This was fixed by shortening the lever arm to less than half the original distance, causing an increase in braking power.
The control system for the brake changed very little from the optimal design. Control of the braking motor comes from a small speed controller which takes a PWM signal from the throttle and braking microcontroller. The microcontroller takes user input signals from the control modes and compares the desired braking position to the position given by the braking feedback transducer. The PWM signal is then modified to drive the braking motor to adjust the mechanical position of the brake until it satisfies the position designated by the user input.

3.7 Roll Cage
The roll cage was implemented from optimal design and consists of quarter inch reinforced round steel tubing. While the roll cage has never been tested in a roll over it has withstood g-forces incurred from a front collision and from extreme pressure on the rear suspension, which it supports.

3.8 Seating System
The seat actuator assembly worked perfectly off the optimal design using a track on delrin spacers which allow for high weight capacities to move with minimal friction on the two support rails (Figure 17). The seat actuator assembly has been able to withstand over two hundred pounds of force under driving conditions without bending or braking and over four hundred pounds of static load.

The seat bracket for the bucket seat followed the optimal design perfectly, however the seat bracket for the client’s Carrie Seat needed to be modified since a new Carrie Seat had been purchased after the optimal design was finalized. The new design uses the existing bolt-hole pattern to mount a permanent steel fixture with welded nuts. A modular seat bracket fixture contains two bolts that fit into the pre-welded nuts and can be removed so the Carrie Seat can be used as a car seat. When the unit is bolted together it allows for the universal bracket to fit into the six-hole bolt pattern for mounting purposes.

3.9 Suspension and Chassis
The front and rear suspension systems were fabricated based on the optimal design specifications. All components went together as planned and have held up to rigorous field testing. The only modification of the rear suspension was to clamp the rear suspension together to avoid failure of the suspension in

![Figure 17: Seat actuator with switch](image)
the event that the rear wheels leave the ground.

The front bumper and chassis followed exactly from the optimal design. The chassis was cut, welded, and ground as well as primed and painted for outdoor use. During field testing, the front bumper as well as the rigid chassis held up to substantial impacts without any bending or denting. No welds showed any signs of cracking after close inspection and upon further test driving the vehicle showed no signs of defect from the impromptu crash test.

### 3.10 Killswitches

The original killswitch was created based on the optimal design and operates as it was intended to. After testing the need was seen for a killswitch that does not require software and a killswitch that directly grounds the engine spark plug was added. Additionally, testing revealed the original remote killswitch module to be unreliable and it was replaced with a system capable of both directly grounding the engine spark plug and triggering the emergency loop in the software (Figure 18).

### 3.11 Print Circuit Board

All electrical circuits for this project were created originally on a bread board. After testing systems using the bread board the design was transferred into the SPICE program Multisim. From there, the design was imported into National Instruments Ultiboard for the design of the final print circuit board (PCB) (Figure 19). The PCB incorporates all the central electronics into a single area and allows for the connection of all peripheral devices to the control electronics. The PCB features a number of different sections that are integrated to control the vehicle. These include the three microcontrollers, the timing circuit, the voltage regulators, and the output pins. The PCB uses mostly through hole components for their robustness under the relatively extreme conditions of go-kart driving. By using a PCB for the main body of circuitry, the electronics are condensed and are able to fit into the electronics housing of the go-
kart. It creates a permanent system that will not shake loose or become disconnected during normal driving conditions.

### 4. Troubleshooting

<table>
<thead>
<tr>
<th>Problem</th>
<th>Possible Cause</th>
<th>Possible Solution</th>
</tr>
</thead>
</table>
| Engine Fails to turn  | 1. Battery is dead                                                            | 1. Charge the battery using a 12V battery charger or by jumping the battery.  
                                                                                | 2. Battery is not connected                                                    | 2. Ensure that battery is in place and the red wire is connected to the positive terminal and the gray to the negative terminal. |
|                       |                                                                               |  |
|                       | 1. Hard killswitches have not been reset                                       | 1. Reset hard killswitches.  
                                                                                | 2. Software shutdown routine was not properly reinitialized                       | 2. Turn key to OFF, wait 5 seconds and try again.                                      |
|                       | 3. There is no fuel                                                            | 3. Check fuel level and fill if necessary.  
                                                                                | 5. Engine is cold                                                               | 5. With engine choked fully and all other causes ruled out (to prevent flooding engine) hold key in the starter position for longer while giving half throttle.  
<pre><code>                                                                            | 6. Maintenance overdue                                                         | 6. Check engine’s maintenance schedule and perform a full check up               |
</code></pre>
<p>| Chain is loose        | 1. Normal wear on chain                                                         | 1. Tighten the lead screw on the transmission trolley until the chain is tight to the touch and is deflected minimally by the tensioner. |</p>
<table>
<thead>
<tr>
<th>Issue Description</th>
<th>Possible Cause(s)</th>
<th>Solution(s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chain continually loosens</td>
<td>1. Old chain</td>
<td>1. Replace drive chain with proper length of number 420 roller chain.</td>
</tr>
</tbody>
</table>
| S-90 behaves abnormally when in wireless control mode | 1. The remote control is off  
2. The remote control has a low battery  
3. The remote control is out of range  
4. The vertical and horizontal trims are incorrectly set  
5. Wireless interference with other electronic devices  
6. Wrong joystick is being used to control the S-90 | 1. Turn the remote control on  
2. Charge the remote control’s battery  
3. Move closer to the go-kart  
4. Set vertical trim to center. Set horizontal trim to the rightmost position.  
5. Move away from possible sources of electronic interference.  
6. Ensure that the right joystick is being used to operate the go-kart |
| Steering fails to work in any mode                   | 1. Steering gear rack and pinion gear are not meshing  
2. Battery is too low to operate the gear motor  
3. Signal wire to the speed control became unplugged | 1. Realign the rack and pinion gear and the steering gear. Reset the set screws in the pillow block and the steering gear and the rack and pinion gear.  
2. Charge the battery using a 12V battery car battery charger or jump the battery using traditional methods.  
3. Plug in the signal wire to the speed controller |
| Controls are non-responsive or unusual in joystick mode | 1. The joystick is not plugged in                                                | 1. Plug the joystick in                                                     |
| The drive chain is skipping                           | 1. Chain is loose  
2. The chain is old                                                               | 1. Tighten the lead bolt to the transmission trolley  
2. Replace drive chain with proper length of number 420 roller chain          |
| Cannot align seat bracket with mounting fixture      | 1. The bracket is set too far back  
2. Mounting bolt was bent                                                           | 1. Move bracket all the way forward and try again.  
2. Attempt to bend bolt back to original position or remove bolt permanently. |
| Black smoke is coming out of the engine               | 1. The engine is burning oil  
2. The choke is on                                                                   | 1. Change the oil and refill to standard operating level.  
2. Unchoke the engine                                                           |
| Vehicle refuses to start and lights are flashing     | 1. The emergency stop routine has been activated                                  | 1. Ensure that the killswitch is not being pressed and try again             |
S-90 comes to a stop when in wireless control mode.  
*Note: This problem occurs with relative frequency when operating in wireless mode, but is not dangerous as it only forces the S-90 to stop.*  

1. Wireless controller is too close to the S-90  
2. Wireless controller may be out of range  

1. Change position of the supervising driver relative to the S-90  
2. Apply the brake from the remote control for 3 seconds  
3. Apply the throttle more confidently when attempting to start again