

# REVIEW OF GOLF ROBOT

Presented By:



# Project Description

- The robot delivers a golf ball to a given set of target coordinates on a golf green.
- It has the ability to wirelessly communicate with a PC to receive target coordinates, moves freely across a golf green, and carries and drops a golf ball at the target coordinates.

# Team Roles

| Name                     | Discipline | Task(s)   |
|--------------------------|------------|---|
| Jeff Cosimano            | ME         | Customer Needs, Mechanical Concept Generation, Navigation Algorithm, Feasibility/Error Analysis   |
| Marcus Grant             | EE         | Navigation Algorithm, Sensor Analysis, Battery Level Sensor Algorithm, Feasibility/Error Analysis   |
| Cory Gregory             | EE         | Project Plan, Ball-Placement Algorithm, Risk Assessment, Ball-Placement Mechanism Circuitry   |
| John Gutmann             | CE         | Team Norms/Values, Bill of Materials, Electrical System Design, Robot Chassis CAD Drawings  |
| Derek Hugo               | CE         | Software Concept Generation, Communication Algorithm, AR Golf Communication Software  |
| Tenzin Seldon            | ME         | PRP, Beacon Design CAD Drawings, Ball-Placement Mechanism CAD Drawings  |
| Karikalan Thirumavalavan | EE         | Engineering Specifications, Battery Level Sensor Algorithm, Object Avoidance Algorithm  |
| Jason Thrush             | EE/CE      | Electrical Concept Generation, System Decomposition, Risk Assessment, Robot/Beacon Communication Circuitry, Electrical Connection Schematic |

# Customer Needs

## Task

| Customer Need # | Importance | Description   |
|-----------------|------------|---|
| CN1             | 1          | Robot must deliver golf ball to a given set of coordinates on golf green. |
| CN2             | 1          | Robot must complete task without interrupting the flow of the game.       |
| CN3             | 2          | Minimal movement of the ball after placement.                             |

## Navigation

| Customer Need # | Importance | Description   |
|-----------------|------------|---|
| CN4             | 1          | Robot should move freely across a reasonable sized golf green.                  |
| CN5             | 1          | Robot should travel to given coordinates within a unnoticeable margin of error. |
| CN6             | 1          | Robot must communicate with the simulator.                                      |

## Environment

| Customer Need # | Importance | Description  |
|-----------------|------------|--|
| CN7             | 1          | Robot may not obstruct path of the ball to the hole.                       |
| CN8             | 1          | Robot may not obstruct user access of the ball.                            |
| CN9             | 1          | Robot must complete task without causing visible damage to the golf green. |
| CN10            | 2          | Robot must stop if anything comes within close proximity.                  |
| CN11            | 2          | Robot must be durable and function outdoors in varying weather.            |
| CN12            | 2          | Robot needs to be portable.  |

# Customer Needs (cont.)

## Power

| Customer Need # | Importance | Description   |
|-----------------|------------|---|
| CN13            | 1          | Robot battery should be able to be swapped out without interrupting the flow of the game. |
| CN14            | 1          | Robot should operate for a reasonable amount of time.                                     |

## User Interaction

| Customer Need # | Importance | Description   |
|-----------------|------------|---|
| CN15            | 1          | Users, operators and spectators should be able to harmlessly interact with robot. |
| CN16            | 2          | Robot must cease operation while the user is putting and resume after.            |
| CN17            | 2          | Robot must be user friendly and intuitive.  |
| CN18            | 3          | Robot should interact with the user for a pleasurable experience.                 |

# Engineering Specifications

## Task

| Eng. Spec. # | Importance | Source   | Specification                             | Unit of Measure    | Marginal Value | Ideal Value | Comments/Status |
|--------------|------------|----------|---|--------------------|----------------|-------------|-----------------|
| ES1          | 1          | CN2      | Robot speed                               | ball deliveries/hr | 10             | > 10        |                 |
| ES2          | 1          | CN1, CN3 | Ball must be within radius of coordinates | in                 | 2              | < 2         |                 |

