ME218b Smart Product Design

ME 218b Winter 2013 Project: Bat-tleship

Project Preview on February 28, 2013 6-10PM in SPDL
Grading Session on March 5, 2013 6-10PM
Project Presentations on March 6, 2013 in the Peterson Atrium starting at 7:00 PM

Goals:

The goal of this project is to provide you with an opportunity to apply your knowledge to solve an open-ended problem. The task is to design and build a machine that can play an interesting game against an opponent machine.

Purpose:

The underlying purpose of this project is to give you some experience in integrating all that you have learned. The avenue through which you will gain this experience is the design and implementation of an autonomous mobile robot that can compete in a game of skill and strategy against a machine constructed by another team from the class.

The Game:

The game is patterned loosely on the table-top game Battleship. The object of the game is to sink the ships of your opponent's fleet by hitting them with Nerf® balls. The field will be equipped with a vision system that recognizes fiducials carried by the robots and ships. Information about the location of the robots and ships will be made available to your robot.

Specifications

The Battle-scene:

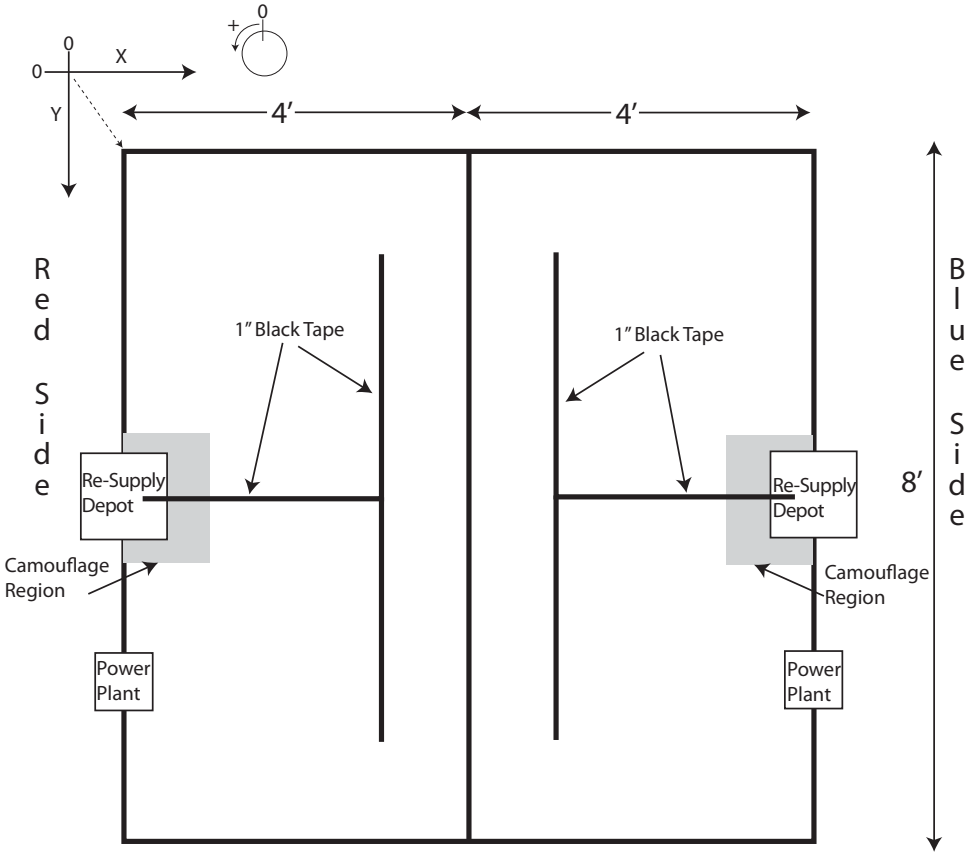
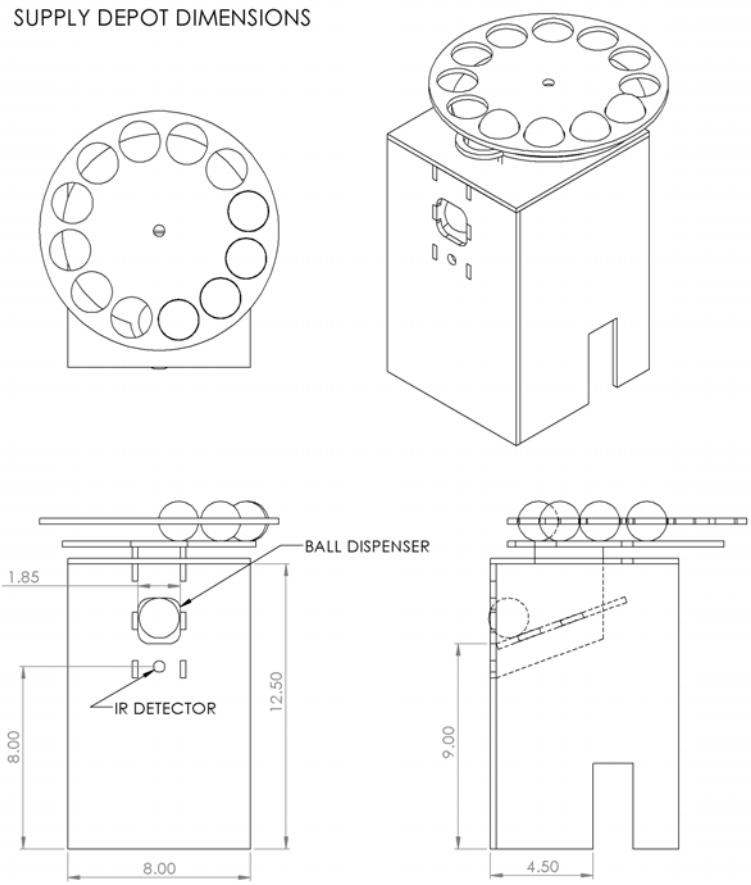


