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## Remote controlled stroller

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# Remote Controlled Stroller



May 2007

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**Abstract:**

Our capstone project is an intelligent remote controlled electrically powered stroller that requires no direct physical interaction with the user. The stroller provides an unprecedented level of safety and convenience to both the operator and the passenger. The first concern of the product is obviously safety; therefore the following features are included: a safety key, seat belt alarm system, remote controlled brakes, and obstacle detection. If the safety key is pulled out for any reason, the brakes will be engaged. The remote controlled brakes allow for simple push button braking. The obstacle detection will ensure the stroller will not travel into anything, such as curbs, walls, ground obstacles (hazardous to wheel function), or pedestrians. Conventional strollers have no guarantee they will be able to avoid collisions, even if the stroller operator is paying complete attention to the stroller. Finally the stroller has a five-point harness with an alarm that will not allow the stroller to move and sound an alarm if the seatbelt is not fastened. Therefore, these safety features will keep the baby at or above the current accepted level of safety in conventional strollers.

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## Introduction and related work

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Our capstone design idea is to build an intelligent remote controlled electrically powered stroller that will require no direct physical interaction with the user. The stroller will provide an unprecedented level of safety and convenience to both the operator and the passenger.



**Figure 1 - Stroller Attached to a Wheelchair**

The need for this design was identified by a hole in the ability of a handicapped person to lead a normal life. It is virtually impossible for a person in a wheelchair, using a cane or walker, or weakened by an illness or injury to push a stroller. For example, if a person is confined to a wheelchair and has a baby, they have no option but to carry the baby on their lap in the wheelchair. With a child on their lap, the disabled person has no room to place items on to carry around, such as groceries or other items while shopping. This also causes circulation in the legs to get cut off after long periods of time with the child on the lap. Not to mention that sitting on a lap is not as comfortable and safe for the child as sitting in a stroller seat.

There has been an invention that allows a stroller to be physically attached to a wheelchair but this invention still requires the handicapped person to have a great deal of strength to physically move both themselves and the child in the stroller seat. This was developed by mechanical engineering students Southern Methodist University. The idea for the stroller project came from Attorney Lydia Springer who is confined to a wheelchair and after having a child realized that the wheelchair impaired her from being able to care for her child<sup>1</sup>. For the project, students used an inexpensive stroller and designed clamps so that the stroller can attach to the wheelchair. A picture of this invention can be seen in Figure 1. The only problem with this invention is that it still requires a great amount of physical ability and effort for the user to move both herself and the child in the stroller. A motorized alternative would be much more beneficial.

Though electronic strollers such as the Peg Perego Dinamico stroller<sup>2</sup>, shown in Figure 2, have been developed, they are controlled with buttons on the handlebar, still requiring the operator to be in direct physical contact with the stroller while pushing it. Also, the buttons only allow the stroller to move forward and backward, requiring the operator to manually turn the stroller when needed. The details are given in patent #5937961<sup>3</sup>. Our design will make physical contact optional, with a remote designed to fit comfortably in the palm of the hand or to be attached to the waist or handle for situations where both hands need to be free. The remote will allow the operator to move the stroller forward, backward, left, or right with no need for continuous input. Once the stroller reaches a desired speed, the button can be released and it will continue to move at this speed until changed.



**Figure 2 - Peg Perego Dinamico Stroller**

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<sup>1</sup> <http://www.smu.edu/newsinfo/releases/00224.html>

<sup>2</sup> <http://babyride.stores.yahoo.net/ipdi28us10wt46wt53.html>

<sup>3</sup> <http://www.uspto.gov/patft/index.html>

The first concern of the target demographic is obviously safety; therefore the following features will be included: a safety key, seat belt alarm system, remote controlled brakes, and obstacle detection. If the safety key is pulled out for any reason, the brakes will be engaged. In the event the stroller escapes from the operator, the safety key will be pulled out, stopping the stroller. Any possible stroller speed malfunctions as well as operator proximity are encompassed in this feature. The remote controlled brakes allow for simple push button braking, not requiring the operator to be in contact with the stroller to stop it his or herself. The obstacle detection will ensure the stroller will not travel into or off of anything, such as curbs, walls, ground obstacles (hazardous to wheel function), or pedestrians. Conventional strollers have no guarantee they will be able to avoid collisions, even if the stroller operator is paying complete attention to the stroller. Finally the stroller will have a padded five-point harness with an alarm that will go off if the stroller is moving three miles per hour or more and the harness is not buckled. Therefore, these safety features will keep the baby at or above the current accepted level of safety in conventional strollers.