## Navigation

| Eng. Spec. # | Importance | Source | Specification                | Unit of Measure | Marginal Value | Ideal Value | Comments/Status |
|--------------|------------|--------|------------------------------|-----------------|----------------|-------------|-----------------|
| ES3          | 1          | CN4    | Distance robot should move   | ft              | 30             | < 30        |                 |
| ES4          | 1          | CN5    | Navigational margin of error | %               | 0.40           | < 0.40      |                 |
| ES5          | 1          | CN6    | Wireless communication range | ft              | 40             | > 40        |                 |

## Environment

| Eng. Spec. # | Importance | Source | Specification           | Unit of Measure | Marginal Value | Ideal Value | Comments/Status |
|--------------|------------|--------|-------------------------|-----------------|----------------|-------------|-----------------|
| ES6          | 1          | CN9    | Smooth treads on wheels | N/A             | N/A            | N/A         |                 |
| ES7          | 2          | CN11   | Solid outer shell       | N/A             | N/A            | N/A         | Water Resistant |
| ES8          | 2          | CN11   | Clearance from ground   | in              | 1.5            | > 1.5       |                 |
| ES9          | 2          | CN12   | Weight of robot         | lbs             | 50             | < 50        |                 |

# Engineering Specifications (cont.)

## Power

| Eng. Spec. # | Importance | Source    | Specification | Unit of Measure | Marginal Value | Ideal Value | Comments/Status |
|--------------|------------|-----------|---------------|-----------------|----------------|-------------|-----------------|
| ES10         | 1          | CN13,CN14 | Battery life  | hrs             | 1              | > 1         |                 |

## User Interaction

| Eng. Spec. # | Importance | Source            | Specification                            | Unit of Measure | Marginal Value | Ideal Value | Comments/Status |
|--------------|------------|-------------------|--|-----------------|----------------|-------------|-----------------|
| ES11         | 1          | CN7,CN8,CN10,CN15 | Distance kept from user                  | ft              | 1              | > 1         |                 |
| ES12         | 2          | CN16              | Sensor to detect ball returned to robot  | N/A             | N/A            | N/A         |                 |
| ES13         | 3          | CN17,CN18         | Have funnel for ball insertion by golfer | N/A             | N/A            | N/A         |                 |

# Bill of Materials

| Sub-System   | Part #                     | Part                            | Unit Cost | Quantity | Total Cost | Distributor  |
|--------------|----------------------------|---------------------------------|-----------|----------|------------|--------------|
| Drive System | M7-RS775-12                | RS775 Motors                    | \$12.75   | 3        | \$38.25    | Banebots     |
|              | P60K-4444-0007             | Gearboxes                       | \$74.50   | 2        | \$149.00   | Banebots     |
|              | am-0570                    | Wheels                          | \$20.00   | 5        | \$100.00   | Andy Mark    |
|              | 6412K41                    | Shaft Couplings                 | \$10.25   | 5        | \$51.25    | McMaster     |
|              | 6435K14                    | Shaft Collar                    | \$1.79    | 8        | \$14.32    | McMaster     |
| Chassis      | 275-1035                   | 35 holes x 35 holes Chassis Kit | \$33.95   | 1        | \$33.95    | Vex          |
|              | 276-2232                   | Booster Kit                     | \$179.99  | 1        | \$179.99   | Vex          |
| Power        | am-0009                    | Battery Cable                   | \$15.00   | 3        | \$45.00    | Andy Mark    |
|              | am-0282                    | 120A Breaker                    | \$29.00   | 1        | \$29.00    | Andy Mark    |
|              | N/A                        | Bussman Fuse Panel              | \$10.00   | 1        | \$10.00    | Autozone     |
|              | am-0795                    | 2 x 18 Ahr SLA Batteries        | \$83.00   | 1        | \$83.00    | Andy Mark    |
|              | 888-XB24-ACI-001           | Xbee 1mW Chip Antenna           | \$19.00   | 2        | \$38.00    | Mouser       |
|              | 782-A000021                | Arduino Xbee Shield             | \$19.32   | 1        | \$19.32    | Mouser       |
|              | WRL-08687                  | XBEE Explorer USB               | \$24.95   | 1        | \$24.95    | Sparkfun     |
|              | CAB-00598                  | USB Mini-B Cable - 6'           | \$3.95    | 1        | \$3.95     | Sparkfun     |
|              | 782-A000047                | Arduino Mega 2560               | \$63.76   | 2        | \$127.52   | Mouser       |
|              | VICTOR-884-12/12           | Motor Controller                | \$89.99   | 2        | \$179.98   | IFI Robotics |
| 276-2156     | Encoders (2-Pack)          | \$19.99                         | 1         | \$19.99  | Vex        |              |
| SEN-07915    | Digital Compass            | \$34.95                         | 1         | \$34.95  | Sparkfun   |              |
| SEN-09418    | Digital Temperature Sensor | \$5.95                          | 1         | \$5.95   | Sparkfun   |              |
| SEN-00639    | Ultrasonic Range Finder    | \$25.95                         | 4         | \$103.80 | Sparkfun   |              |



