

# INNOVATIVE ANALYSIS

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## SAFER GOLF CARTS

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## 1. BRIEF DESCRIPTION OF THE SITUATION

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Roughly 40% of golf car accidents involve a person falling out of the car, and many of these accidents involve young children. One common scenario for a passenger ejection accident occurs when a car, traveling near its maximum speed, is turned sharply to the left. During a sharp left turn, centrifugal acceleration forces tend to force the passenger to the right, which can lead to ejection. Sharp turns are less likely to lead to a driver ejection because the driver has the steering wheel to hold onto and can always anticipate when he or she is about to initiate a turn.



Golf cars are typically not equipped with seatbelts because of the need to allow passengers to enter and exit the vehicle frequently with ease. For similar reasons, golf carts do not have doors. Golf cars are designed with rectangular or semicircular bars that rise up from each side of the car's bench seat and are designed to serve as both handholds and hip restraints. One deficiency of this design is that the location of the handhold (i.e. at the outboard edge of the seat) is also the fulcrum about which an ejected passenger will tend to rotate. Therefore, this type of handhold, even when used, does not provide the passenger sufficient leverage to prevent ejection.



Needed is a golf cart design that makes it less likely for a passenger to be ejected without interfering with convenient entry and exit from the passenger side of the seat.

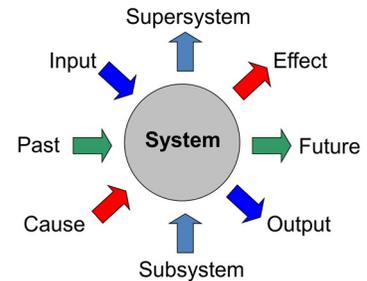
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## 2. DETAILED DESCRIPTION OF THE SITUATION

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### 2.1 SUPERSYSTEM/SUBSYSTEM ANALYSIS

The golf cart restraint bars are designed to keep the driver and passenger in place while the cart is in motion and to prevent them from serious injury caused by falling out of the cart. The restraints can be made from molded plastic or various types of metal and sometimes encased in foam rubber. The bar is usually waist high to enable its use as a hand hold and to add to rider stability. The golf cart seats are un-contoured and covered in vinyl. The slippery surface of the vinyl can cause riders, especially children, to slide during turns, resulting in the potential for them to be ejected. Hand holds are sometimes included in the roof of the vehicle to aid the passenger though these are not usually useful to the driver. Doors, flaps, and various sizes of restraint bars have been added over the life of the golf cart. Some of these designs proved to be cumbersome. These attempts usually just restrict access and complicate entry and exit.



Lack of adequate suspension systems can also lead to passengers falling off the vehicle. Over rough terrain, the riders are bounced and can more easily go over the restraint system.

Other than the rectangular bar, there are no systems that help keep the driver and passengers in place.



[http://bp3.blogger.com/\\_uE0wtsbZdVk/SD2x55D9S-I/AAAAAAAAABAY/bajZF0uaenM/s320/Golf\\_Cart.jpg](http://bp3.blogger.com/_uE0wtsbZdVk/SD2x55D9S-I/AAAAAAAAABAY/bajZF0uaenM/s320/Golf_Cart.jpg)

## 2.2 INPUT/OUTPUT ANALYSIS

- Driver and passenger(s).
- Weight distribution of occupants and equipment.
- Motor turns wheels.
- Rotating wheels make cart move.
- Pushing the pedal causes electricity to flow to the motor making the golf cart to move forward.
- The further the pedal is pushed, the more electricity (wattage) that flows to the motor making the faster the cart moves.
- The cart is equipped with disk brakes to allow the driver to slow the vehicle.
- The driver of the cart is required to steer the vehicle.
- Driver moves steering wheel.
- Steering wheel moves linkages.
- Linkages move wheels.
- Size and output power of the engine.
- Suspension capabilities of the cart.
- Side restraints keep riders in the cart.
- The cart easily transports golfers from one hole to the next.
- Carts require electricity (charge).
- Recreational use - families and kids.

### 2.3 CAUSE/EFFECT ANALYSIS

Golf carts are used to transport golfers to each hole on the course. The lack of adequate restraint systems can lead to drivers and/or passengers being ejected from the moving vehicle. Extremely sharp turning at high speeds makes it easier for the occupants to fall out. Left turns cause the passenger to be forced outward. Drivers are able to stay in the cart because they are holding onto the steering wheel for stability and they know when they are getting ready to turn.