The projected cost for this stroller is \$375, a reasonable figure in keeping with the cost of commercially available electronic stroller designs lacking our proposed additional safety features and remote operation ability. Additionally, the Peg Perego Dinamico stroller costs \$599 MSRP, but has fewer features and was not intended for jogging speed. Also the controls are mounted on the handle, so there is no added convenience of a remote, and the stroller still must be turned manually.

Our primary market would be to handicapped individuals who lack the physical ability to operate a stroller. The remote control capability allows them to operate a stroller, which is something they would not usually be able to do. Our stroller is designed for use by the handicapped, but will be equally useful for simple everyday use by anyone. It will also much greater freedom during everyday tasks such as running errands or shopping; allowing the user two free hands to look at items, interact with others, or even tend to other perambulatory children.

Therefore, we feel the added cost will be completely justified in the substantial improvement of the lives of parents in need of constant use of strollers. We have identified interest from the target demographic, with no comparable product on the market. Development of an intelligent electrical stroller market seems to coincide with that of the powered wheelchair market. Prior to the widespread recognition and adoption of the increasingly functional powered wheelchairs, the majority of handicapped individuals desiring independent mobility relied on manual wheelchairs. These were only able to be independently operated with a requisite level of physical exertion and inconvenience the powered versions made unnecessary. We hope our design will produce a similar redundancy in the stroller market.

## Design Specification

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We hope to include several safety features in our remote controlled stroller since the safety of the child inside the stroller is very important. The first safety feature we will include is a key, much like a key on a treadmill, to make the stroller work. The key will be attached to the operator's waist and if the stroller gets to far away, the key will be pulled out and the stroller will stop. This feature will be very useful in several situations. First, if the operator is unable to keep up with the stroller, it will stop instead of continue to move forward away from the operator. Another situation that the key will prove useful in is if the operator loses control of the stroller for any reason. Once it gets far enough away to pull the key out, it will immediately stop, preventing the child from risk of injury. Our second safety feature is a speed sensitive child safety restraint system. It includes a padded 5-point harness with warning system that sounds an alarm if the harness is not buckled and the stroller is moving three miles per hour<sup>4</sup>. It will also limit the speed to three miles per hour until the harness is buckled. Our third safety feature is a lighting system with warning lights, brake lights and blinkers. There will be a light on the back of the stroller to warn the operator when the stroller is evaluating terrain. In addition, there will be a brake light for when a validated obstacle is present or the brake is activated and the stroller must stop. There will also be blinkers on the back and side to warn others when the stroller is turning.

The brake can be engaged by the operator using the remote or through some simple obstacle detection; the stroller will stop if it senses any dangerous situations. The obstacle detection system will use ultrasonic sensors insensitive to temperature, humidity and pressure changes attached to the front of the stroller. The system will be able to monitor forward terrain and determine if there is a danger of hitting any hazardous obstacles such as trees, walls, cars, or large objects. Essentially, if any obstructions are identified within 3 meters of the stroller, the stroller will stop. Also, if an object is found to have positive velocity toward the stroller and is within about 10 meters a warning light will illuminate.

Since the stroller is designed for use while walking, it will operate at speeds up to four miles per hour. The speed of four miles per hour also takes into consideration the safety of the child. The stroller will have three wheels; the back two will be powered while the front wheel will pivot, allowing the stroller to turn efficiently. The stroller will be powered by a battery with approximately four hours of operation time before needing to be recharged. Simply plugging the stroller into an outlet will recharge the battery.

Using the remote, a pace can be set and the stroller will continue to move at that speed unless changed. There is no need to constantly push the forward button on the remote to move the stroller forward. The backward button will decelerate, also holding the speed constant once released. The momentary left and right buttons will control real time turning. The brake button will immediately fully engage the brake. The remote can either fit comfortably in the palm of the hand, be attached to the wrist or mobility device for use when using a cane, walker, or wheelchair, or can be attached to the handle of the stroller, leaving both hands free. The safety key is the remote itself. If the remote gets too far away from the stroller, it will get unplugged and the stroller will stop. This ensures that the stroller will not get out of close proximity to the operator.

The size of our stroller is the same size as a regular jogging stroller. However there is added weight due to the motor, battery, and controller. The remote controlled stroller will weigh about fifty pounds and can carry a child weighing up to fifty pounds.