# Bill of Materials (cont.)

|                                 |              |                                    |          |     |          |                  |
|---------------------------------|--------------|------------------------------------|----------|-----|----------|------------------|
| <b>Ball-Placement Mechanism</b> | 276-2162     | 3-Wire Servo                       | \$19.99  | 1   | \$19.99  | VEX              |
|                                 | 276-142      | IR Emitter and Detector            | \$3.49   | 1   | \$3.49   | Radio Shack      |
|                                 | 2202         | VPC 2" x 2' PVC Pipe               | \$3.36   | 1   | \$3.36   | Home Depot       |
|                                 | 447-020HC    | Mueller Streamline 2" PVC Cap      | \$0.98   | 1   | \$0.98   | Home Depot       |
|                                 | N/A          | U-Bolts                            | \$1.50   | 2   | \$3.00   | Home Depot       |
|                                 | 89K0701      | LM339N Comparator                  | \$0.29   | 2   | \$0.58   | Newark           |
|                                 | 58K3796      | 1k Ohm Resistor                    | \$0.05   | 10  | \$0.50   | Newark           |
|                                 | 66H7462      | PCB Prototyping Board              | \$6.10   | 1   | \$6.10   | Newark           |
| <b>Beacons</b>                  | XDR-24       | 24kHz Ultrasonic Transducers       | \$1.25   | 6   | \$7.50   | All Electronics  |
|                                 | 41K6165      | Tone Decoder IC                    | \$1.59   | 4   | \$6.36   | Newark           |
|                                 | 89K1489      | Dual Timer IC                      | \$0.29   | 2   | \$0.58   | Newark           |
|                                 | 96K4516      | Instrumentation Amplifier IC       | \$2.26   | 3   | \$6.78   | Newark           |
|                                 | N/A          | Various Resistors, Capacitors, Etc | -        | -   | \$10.00  | N/A              |
|                                 | PVC044000200 | Charlotte 4" x 2' PVC Pipe         | \$6.31   | 4   | \$25.24  | Home Depot       |
|                                 | 3P16         | NDS 4" x 4" PVC Adapter            | \$4.94   | 2   | \$9.88   | Home Depot       |
|                                 | 447-040HC    | Mueller Streamline 4" PVC Slip Cap | \$7.35   | 4   | \$29.40  | Home Depot       |
| <b>Camera</b>                   | RB-Sea-04    | CMUcam3                            | \$239.00 | 1   | \$239.00 | Seattle Robotics |
|                                 | AM-0568      | Pan and Tilt Assembly              | \$64.00  | 1   | \$64.00  | Andy Mark        |
| <b>Miscellaneous Costs</b>      | N/A          | N/A                                | N/A      | N/A | \$100.00 | N/A              |