In addition to speed, the ground conditions impact the potential for ejection. Rough terrain and bumps make it more likely for occupants to be thrown from the vehicle, since they are not firmly planted on the seat.

The height of most restraint systems implement on golf carts are located at hip level, which can act as a fulcrum. The fulcrum then makes a passenger more likely to fall out.

The speed of the golf cart can increase the likelihood of being ejected. Carts with gasoline engines are more powerful and faster, though not as common. The faster the cart moves during turns, the more power centrifugal force will have on the riders, pulling them outward.

### 2.4 PAST/FUTURE ANALYSIS

Little change has occurred over the life of the golf cart. Unlike automobiles, there has been little innovation on these vehicles. Golf carts were introduced in the mid-1930s as 3 wheeled vehicles specifically to allow the disabled easier access around the golf course. These first golf carts were powered electrically, but it wasn't long before gas powered models appeared on the market. In the 70s and 80s, manufacturers began using 4 wheels to keep vehicles from tipping over. A bar was also added to both outer ends of the seat designed to keep occupants in place. Many variations and sizes of this bar have been tried over the years. The focus here has been less about safety and more about allowing easy entry and exit. Throughout the 80s, 90s, and 2000s, minimal modifications have been made to the design. Most of those changes have been cosmetic in nature and none of those designs focuses on occupant safety. Some newer manufactures have introduced seat belts, but those impede on ease of entry and exit. The United States government requires current golf cart manufacturing companies to include seat belts and a few states require doors. No regulations are in place for the size or shape of the side-bar restraint.



1940

<http://www.tractorshed.com/gallery/upstest/a27670.jpg>



1964

[http://farm1.static.flickr.com/228/522531651\\_5bb1b9fd7d.jpg](http://farm1.static.flickr.com/228/522531651_5bb1b9fd7d.jpg)



MID-1980 - PRESENT

<http://bestbatterytips.com/wp-content/uploads/2010/03/Golf-Cart2.jpg>



MID-2000 - PRESENT

[http://image.europeancarweb.com/f/features/epcp\\_1008\\_paul\\_smith\\_tsovet\\_garia\\_glenfiddich\\_bu\\_gatti\\_embraer/29749363+pheader\\_460x1000/epcp\\_1008\\_01\\_o+garia+golf\\_cart.jpg](http://image.europeancarweb.com/f/features/epcp_1008_paul_smith_tsovet_garia_glenfiddich_bu_gatti_embraer/29749363+pheader_460x1000/epcp_1008_01_o+garia+golf_cart.jpg)



MID-2000 - PRESENT

<http://www.gonev.com/images/gem-car-4-door-3.jpg>

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### 3. RESOURCES, CONSTRAINTS, AND LIMITATIONS

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#### 3.1 AVAILABLE RESOURCES

|              |                |                       |                   |
|--------------|----------------|-----------------------|-------------------|
| Metal Bar    | Occupants      | Virtual safety tests  | Gravity           |
| Plastic Bar  | Power Source   | Government Regulation | Speed             |
| Carbon Fiber | Seats          | Natural forces        | Safety mechanisms |
| Rubber       | Seat coverings | Weight Distribution   |                   |
| Seat Belts   | CAD            | Centrifugal force     |                   |