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<sup>4</sup> Road Engineering Journal: Study Compares Older and Younger Pedestrian Walking Speeds  
<http://www.usroads.com/journals/p/rej/9710/re971001.htm>

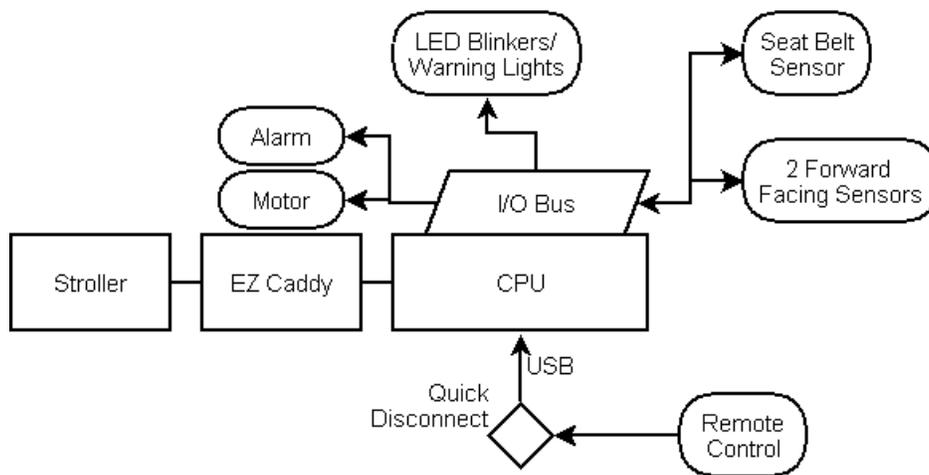
**Features:**

- Remote controlled
- Safety-key braking system
- 0 to 4 miles per hour speed
- Up to 3 meter collision avoidance
- Up to 9 meter obstacle/obstruction detection
- Alarmed 5 point seatbelt system
- Speed limited
- Lighting system
- Battery powered (~4hours) dual electric motor
- 50 pound weight
- Carries up to 50 pounds
- Power Assisted and Obstacle Detection Mode

## Design Overview

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Below is a block diagram of the remote controlled stroller.



**Figure 3 - Block Diagram**

As can be seen, all sensors are connected to the I/O bus, which is in turn connected to the CPU. The forward facing sensors are ultrasonic sensors that are triggered by the CPU and send back TTL signals, which are in turn read by the I/O board and interpreted by the CPU. The remote control is connected to the CPU through a quick disconnect. The LED blinker, warning and brake lights are powered from the battery and receive a signal from the CPU telling them to turn on and off. The signals from CPU control the alarm and motor, which receive power from a battery. The base of the stroller is an EZ Caddy with a stroller attached to it.

## Prototype Design Details

### 1. Base of Stroller

The first task that we completed was to combine the stroller and remote control golf cart, the Ezcaddy, shown in Figure 4. We took the wheels off of the stroller and cut pieces of wood to attach to both the front and rear legs of the stroller. With these pieces of wood attached we were able to securely sit the stroller onto the base of the Ezcaddy with the front weight of the stroller resting on the front wheel of the Ezcaddy and rear weight resting on the metal box that houses the motors. To securely attach the stroller further we added braces to attach the back of the stroller to the metal bar that would usually hold the golf bag in place. We took the seatbelt off of the stroller and attached a sturdy 5-point harness seatbelt. With the stroller integrated into the Ezcaddy we have a battery-powered stroller that is run by two electric motors.



Figure 4 - Ezcaddy's Remote Control Golf Cart

### 2. PC/104 Embedded CPU and I/O Module

Our project relies on quick response and component integration which presented a challenge. To orchestrate both of these, a PC/104 board was used with an I/O expansion module. Our project required development with ultrasonic sensor inputs (which can be converted in many ways), LEDs, USB, and a motor interface. Due to a combination of knowledge and finance, this could really only be accomplished economically by a PC/104 solution. This led to the Morpheus board from Diamond Systems, which is a low cost, stripped down version of a 400MHz Intel Celeron board with a PC/104 bus. We chose a low cost Diamond Systems Onyx I/O board since our project required several readable connections to the I/O module itself. The Onyx uses two 82C55 ICs for I/O and an 82C54 IC for counting/timing. Combined, this allowed development of an algorithm for ultrasonic ranging and classification of obstacle threat level to the path of motion and full integration for control of the other system components.

Example pseudocode used to run the system and perform obstacle detection can be seen in the Appendix.



Figure 5 - Digitally Controlled I/O Module



Figure 6 - PC/104 Embedded CPU

### 3. Obstacle Detection System

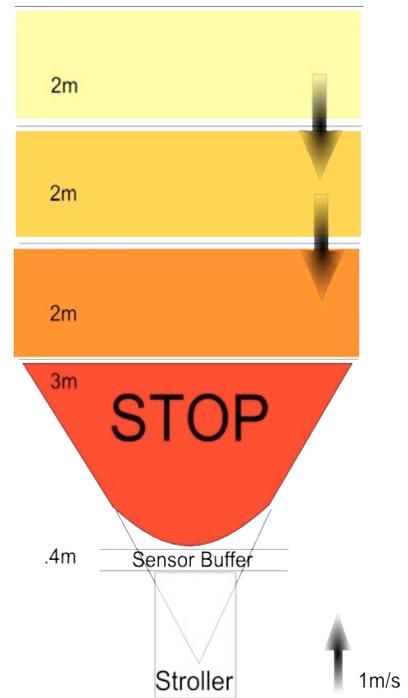


**Figure 7 – SensComp  
“Smart Sensor”**

We designed an obstacle detection system using electrostatic ultrasonic transducers for sensing, shown in Figure 7, and a CPU for processing. The sensors are sensitive from .5-20 feet for the two main ranges of interest. We used two sensors. One mounted at the top of the stroller looking forward for objects such as people, walls, and trees. The other is mounted over the front wheel of the stroller and looks for lower obstacles such as forward facing curbs and rocks. These sensors are mounted securely: enclosed, calibrated, & integrated into the system to be reduced to timed TTL compatible outputs. The transducers were calibrated with ranging modules and extensive infield testing of dangerous readings.

The sensor output is a TTL signal that is read by the CPU. The data passed on the hardware level will be interpreted by functions written in C. The algorithms (and the requisite programming environment) will function to provide a temporal disparity echo signal based location routine. This will include detection of obstacles, obstacle distance/position, and classification of danger to the wheels' continued path. Figure 8 shows a diagram of how the obstacle detection algorithm works. If an obstacle is found to be in the “STOP” area the stroller will stop and brake lights will illuminate. If an object is found to be moving toward the stroller, meaning it crosses from one window to the other such as gold to orange or yellow to gold, the warning light will illuminate. There is a small buffer in front of the stroller, which is an inherent property of the sensor.

The processing system will produce outputs to be interpreted by functions controlling the interface to the LED's and motors for obstacle warning state excitation and to give validation for the initiation of braking. If the operator does not wish to use the obstacle detection system for some reason, such as operating the stroller in a busy area like a mall, “Power Assisted Mode” can be used which enables the remote to still function normally, but the stroller will not stop automatically or warn of obstacles. When the operator wishes to use the obstacle detection system, “Obstacle Detection Mode” should be on. There is a light on the top of the stroller that signifies which mode the stroller is in.



**Figure 8 - Obstacle Detection  
Operation**

#### 4. Remote Control



**Figure 9 - USB Mobile Controller Gamepad**

The remote will be a custom molded plastic piece in the final product that will fit comfortably into the palm of the hand and connect to the CPU through USB. However, for our prototype we will use a USB remote control, shown in Figure 9, with a quick connect from an Xbox controller, shown in Figure 10, spliced to the cord.

Using the buttons on the controller, we will have controls for moving forward, backward, left, right and stop. These will be custom pieces on the final product, but for the prototype we will use the directional pad on the USB remote for steering and acceleration, and a button for stop. We will allow for the speed of the remote controlled stroller to stay constant when the button is released, by having the speed set by the CPU until modified by the remote.

The remote will also act as the safety key for the stroller. This will be achieved by detecting when the controller is connected to the USB port. The port will be attached to the handle bar so it is easily visible to the user and will be the quick connect from the Xbox controller. If the controller is disconnected from the USB port the stroller will stop immediately. Processing for the functions of the remote will be done in C through simple reading of the USB device. Example pseudocode can be seen in the Appendix.



**Figure 10 - Quick Connect from Xbox controller**

#### 5. Seatbelt



**Figure 11 - Five Point Harness**

Another safety feature of the stroller will be a 5-point harness, as shown in Figure 11. The harness will be buckled with a three-part buckle, able to detect whether it is fastened or not. To achieve this, a connectivity detection system will be integrated into the 5-point harness buckle that will measure conductivity between the upper and lower halves of the buckle. This will be connected via a wire within the seat belt to the I/O. The status of the seat belt will be readily available to the rest of the control system by sending a TTL voltage signal, and will be checked every time a signal is sent from the remote telling the stroller to move. If the seatbelt is not fastened and the user tries to move the stroller an alarm will sound and the stroller will not move until the seatbelt is fastened. The connectivity is also monitored while the stroller is moving to ensure the seatbelt has not been unbuckled.

## 6. Brake/Blinker/Warning Lights

Seven LED light clusters will be used on our remote controlled stroller, two red, two yellow, two green, and one white. The two red LED clusters will be mounted in a box above the handlebars of the stroller and will act as the brake lights, illuminating when the stroller is stopping. The two yellow LED clusters will also be mounted in the box above the handlebars they will contain blinking LEDs, and be used as turn signals. The green LED clusters will also act as blinkers but will be attached at the sides of the stroller. Finally, the white LED cluster will be attached in the center of the box above the handlebar and will act as the warning light. A picture of the LEDs above the handlebars and attached at either side of the stroller can be seen in Figure 12.

There are four LED switching circuits for each of the four possible LED initiating events: stop, warn, left, and right. They were designed to give the LEDs enough power through the use of the battery, while allowing the control signals for turning them on and off to come from the CPU. Each of these circuits is identical, with the only difference being the control signal from the processor. The design functions via a simple voltage divider and an npn transistor switch with a current limiting resistor.



**Figure 12 - LED's for Stroller**

## Prototype Design Evaluation

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**Figure 13 - Finalized Prototype**

Our project works just as expected to. A picture of our final project can be seen in Figure 13. The sensors are able to find stationary obstacles within 3 meters and stop. The warning light illuminates when an object is found to be moving toward through the windows in front of the stroller. LED's light up corresponding to the actions of the stroller, stop when the stroller is stopped either by the remote or obstacle detection system, warn when an object is moving toward the stroller, and blinkers when the stroller is turning. The CPU is able to determine if the seatbelt is connected and if disconnected the stroller will not move and an alarm will sound.

We did extensive testing of the sensors to correctly calibrate the ranging and ensure the stopping distances were correct. This was done in accordance with our calculated distances of response versus range.

The best improvement to the design would be to build the base from scratch instead of use the EZ Caddy. We did not have any other option for this project given all of the other features we wanted to accomplish but using different motors we would be able to better control the speed in a range that is comfortable for someone walking slowly, operating a wheelchair, and walking at a brisk pace. We would also like to have a pivoting front wheel for turning instead of braking one wheel and moving the other to turn.

## Productized Design

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A productized version of our system would contain all of the above features and logic for control, but would be assembled with significantly different parts and lower cost. The motorized component of the stroller would be two separate, individually controlled motors mounted to the axle of a single high quality stroller made of impact resistant molded plastic. The motors would be carefully calibrated in development with shaft encoders to control exact voltage levels and duration of signaling to provide specific turning angles and response. The remote to control these would be pressure and velocity sensitive to react more responsively to the user. The remote itself would be a molded ergonomic remote designed to be comfortable in the palm of a hand, not simply a plastic box. The seat of the stroller would be bucket shaped, with a padded 5 point harness. The processing would be done on a much lower cost dedicated FPGA that would be capable of executing a timed logical equivalent of the algorithm based on reading and outputting voltages. This would be concealed in the molded plastic exterior which would also provide mounting recessions for the sensors, and protect all electronics from unnecessary exposure and damage. The sensors will continue to be environmental grade and use ultrasonic imaging. The LEDs would become covered LED lights similar to those found on recent automobiles, mounted further apart on the rear of the stroller and sides. This would all be powered by a smaller high output, longer life battery. With these changes, and supplies purchased in bulk, our design is capable of becoming a serious competing product in the mobility assistance market.

## Parts

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| Part                       | Cost for Prototype | Cost for Production | From               |
|----------------------------|--------------------|---------------------|--------------------|
| Ezcaddy                    | \$299.95           | \$100               | Ebay               |
| Stroller                   | \$11.88            | \$7                 | Target             |
| 5-Point Harness            | \$11.35            | \$2                 | Ebay               |
| (2) 12 Volt Batteries      | \$0.00             | \$40                | Borrowed           |
|                            |                    |                     |                    |
| 6 GB Hard Drive            | \$19.98            | \$10                | Ebay               |
| Board                      | \$679.00           | \$100               | Diamond Sys. Corp. |
| Cover for Board            | \$7.33             | \$3                 | NEU Bookstore      |
|                            |                    |                     |                    |
| Remote                     | \$47.74            | \$5                 | Game Choice Club   |
| USB Quick Connect          | \$6.94             | \$1                 | Amazon             |
| USB Extension              | \$15.28            | \$1                 | Amazon             |
|                            |                    |                     |                    |
| Sensors & Enclosures       | \$120.00           | \$60                | SensComp           |
|                            |                    |                     |                    |
| (16) Red LED's             | \$8.42             | \$2                 | Digi-Key           |
| (14) Yellow LED's          | \$3.16             | \$2                 | Digi-Key           |
| (12) White Blinking LED's  | \$13.86            | \$3                 | Digi-Key           |
| (16) Green Blinking LED's  | \$14.28            |                     | Digi-Key           |
| (10) Yellow Blinking LED's | \$11.76            | \$3                 | Digi-Key           |
|                            |                    |                     |                    |
| Custom Plastic Molding     |                    | \$24                | Unknown            |
| Metal Clamps               | \$4.97             | \$1                 | Home Depot         |
| LED & Motor Enclosures     | \$15.29            | \$5                 | RadioShack         |
| PC Boards                  | \$7.52             | \$5                 | RadioShack         |
| Wire                       | \$0.00             | \$1                 | NU                 |
| Drill                      | \$0.00             | \$0                 | Borrowed           |
| Soldering Iron             | \$0.00             | \$0                 | Borrowed           |
|                            |                    |                     |                    |
| <b>TOTAL</b>               | <b>\$1,298.71</b>  | <b>\$375.00</b>     |                    |

Table 1 – Parts

## References

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- [1] <http://www.smu.edu/newsinfo/releases/00224.html>
- [2] <http://babyride.stores.yahoo.net/ipdi28us10wt46wt53.html>
- [3] <http://www.uspto.gov/patft/index.html>
- [4] <http://www.joggingstroller.com/Mountain-Buggy-Urban-Single.pro>
- [5] Road Engineering Journal: Study Compares Older and Younger Pedestrian Walking Speeds  
<http://www.usroads.com/journals/p/rej/9710/re971001.htm>
- [6] The National Oceanic and Atmospheric Administration Coastal Services Center  
<http://www.csc.noaa.gov/>

## Appendix

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### *Remote Psuedocode*

```
Check_Remote()
    Result = Poll_Remote(&Remote_State)

    If (Result == Remote_Disconnected)
        Return Remote_Disconnected

    If (Remote_State.Buttons == Change_Modes)
        Return Change_Modes

    If (Remote_State.Buttons == Stop)
        Return Stop

    If (Remote_State.Direction != Neutral)
        Return Remote_State.Direction

    Return 0;
```

### *Obstacle Detection Psuedocode*

```
receivedUserInput = checkRemote()

switch (receivedUserInput)
    case noInput:    controlState.Motor = nothing
    case forward:   controlState.Motor = forward
    case left:      controlState.Lights = leftBlinkers
                   controlState.Motor = leftTurn
    case right:     controlState.Lights = rightBlinkers
                   controlState.Motor = rightTurn
    case reverse:   controlState.Lights = warning
                   controlState.Motor = reverse
    case stop:      controlState.Lights = stop
                   controlState.Motor = stop
    case obstacleDetectMode: obstacleDetect = true
    case powerAssistedMode: obstacleDetect = false
    case shutdown:  controlState.Motor = stop
                   shutdownRoutine()

// send control to motor and LEDs
outputControl(controlState)

if (obstacleDetect)
    // send sensor transmit signal
    sensorControl(transmit)

    wait(time)
    sensorControl(receive, &echo)
```

```

// immediate stop condition w/first set of returns
if (echo.forwardSensors = obstacle)
    controlState.Lights = stop
    controlState.Motor = stop
    outputControl(controlState)
// end if

// read returns per sensing window
// weight threats by velocity
// trigger immediate LED response
weightedThreats = senseWindowReturns()

// clear sensors
sensorControl(clear)
//end if

// check seatbelt, stall until resolved or powered off
seatbelt = readSeatbelt()
if (seatbelt = disconnected)
    do
        // stop motor
        controlState.Lights = stop
        controlState.Motor = stop
        outputControl(controlState)

        // sound the horn
        controlState.Motor = horn
        outputControl(controlState)

        seatbelt = readSeatbelt()

        // check for power off
        receivedUserInput = checkRemote()
    while
        (seatbelt = disconnected) & (receivedUserInput != shutdown)
//end if

```