Total Cost: \$1,828.91

Available: \$171.09

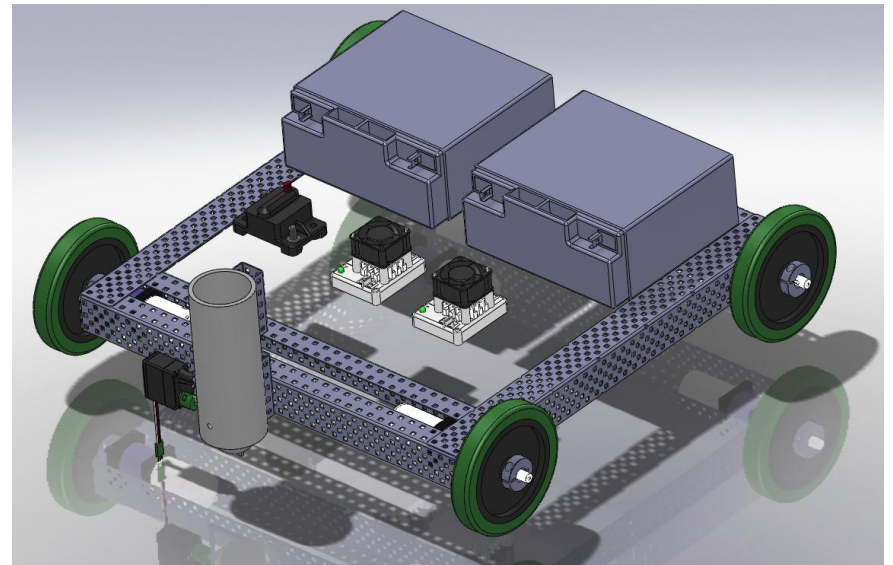
# Main Components

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- Chassis
- Ball Placement Mechanism
- Camera (CMUcam3)
- Communication System
- Sensors (Compass, Encoders, Ultrasonic Rangefinders)
- Additional Navigation Methods

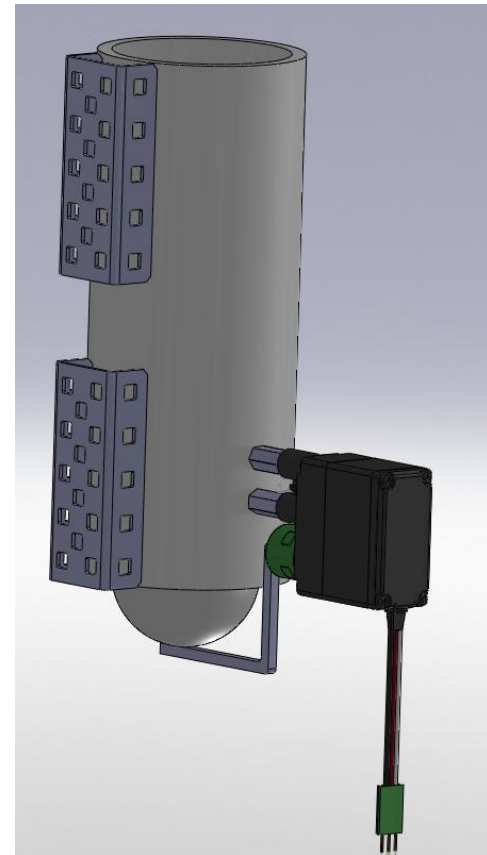
# Chassis

- VEX Kit
- 256:1 gearbox ratio
- Plexiglass Shell
- 8" Drive Wheels
- 3" Back Casters