Fig. 1 The Playing Field

- ☐ The playing field is an 8'x8' area with exterior walls 3.5" tall and a center dividing wall, 5.5" tall.
- ☐ The center dividing wall will be mounted so that there is a 2" gap between the lower edge of the wall and the playing field below the wall.
- ☐ The Red 'bot will start on the Red side. The Blue 'bot will start on the Blue side.

- ☐ Important objects on the field carry unique fiducial markers that are recognized by a sophisticated machine vision system connected to every 'bot's Forward Artillery Controller (see below). Only objects with completely un-obscured fiducials are recognized by the system, henceforth described as "visible".
- ☐ Each side will have a re-supply depot located at the center of the back wall (as shown).
- ☐ Each re-supply depot has an associated power plant. The power plant will be located along the back wall, but its position along the wall will vary from round to round.
- ☐ Each side will have a set of 1" black tape lines, as shown in Fig. 1.

The Re-Supply Depots:



- ☐ The re-supply depot will deliver a single ball each time its IR detector receives a series of 10 pulses with a 10ms (±0.1ms) on time and a 30ms (± 0.1ms) off time. While delivering these pulses the ship must also illuminate a visible LED that is clearly visible to any observer.
- ☐ The time from request to physical delivery of the a ball may be as much as 3 sec. During this time, the 'bot may not request another ball.
- ☐ The IR detector at the re-supply depot will be mounted at a height of 8" off the playing surface.
- ☐ The re-supply depot and a small surrounding area are camouflaged so that a 'bot at the re-supply depot is invisible to the FAC (see below).

The Power Plants:

- ☐ Each Power Plant will have a beacon emitting modulated IR driven by a 50% duty-cycle square wave. The emitters for the beacons will be LTE5208A IR LEDs. The IR emitters will be mounted at a height of 10" off the playing surface.

- ☐ The beacon on the Red Side will be modulated with a period of 20mS, the beacon on the Blue Side will be modulated with a period of 14mS.

The Fleets:

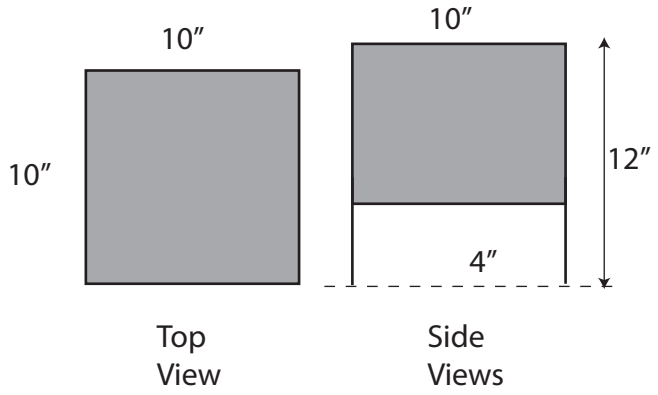


Fig. 2 The Ships of the Fleet.