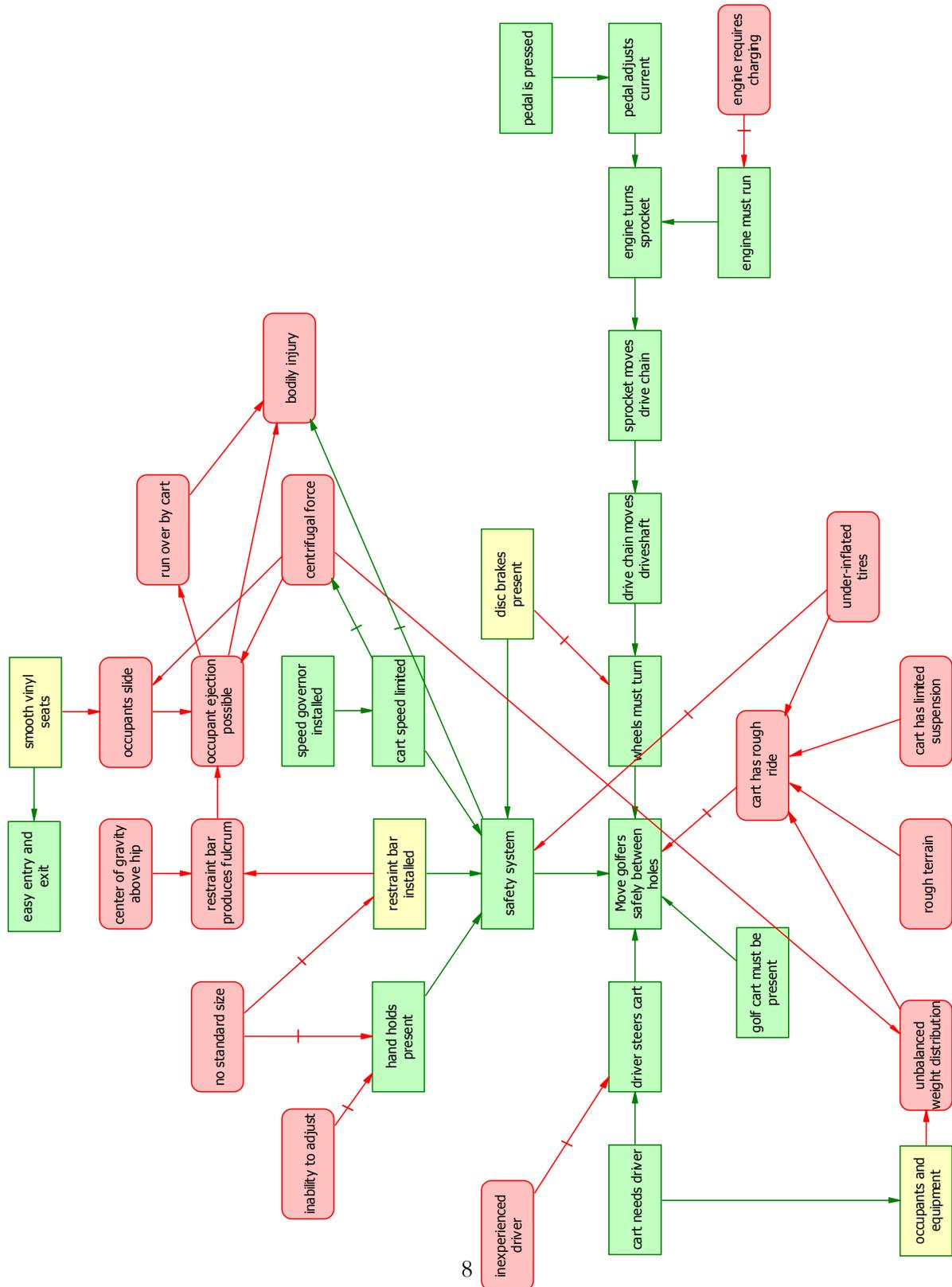
#### 3.2 ALLOWABLE CHANGES TO THE SYSTEM

All functions and designs of the golf cart can be modified. The driver must be able to easily recognize, understand and use driving/steering system . The cart will still need to be easy to enter and exit for quick travel. The cart also will need to be able to accommodate golfing equipment and clubs.

#### 3.3 CONSTRAINTS AND LIMITATIONS

Golf cart designs will have to be user friendly, so that everyone can use them. The cart must fit onto pre-existing cart paths, so size cannot be altered. The vehicle must be light enough not to damage course grass. Occupants must be able to easily enter and exit the vehicle. Speed must be limited so that the driver does not lose control of the vehicle. Regulations limit the speed of a golf cart to 25mph. Steering systems should be easily recognizable and usable by golfers. The golf cart must meet all federal and state safety regulations.

## 4. PROBLEM FORMULATION



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## 5. IDEAS

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**9. Find an alternative way to obtain *cart needs driver that provides or enhances driver steers cart and occupants and equipment.***

**Introduce a dynamic device** – Use a dynamically controlled steering device that will not allow the driver to turn as tight at high speeds, reducing the likelihood of occupant ejection.

**10. Find an alternative way to obtain *hand holds present that offers the following: provides or enhances safety system is not influenced by inability to adjust and no standard size.***

**Make and object dismountable** – Use a flip-down handle can be adjusted in respect to occupant's height.

**11. Find an alternative way to obtain *restraint bar installed that offers the following: provides or enhances safety system does not cause restraint bar produces fulcrum is not influenced by no standard size.***

**Integrate to obtain a new property** – Integrate netting between the restraint bar and roof that will 'catch' occupants falling out but will not restrict entry or exit.

**Synthesize a new system** – Use netting instead of a restraint bar to hold occupants in cart. Netting connects between lower seat and roof. Netting is cheaper than customized restraint bars or doors and can be easily replaced when damaged.

**22. Find a way to eliminate, reduce, or prevent *centrifugal force in order to avoid occupants slide, occupant ejection possible and unbalanced weight distribution.***

**Introduce a dynamic device** – Dynamic suspension system that raises one side of the cart to counteract the force of a turn. (Tips the opposing side up, like motorcycle leaning into turn.)

**Introduce a dynamic device** – Use a seating system that will pivot/lean into the turn, opposing centrifugal force. Each seat can be mounted on its own system to allow independent tilt.

**Counterbalance** – Use a counterweight to counteract outward lean and centrifugal forces when turning the cart.

**23. Find a way to eliminate, reduce, or prevent *cart has limited suspension in order to avoid cart has rough ride.***

**Add an isolating substance** – Introduce a full independent coil-over hydraulic suspension to better navigate rough terrain and cause less bouncing in cart.

**30. Resolve the contradiction: *occupants and equipment shouldn't be provided to avoid unbalanced weight distribution.***

**Counterbalance** – introduce a counterbalance to make weight side to side and front to back balance to reduce the likelihood of cart lean.

**31. Find a way to eliminate, reduce, or prevent *under-inflated tires in order to avoid cart has rough ride.***

**Add an isolating substance** – Properly inflate tires in accordance to manufacturer's recommendations.

**Exclude the cause** – Use air free (molded rubber) tires so that they are never underinflated or flat.

**32. Find a way to eliminate, reduce, or prevent *inexperienced driver.***

**Synthesize a new system** – Computer controlled driving system that uses centralized cart monitoring and GPS-based guidance that controls all carts on the course. Computers can determine whether it is safe to make a turn and react to ground conditions, reducing the problems encountered with driver error.

**Introduce a dynamic device** – Use a dynamic steering control that will limit the angle of a turn as carts move faster. The faster the cart is moving, the wider it turns. (Variable effort steering)

**34. Find a way to eliminate, reduce, or prevent *occupants slide in order to avoid occupant ejection possible under the conditions of centrifugal force and smooth vinyl seats.***

**Apply physical effects** – Contour seats (like racing seats) to help hold occupants in place.

**Partition then integrate** – Split current bench seat into two individual seats with a center armrest/restraint to limit the possibility of occupant sliding.

**35. Find an alternative way to obtain *easy entry and exit that does not require smooth vinyl seats.***

**Replace field with more effective** – Change seat covering from smooth vinyl to a water-resistant fabric that will help grip the clothing of occupants to keep them in place.

**19. Find a way to eliminate, reduce, or prevent *inability to adjust*.**

**Divide into compensating parts** – Restraint bar can be separated into a base and an adjustable side restraint. The bar can then be raised or lowered depending on occupant's height.

**36. Find an alternative way to obtain *smooth vinyl seats* that offers the following: provides or enhances *easy entry and exit* does not cause *occupants slide*.**

**Synthesize a new system** - Introduce a radically redesigned cart that provides front-entry seating. The driver and passenger would be seated in a bobcat-like style where they would sit to drive and then stand up and step out at their destination. By having the front of the cart open, the need to have open sides would be eliminated, thus virtually eliminating the possibility for ejection.

**39. Find a way to eliminate, reduce, or prevent *run over by cart* in order to avoid *bodily injury* under the conditions of *occupant ejection possible*.**

**Introduce a dynamic device** – Introduce a weight controlled system that will stop or slow a cart in motion when a sudden change in weight is detected on the seat. By stopping or slowing the cart, there is less of a chance of ejected passengers getting run over by the vehicle.

**40. Find a way to eliminate, reduce, or prevent *bodily injury* under the conditions of *occupant ejection possible* and *run over by cart*.**

**Apply an inflatable construction** – Use inflatable side skirts to 'catch' an occupant falling out of the moving cart. If an occupant is detected to be falling out of the cart, explosive charges can be used to rapidly inflate an airbag-like landing pad to cushion the fall of the occupant and guide them away from the moving cart.