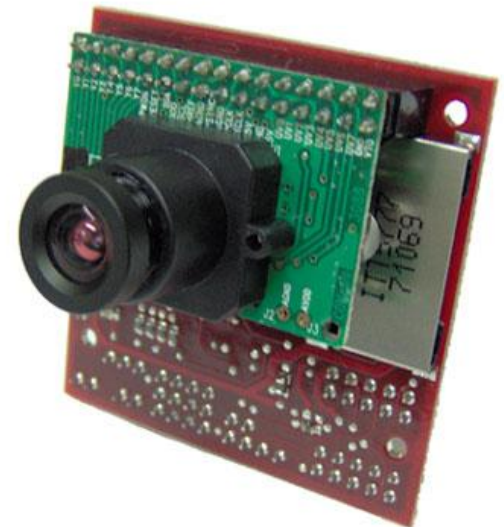
# Ball Placement Mechanism

- Holds golf ball while robot navigates
- Main Components:
  - Emitter/Phototransistor
  - Servo

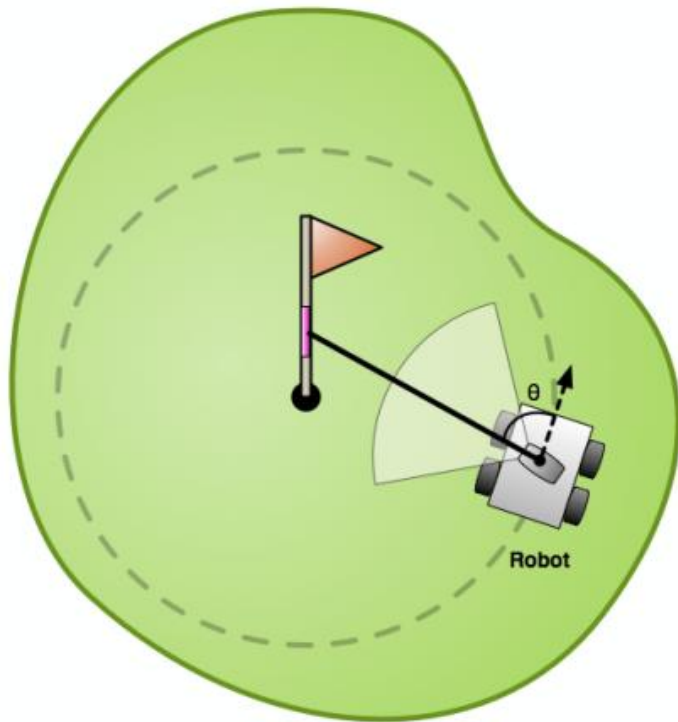


# Camera (CMUcam3)

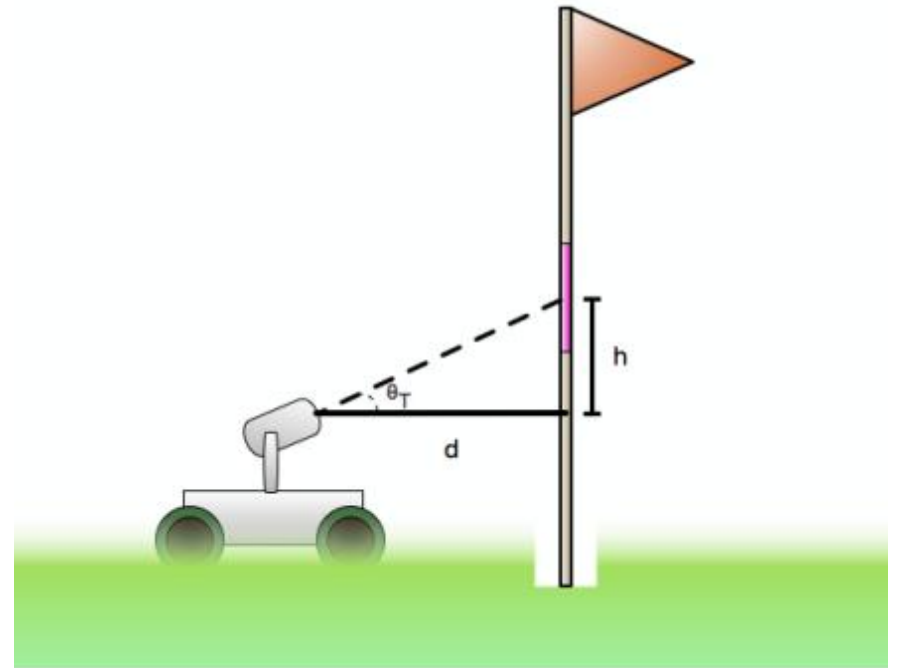
- Tracks color on flag pole
- Produces distance/angle from flag pole
- Attached to pan/tilt mechanism