- ☐ The Fleets are the sets of non-moving ships in the game. The Red Fleet ships will be numbered 20-29. The Blue Fleet ships will be numbered 30-39.
- ☐ Each ship will carry a top mounted fiducial that will be recognized by the field to report its position. When a ship is hit, the ship will no longer be reported by the Forward Artillery Controller (see below).
- ☐ Your robot may not take any action that obscures a ship's fiducial.
- ☐ The fiducial will be mounted within the ship and balanced on a supporting pin. If the fiducial is struck from above or the supporting pin struck at the field level, the fiducial will fall indicating that the ship has been sunk. Bumping into the ship will likely also sink the ship.
- ☐ Ships will be placed with one of their sides parallel to the dividing wall.

The Forward Artillery Controller:

- ☐ The FAC will provide the co-ordinates of each of the ships (including both 'bots) on the field. In addition, the FAC will provide orientation information on both 'bots.
- ☐ The Forward Artillery Controller (FAC) will communicate with your robot over a 4-wire SPI bus.
- ☐ The FAC will be recognized by and communicate wirelessly with the field infrastructure, so it must be mounted on the top-most level of your robot with no fixed structure above or surrounding it.
- ☐ The top of the FAC will carry a fiducial mark that is used to identify the 'bot.
- ☐ A complete description of the Forward Artillery Controller, from both an electrical and protocol standpoint, is included in a separate document that accompanies this project description.

The Bat-tleships:

- ☐ Your robot must be a stand-alone entity, capable of meeting all specifications described in this document. Battery power is required. Your robot must execute from code on either (or both of) the 'C32 and 'E128.
- ☐ Robots will be numbered 3-19 corresponding to your team number.
- ☐ Robots must be autonomous and un-tethered.
- ☐ The only parts of the robot that may ever touch the playing field surface are wheels, ball transfers, or slippery supports used to balance the robot.

- ☐ The smallest bounding box (projected onto the plane of the playing field) that entirely encloses your robot must not exceed a 1 square foot at the beginning of the game. The FAC must be mounted so that the top surface of the FAC is 12" off the playing field.
- ☐ If your robot shoots the Nerf® balls, then the Nerf® balls must exit your robot with a horizontal or above-horizontal trajectory, land no more than 6 feet from the robot and reach a peak height of no more than 3' above the floor of the playing field. Nerf® balls may also be rolled across the surface of the field.
- ☐ Each robot will carry an easily accessible switch on the top of the robot. The purpose of the switch will be to cut power to the 'bot in case of a software or hardware malfunction.
- ☐ Each robot may carry a maximum of 5 balls at any time. Each robot will start a round loaded with up o 5 balls.
- ☐ Each Bat-tleship may carry a cloaking device that is capable of covering the fiducial, fully or in part. When sufficiently covered, the Bat-tleship will become invisible to the FAC. A cloaked ship may not fire. Firing while cloaked is grounds for immediate forfeiture of the game.
- ☐ Each Robot must be constructed as part of ME218b. It may not be based on a commercial or otherwise pre-existing platform.
- ☐ Any exterior corners on the robot must have a radius of at least 1/4".
- ☐ You are limited to an expenditure of **$200.00/ team** for all materials and parts used in the construction of your project. Materials from the lab kit or the Cabinet Of Freedom do not count against the limit, all other items count at their Fair Market Value.
- ☐ Each 'bot must provide a clearly visible indicator when it thinks that the game is in progress. This indicator should be activated when the 'bot determines that a game has started and be de-activated at the end of 2 minutes or when the game status indicates the end of the game.
- ☐ The supplied motors must be used to drive anything that transfers force to the ground.

Game Play:

- ☐ The game is a head-to-head match up between Bat-tleships as they attempt to score points by sinking the ships and Bat-tleship of the opposing fleet.
- ☐ At the beginning of each game, each team must submit a battle plan that includes the positions of their ships, power station and the initial position of their Bat-tleship. The Bat-tleships will be placed on the field by a member of the team. The ships of the fleets (3-10 ships, with the number specified by the teaching team before the battle plan is submitted) will be placed by the teaching staff at the direction of the team.
- ☐ Hitting the power station with a ball will prevent the re-supply depot from delivering replacement balls for 10 seconds.
- ☐ The game will begin when a query to the FAC indicates that the game state has changed from stopped to in play.
- ☐ Your robot must be visible, as indicated by your FAC, to shoot.
- ☐ A direct hit, through the air, on the opposing 'bot scores 1 point and ends the round.
- ☐ Each ship is worth 1000 points when sunk. A hit on the Power Station is worth 100 points.
- ☐ Bat-tleships will begin each round in the un-cloaked state.
- ☐ The round ends no more than 2 minutes after the FAC first indicated that the game was in play. At that time, 'bots must stop all movement for at least 5 seconds and deactivate their game in progress indicator.
- ☐ In case of a tie at the end of a round, a sudden death round will determine the winner.

- ☐ If the score does not change throughout a round, then both robots are removed from the competition.

Rules:

- ☐ No solder-less breadboards (proto-boards) are permitted in the final project.
- ☐ The only thing allowed to cross or be propelled across the center wall are Nerf® balls.
- ☐ Each Robot must start and remain in one piece during the round. Any locomotion of the robot should cause all parts of the robots to move.
- ☐ Your Robot may not **IN ANY WAY** alter the condition (e.g. mar the walls or the floor) of the playing field or the Nerf® balls.
- ☐ Intentional jamming of your opponent's senses is prohibited.

Safety:

- ☐ The Robots should be safe, both to the user and the spectators. The teaching staff reserves the right to disqualify any Robot considered unsafe. This also applies during testing, so keep the 'bot velocity and shooting velocity low enough so as not to cause problems.
- ☐ Robots must be stable in the presence of a 30MPH wind.
- ☐ No part of the machine may become ballistic. The Nerf® balls are not part of your machine.
- ☐ All liquids, gels and aerosols must be in three-ounce or smaller containers. All liquids, gels and aerosols must be placed in a single, quart-size, zip-top, clear plastic bag. Each 'bot can use only one, quart-size, zip-top, clear plastic bag.
- ☐ Robots may alter the Space-Time continuum only during the public presentations.

Check-Points

Design Review:

During the day on **02/12/13** we will conduct design reviews. Two teams at a time will meet with the teaching staff to present their ideas and get feedback on their proposals. Each group should prepare a **few** sheets of paper showing your idea(s). The focus should be on the overall design and how you are tackling what you think are the critical subsystems. These should be scanned into a no-frills PowerPoint file (landscape, 4:3 format, .ppt, not .pptx) for projection. You will have 10 minutes to walk us through your ideas. The members of the other team, the teaching staff, and coaches will be on hand to hear about your ideas and provide feedback and advice.

First Check-Point:

On **02/15/13**, you will turn in a set of Protel schematics, textual descriptions and software design documentation (including refined state chart) that describes the state of the design *at that point in time*. The designs need not be tested at this point, but must include designs to address all of the major subsystems. It must be turned in as soft copy. Only one team member needs to submit your checkpoint.

Second Check-Point:

On **02/20/13**, you must demonstrate your motorized platform moving under autonomous software control. Your platform must be able to rotate in 90° increments and drive forward under software control.

Third Check-Point:

On **02/23/13**, you must demonstrate the integration of the FAC with your mobile platform and your robot's ability to communicate with the FAC, exercise all of the FAC's capabilities and move to a location based on the data provided by the FAC.

Fourth Check-Point:

On **02/27/12**, you must demonstrate your robot's ability to sense and locate the IR beacon on the Power Station and be able to shoot at the Power Station.

Project Preview:

At the Project Preview on **03/02/13**, each Robot must demonstrate (in an integrated form) 1) the ability to move under software control and 2) the ability to communicate with the FAC and 3) the ability to request a ball from the re-supply depot.

Grading Session:

During the **Grading Session on 03/05/13** each Robot will be required to demonstrate the ability to 1) sink at least 1 of the opponent's ships; 2) navigate to the re-supply depot, request and accept a ball from the re-supply depot; 3) locate and shoot at the opponent's power station; 4) stop moving at the end of two minutes. If your 'bot fails at its first attempt to demonstrate its ability, it must then demonstrate the ability two times in succession at its next attempt. These increases continue after repeated failed attempts to a maximum of 4 required successive demonstrations. This evaluation will take place without an opponent. Evaluation for grading purposes will occur only during these sessions. At the time of the grading session, you must submit a copy of the .S19 file that you run during the grading session to your Reports folder for archiving.

Public Presentation:

Will take place on **03/06/13** starting at 7pm in the Peterson Atrium.

Report:

Draft due on **03/11/13** at 4:00pm. Final version with revisions due by 5:00pm on **03/15/13**.

Evaluation

Performance Testing Procedures:

One or more of the team members will operate the Robots during the performance evaluation. A competition among the class's Robots will take place after the performance evaluation.

Performance Evaluation:

Performance evaluation will take place twice during the project duration, at the Project Preview and at the Grading Session. Everyone will participate at this level.

The Competition:

On the night of the public presentations, a tournament will be held. **Performance during the tournament has no impact on your grade**.

Grading Criteria:

- ☐ **Concept (10%)** This will be based on the technical merit of the design and coding for the machine. Included in this grade will be evaluation of the appropriateness of the solution, as well as innovative hardware, software and use of physical principles in the solution.
- ☐ **Implementation (15%)** This will be based on the prototype displayed at the evaluation session. Included in this grade will be evaluation of the physical appearance of the prototype and quality of construction. We will not presume to judge true aesthetics, but will concentrate on craftsmanship and finished appearance.
- ☐ **Check-Point Performance (10%) Based on demonstrating the required functionality at the checkpoints.**
- ☐ **Preliminary Performance (10%)** Based on the results of the performance testing during the **Project Preview.**
- ☐ **Performance (20%)** Based on the results of the performance testing during the **Grading Session**.

- ☐ **Report (20%)** This will be based on an evaluation of the written report. It will be judged on clarity of explanations, completeness and appropriateness of the documentation. The report should be in the form of a web site and must include schematics, pseudo-code, header & code listings, dimensioned sketches/drawings showing relative scale, a complete Bill-of-Materials (BOM) for the project as well as a 1 page description of function and a "Gems of Wisdom for future generations of 218ers" page. The web-site must be submitted as a single **Zip** file (The zipping software (7-zip) is installed on all the workstations in the lab). The only file types in your final report should be HTML (including style sheets if you choose), JPEG or other viewable image files and PDF files. Schematics should be PDF files, **not** bitmaps (PNG, JPEG, GIF, etc.). A bitmap place-holder with a link to a PDF is the best solution to readability. Do not include .doc, .docx, .xls, .xlsx or other files that require opening a separate application outside of the browser. **Do not embed video files** directly into your site. If you want to include video, link to a You-Tube or other video sharing site. It is critical that your report be in the Reports folder on time so that the peer reviewing team will have an adequate opportunity to review it before class the following day. Final versions of the reports, incorporating the review comments are due (also in the form of a single zip file) by 5:00pm on 03/15/13. The front page of your project description must be in a file called `index.html` at the root folder of the web site. Test your zip-file by unzipping it into an empty folder. Once un-zipped, you should be able to view the entire site starting from the `index.html` file. Make sure to test all of your links before submitting. If we can't simply unzip it and read it on our machines, then we can't grade it.
- ☐ **Report Review (10%)** These points will be awarded based on the thoroughness of your review of your partner team's report. Read the explanations, do they make sense? Review the circuits, do they look like they should work?
- ☐ **Housekeeping (5%)** Based on the timely return of SPDL components, cleanliness of group workstations as well as the overall cleanliness of the lab. No grades will be recorded for teams who have not returned their tool kit and E128 & C32 boards.

Team Organization

While it may be tempting (as more efficient) to organize your teams around specialists who handle, for example, communications, sensing, motion, etc. I believe that in the long run this will be a mistake. I have heard from many 218 alumni who did this and reported that they were sad that they had because they didn't get, for example, communications experience. I would like to encourage you to remember that, first and foremost, the purpose of the project is to enhance your learning of the material. An organization that deeply involves all of the team members in the details of the design, implementation and debugging of all subsystems will not only provide a better learning experience, it will also prevent you from getting hung up during the integration and testing phase because the "expert" on that subsystem is not available.