# Camera (cont.)



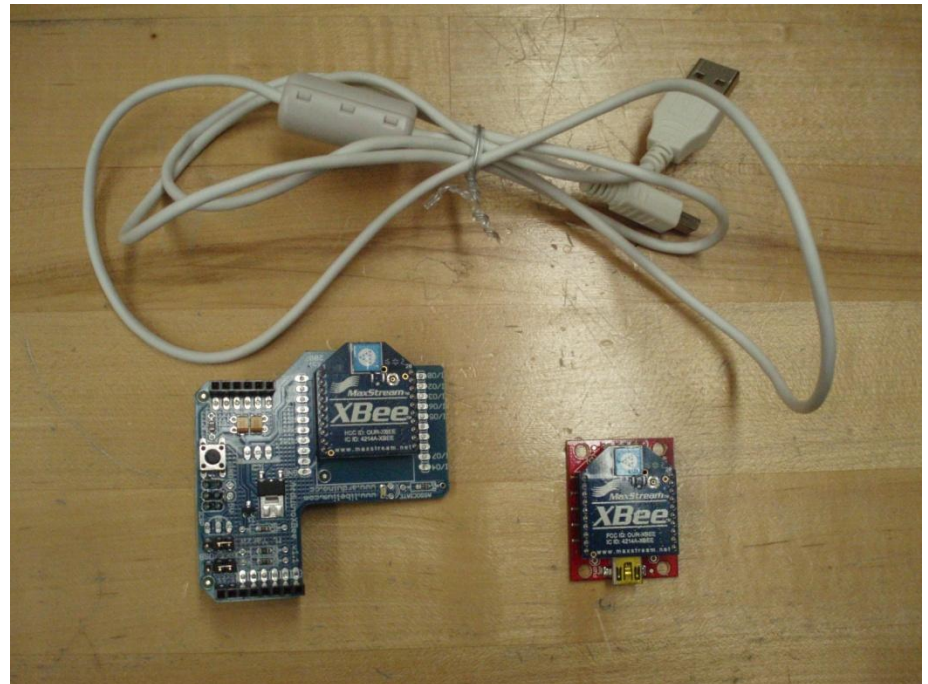
Top View:



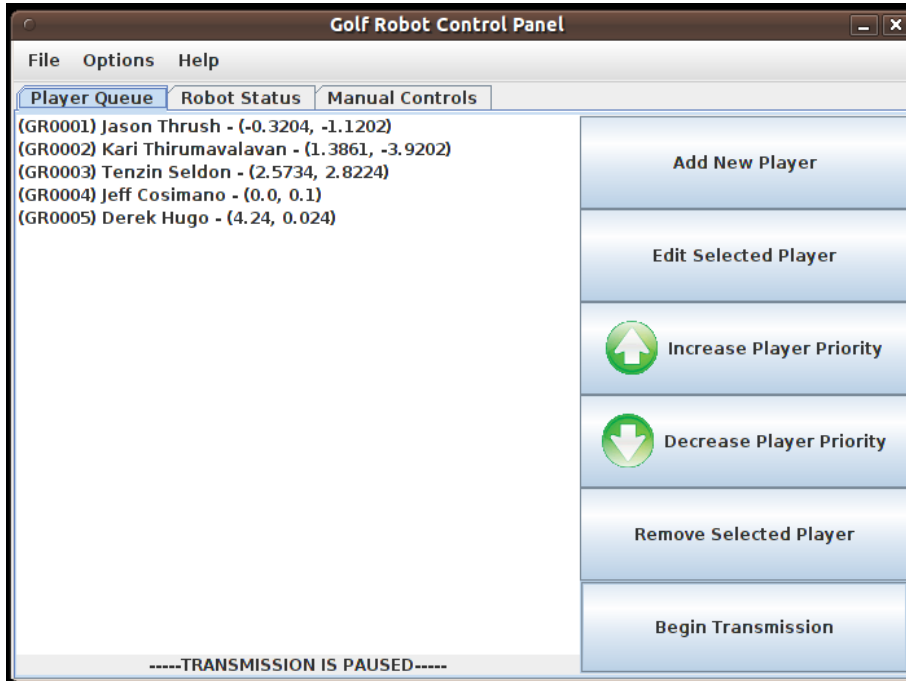
Side  
View:

# Communication System

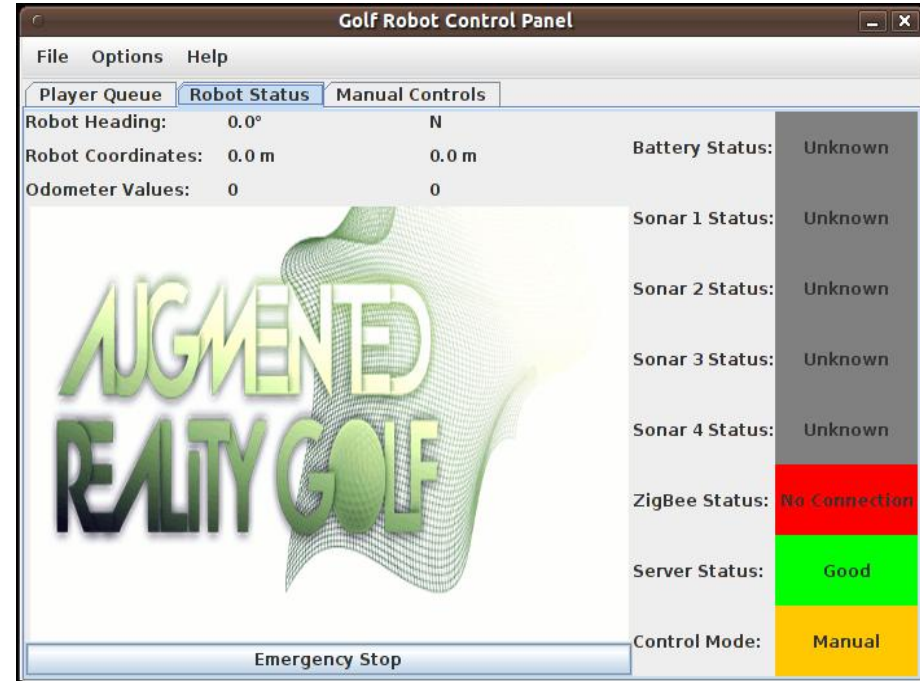
- Coordinate Path:
  - ARGolf to Server
  - Server to Laptop
  - Laptop to Xbee
  - Xbee to Robot
- Relays Robot Status
- Manual Controls



# Communication System (cont.)



Player Queue:



Robot Status:



# Sensors

- Compass
  - ▣ Used in conjunction with the CMUcam3
  - ▣ Produced robot heading
- Encoders
  - ▣ Used for odometry
- Ultrasonic Rangefinders
  - ▣ Object Detection

# Additional Navigation Methods



Ultrasonic Navigation:



Laser Navigation: