Trinity College
Fire-Fighting Home Robot Contest
2013 Rules

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Part I

General Rules and Procedures

These rules and procedures apply to all Trinity College Fire-Fighting Home Robot (TCFFHRC) competitions.

Answers to Frequently Asked Questions will be found on the Contest Website at http://www.trincoll.edu/events/robot/.

The PDF version of this document should be regarded as definitive; text and font conversion errors may affect other file formats. The HTML version may not include clickable cross-references. The chapter and section numbers have changed from previous years and versions; they will certainly change in the future.

If you find an error or inconsistency, please email the Editor (Ed Nisley ed.nisley@ieee.org) with a copy to the Contest Director (Dave Ahlgren david.ahlgren@trincoll.edu). We will defer problems reported after noon on the Monday preceding the Contest weekend until the next year's Contest.

Chapter 1

Registration and Eligibility

1.1 Eligibility and Teams

Anyone may enter a robot.

There is no limit on team size.

In the rest of this document, the term "team" means either the group or the individual associated with a robot entered in the contest.

No more than 15 teams may register from any country outside the United States.

1.2 Multiple Entries and Kits

The challenge presented by the Trinity College Fire-Fighting Home Robot Contest (TCFFHRC) and the associated regional contests is for contestants to prepare a unique robot of their own design. However, we recognize that some teams may wish to enter a kit-based robot, a commercial robot, or a robot that shares many design features with another robot entered in the contest. Therefore, we award prizes in the kit and unique robot categories in the Junior, High-School, and Senior Divisions. The Walking, Expert, and Assistive Divisions do not have separate kit/unique categories.

A team may enter more than one robot. In order to qualify for a unique-robot prize, however, each robot must differ visibly and significantly from other robots in at least some aspects of electronics or mechanics. Thus an individual, team or school may not register multiple identical robots as separate entries in the same Division except in the kit category.

Multiple, possibly identical, robots that function as a swarm may be entered in the Trinity College Expert Robot Contest. Those robots may not be entered as separate robots in other Divisions.

1.2.1 Guidelines for Kit and Unique Robots

Each team must indicate whether their robot is a kit robot or a unique robot, with characteristics as listed below, when registering it for the contest.

Kit Robots

1. May be constructed primarily from a single commercial kit, or
2. Share mechanical design with another robot – even if is not commercial, or
3. Share other major features with another robot.

In cases 2 and 3 above, *both* of the similar robots will be considered as kit robots.

Unique robots

1. Are constructed from a unique assortment of parts or
2. May use some components from a kit, but the overall design is unique.

NOTE Paint, stickers, and other non-functional components will not transform a kit robot into a non-kit robot.

1.3 Registration

Registration for the TCFFHRC is available only on-line through the contest website. We will accept registration applications from 12:01 a.m. on January 15, 2013 until 11:59 p.m. on March 20, 2013. For further details check the Contest Website at http://www.trincoll.edu/events/robot/.

The steps in the registration process are as follows:

1. Go to the registration web site at http://www.trincoll.edu/events/robot/Registration/default.asp.
2. Create a user ID and password and set up the rest of the account information.

3. Fill in *all* of the required information.
4. The contact person provided on the form will receive email confirmation of your successful registration within three days.

1.3.1 Deadline

You must register for the contest between January 15 and March 20 (midnight to midnight), otherwise your robot will not be in the contest. There are *no* exceptions.

You have spent hundreds of hours and perhaps as much money on your robot. Register early!

1.4 Fees

A non-refundable registration fee is required for each robot entered into the contest. The fee must accompany each entry.

If you want to enter two robots, then you must build two robots: the same physical robot cannot be entered twice, even if two entry fees are paid.

We repeat: *registration fees are non-refundable.*

The Division fees for 2013 are:

- Junior - $75
- Walking - $85
- High School - $75
- Senior - $85
- Expert - $125
- RoboWaiter
  - Standard: $50
  - Advanced: $100

1.5 A Note on Following the Contest Rules

The mission of the Trinity firefighting and RoboWaiter contests is to encourage innovation by roboticists of all ages and skill levels by creating an atmosphere of friendly and cooperative competition. The contests foster creativity, cooperation, international understanding, and achievement by the contestants themselves. The contest's highest priority is education, not winning.

The Trinity events succeed when teams and individuals invent their own *autonomous* robots and learn from their successes and failures during that process and the contest weekend, not when they blindly assemble components and programs designed by others.

These Rules represent years of development focused on providing a fair and understandable Contest. Within the Rules, contestants will find three vital categories of information:

1. Dates, times, events, and registration.
2. The tasks that robots must be able to perform to succeed in the contest, including the physical specification for robot designs. Teams must understand this material early in their robot's design process.
3. What is expected of teams on the contest weekend, including rules of poster sessions, Olympiad exam, and rules of the competition itself including number of runs, next-up time limits, judging, language translation, and penalties. Teams must read these Rules carefully, well before the contest, to gain a clear understanding of the requirements.

Because the Trinity Robotics Contest is open to participation by a widely diverse audience, it will achieve its mission only when all teams follow both the letter and the spirit of the rules. Examples of situations to avoid include:

- A group consisting of Junior Division and High School students designs a robot together. For example, consider a second-grade student who enters a microprocessor controlled, stepper motor driven robot that uses modulated IR sensing and a video navigation system. The control program seems to be written in C++ and the team advisors just happen to work for a military contractor.
- A robot created by a group of 6th and 7th grade students with help from an adult advisor would generally enter the Junior Division. When working with students, the advisor's role is to educate—to increase student skills throughout the course of the robot design process. Guiding students in this process requires advisors to impart sufficient knowledge of mechanics, computers, sensors, and programming so that students can create their own robots, whether kit-based or unique creations. Following the spirit of the rules, instructors may guide and direct students in their work, but must not take over the project.

This contest runs on the honor system: we expect that student contestants will bear primary responsibility for their robots. Should we find any case to the contrary, we will reassign the robot to a more

appropriate Division. In these situations, the decision of the Chief Judge is final and cannot be appealed.

1.6 Construction Schedule

Teams should build their robots and bring them to the contest ready to compete: this is *not* a construction contest where you build robots at the event!

Trinity will provide limited time and space for last minute changes, adjustments, and improvements. However, the robots should be completed (or very nearly so) by the time they arrive at the Contest.

1.7 Qualification Trials and Elimination Rounds

Every team registered for the contest will have the opportunity to run their robot in the Contest, assuming it conforms to the specifications given in these Rules. However, in *all* Divisions:

- A robot must extinguish the candle in at least one of its first two trials to qualify for a third trial in the competition

Thus, the first two rounds of the competition serve to eliminate unreliable robots.

NOTE Every team must demonstrate that its robot conforms to the contest specifications at the Robot Inspection Table (Section 2.8 on page 19) before the robot can compete.

1.8 Contest Location, Dates, and Schedule

TCFFHRC events will be held at Trinity College in Hartford, Connecticut, USA, from Friday 5 April 2013 through Sunday 7 April 2013.

`The full schedule of events for the contest weekend will be posted on the Contest Website at http://www.trincoll.edu/events/robot/.`

Chapter 2

Basic Rules and Procedures

The rules and information in this Chapter apply to all Trinity College robot contests, unless otherwise noted.

NOTE These rules change *every year*. Each team is responsible for reading these rules and building a robot that complies with them. Robots designed for previous contests may not be acceptable under the current rules.

2.1 Judge's Rulings

The Chief Judge is the *final* and *absolute* authority on the interpretation of *all* rules and decisions.

A team may challenge any ruling or scoring of the Arena Judges by stating that they wish to appeal the problem to the Chief Judge. The Chief Judge will then be called in to decide the matter.

The challenge *must* be made *before* the team leaves the arena after the completion of a trial.

All results, scores, and decisions become irrevocable after the team leaves the arena.

2.2 Language Translation

Teams from around the world participate in the Trinity Contest. In order to facilitate communication between team members (who may not speak fluent English) and the Judges and Contest officials, the Contest will provide *all* translation services at the arenas and Judging areas.

Judges and Contest officials will communicate directly with the team members, not with team leaders or other translators affiliated with the teams. Team leaders and team translators may not accompany their team at the arena during the team's trial runs.

If any members of your team require translation services, you must specify the language on the registration form.

The English-language version of this Rules document contains the definitive text.

2.3 Safety

Any Contest official may stop any robot at any time if, in their opinion, it is performing or is about to perform any action that could be dangerous or hazardous to people, facilities, or other equipment.

Robots must not use flammable or explosive materials to extinguish the flame.

2.4 Dimensions and Accuracy

The goal of the contest is to make a robot that can operate successfully in the real world, not just in the laboratory. Such a robot must be able to operate successfully where there is uncertainty and imprecision, not just under ideal conditions. Therefore, the arena dimensions and other specifications listed below will not be precisely what the robots will encounter at the contest: they are provided as general aids.

NOTE We recommend designing your robot to cope with with sizes 5 to 10 mm beyond any stated dimensions. Our experience has shown that robots designed with no margin for error generally suffer from the "But it worked in our classroom / lab / arena!" syndrome.

The size limits on robots are, however, absolute and will be enforced by the Judges.

Object dimensions are generally given as length x width x height, as the robot encounters the object.

- Length is front-to-back
- Width is side-to-side
- Height is top-to-bottom.

In the RoboWaiter Contest, "deep" refers to the front-to-back dimension of shelves.

2.5 Arena Environment

Although the robot contest arenas present an idealized version of the real world, you *must not* assume:

- Exactly square corners
- Precisely vertical walls
- Perfectly flush joints
- Recessed fasteners and brackets
- Uniformly colored surfaces
- And so forth and so on...

Every robot must successfully handle small misalignments, inaccuracies, discolorations, and other arena imperfections. You must test your robot under less-than-ideal conditions and verify that it works properly.

NOTE Flash photography *will occur* during the entire contest. Your robot must withstand frequent sensor glitches from IR and UV impulses. If your robot operates incorrectly due to external interference, *it will not be given another trial.*

2.5.1 Arena Environment Checklist

The contest takes place in a gymnasium that will be quite different than your classroom, laboratory, basement, or living room. Some possible problems you should consider:

- Extremely bright fluorescent illumination: 120 Hz IR interference
- High sound levels: the Trinity Contest has an enthusiastic crowd
- Reinforced concrete subfloor: random magnetic field anomalies
- Flash photography: frequent IR and UV sensor glitches
- Imperfections and dirt in the arena: sensor and navigation confusion
- The practice arena may not be the contest arena: slight changes in all conditions

2.6 Practice Time

The contest arenas will be assembled and available for unscheduled test trials on Saturday.

Due to the limited number of arenas and the large number of robots, waiting lines can become very long.

You should use the practice time to calibrate sensors for the conditions in the gym and to troubleshoot any last minute problems. No team has ever accomplished extensive code development and hardware design on Saturday.

NOTE A robot's practice run must not last more than 3 minutes. You and your robot must not occupy an arena while you are changing the program or adjusting the hardware: when you discover a problem, remove your robot from the arena.

Robots should be built, programmed, and ready to compete on arrival at the contest site. Get busy *now*!

There will be limited practice time on Sunday morning, with only a few arenas available.

Some teams bring entire practice arenas along to the competition. You may be able to wheedle your way into those arenas, but that depends entirely on your negotiating skills.

NOTE After leaving the arena to adjust your robot, you must return to the *end of the line* for the arena: you *must not* jump into the line ahead of anyone else. Other team members or adult advisors *must not* "hold a place in line" for anyone else. Team members observed jumping into the line will be reminded of proper Contest etiquette.

2.6.1 Damage During Practice Runs

Only one robot is allowed in a practice arena at any one time.

If two robots collide during practice in an arena and one is damaged, then either:

- *Both* robots will compete in the contest if the damage can be repaired *or*
- *Neither* robot will compete if the damage cannot be repaired

NOTE If you put your robot in an arena where another robot is operating and your robot causes irreparable damage, your team and robot will be disqualified from the contest.

The decisions of contest officials concerning:

- damage to a robot
- which team is responsible for any damage
- which teams (if any) may compete
- which teams (if any) will be disqualified
- and all similar questions

are final and cannot be appealed.

Because we do not monitor practice sessions, *you* are responsible for the safety of *your* robot at all times.

2.7 Power and Facilities

Power will be distributed as 120 VAC 60 Hz. Your equipment must draw less than 10 A from a single US-standard 15 amp outlet.

You must bring along any voltage or frequency converters required to adapt that power to your needs.

You must bring along sufficient extension cords and outlet strips; you will have access to a single outlet that may be 10 meters from your assigned table in the pit area.

Because the power distribution involves cables laid on the floor, you must assume that power to your devices can be interrupted at any time: people occasionally stumble over the cables and circuit breakers may trip without warning.

NOTE Utility AC power will *not* be available in the arena area.

Teams *must not* bring extension cords or external power supplies, such as laptop power bricks, into the arena area. This applies during the Saturday practice sessions as well as the Sunday contests.

Contestants must bring any and all materials, parts, and test equipment that they may need. The Hartford area has very few retail suppliers of electronic and mechanical parts; those suppliers are generally closed during weekends.

The gymnasium is well-lighted, but it is not air-conditioned. Spring weather in Hartford tends to be warm and humid with occasional chilly rain, so plan your wardrobe accordingly.

2.8 Robot Inspection Table

We expect that your robot will meet the specifications described in these rules, so that it will compete fairly with other robots.

Each team must present its robot at the Robot Inspection Table (RIT) prior to the start of the Contest trials to verify that it meet these specifications:

- Overall size
- Extinguisher capacity
- Start Button position, label, and color
- For robots using Sound Start Mode:
  - Microphone position, label, and color
  - Response to the Standard Sound Start Device
  - Operation with standard SPL (Sound Pressure Level)
  - Frequency discrimination of 2.8 and 3.5 kHz tones
- General conformance to the rules

A Judge will record the results on the RIT Checklist and explain any problems. You must correct those problems and present the robot again to verify that it meets the requirements.

NOTE You may present your robot to the Robot Inspection Table *twice*. A robot that does not pass its second inspection *will not compete*.

The most current version of the RIT Checklist will be posted at http://www.trincoll.edu/events/robot/. A sample Checklist appears in Appendix D on page 105.

We recommend that you have another person evaluate your robot using the RIT Checklist. You should resolve all discrepancies before the contest: do not bring a non-conforming robot to the Contest.

NOTE *Robot that do not pass the RIT inspection will not compete in the Contest.*

The RIT will be open on Friday afternoon, most of Saturday, and early Sunday morning before the Opening Ceremony. Check the bulletin board at the Registration Table for the exact times.

NOTE *If your robot has not passed inspection before the RIT closes on Sunday, your robot will not compete in the Contest.*

2.9 Trial Sequence

Each robot has an assigned number that determines the order in which it will compete in the contest. Robots make trial runs in the arena in ascending numeric order, so that the robots compete consecutively. When all robots have completed the first trial, the sequence repeats for the second and third attempts. Once assigned, the order of running will not be changed.

Contestants will have limited time between their trials for adjustments, modifications, and repairs to their robot. However, after the preceding robot has completed its trial, then your robot must be in the arena and ready to start within 1 minute.

The Judges will start a timer when they call for the next robot: that robot must be on the Judge's Table before that clock reaches 1 minute. Any robot that is not ready to compete after 1 minute will forfeit its chance at that trial. It may still compete in any remaining trials.

NOTE If you are not ready, *you will miss your turn.*

2.10 Starting the Trial

The team will place the robot on the Judge's arena table and give the Judge the Trial Options Sheet (Appendix E on page 107) when they arrive for their robot's trial.

The Trial Options Sheet describes all of the Operating Modes applicable to the robot's current trial run. Teams need not select Operating Modes for future trials; they may choose different modes for each trial based on how their robot performs.

Teams may not make any changes to the information on the Checklist after presenting it to the Judge. If a team discovers a mistake on the Trial Run Checklist after presenting it to the Judge, they must choose to either:

- Run the trial using the (erroneous) Modes as entered on the Trial Run Checklist *or*
- Fail the trial as if the robot had not started

Team members *must not* touch the robot after placing it on the Judge's arena table.

The team *must not* transfer any information to the robot regarding the layout of the arena, the starting position, or the position of any objects after placing the robot on the arena table. The team must download any required programs or firmware to the robot *before* arriving at the arena.

The Judges will use the robot's Division and the selected Modes to determine the arena configuration, then place the robot and any objects in the arena. The team must not request special placement of objects or changes to the robot's placement in the arena.

The Judge will determine when the trial begins and will activate the robot using either the Start Button or the Standard Sound Start Device, as required by the Division and Operating Modes.

2.10.1 Failure to Start

If the robot fails to start when activated, then the robot has failed the trial.

The Judges will wait for the time described in Section 6.5.2.2 on page 42, then record a failed trial. Teams may decide that the robot will not move and terminate the trial before that time by informing the Judge.

This applies regardless of the reason the robot does not start. All that matters is that the robot does not begin moving after the Judge presses the Start Button or activates the Sound Start Device.

Teams *must not* request a re-run following a failure to start.

2.10.2 Premature Start

If a robot begins moving *before* the Judge has placed it in the arena, it has failed the trial.

If a robot begins moving *after* being placed in the arena, but *before* the Judge presses the Start Button or activates the Sound Start Device, it has failed the trial.

Teams *must not* request a re-run following a premature start.

Part II

TCFFHRC: Junior, High School, Senior, and Walking Divisions

The Trinity College Firefighting Home Robot Contest (TCFFHRC) advances robot technology and knowledge by using robotics as an educational tool. A winning robot must respond to a fire alarm, discover the blaze, and extinguish it in the shortest possible time.

To accomplish that overall task, the robot must start on a signal (a simulated fire alarm), explore a typical family home (the arena), locate a fire (a burning candle), extinguish it, and optionally return to its starting point. The robot must operate autonomously during all parts of the challenge, without human intervention, using its own sensors, control logic, and actuators.

The 2013 Home Firefighting Robot Contest includes several major changes from previous years:

- "Must extinguish at least one candle in first two runs" rule applies to *all* Divisions (Section 1.7 on page 15)
- New *mandatory* Start Button location (Section 5.2.3 on page 32)
- New *mandatory* Microphone location (Section 5.2.4 on page 32)
- New *mandatory* Arbitrary Start Orientation (Section 5.1.5 on page 30)
- New *mandatory* Dog Obstacle (Section 5.1.6 on page 30)
- New room configurations (Section s 5.1.3 on page 30 and 5.1.4 on page 30)
- Sound Start *prohibited* in Junior Division (Section 6.5.1.3 on page 39)
- Removed Uneven Floor Mode (Section 6.5.1.9 on page 40)
- *Mandatory* inspection at Robot Inspection Table (Section 2.8 on page 19)
- Posters included in BURP score (Section 4.1 on page 27)

You will find other changes throughout this Rules Document; it is your responsibility to build a robot that conforms to the rules applicable to the 2013 Contest.

Additional contests held during the TCFFHRC weekend provide different challenges, as described in these rules.

Direct questions and comments about the contest to the Contest Director: Dave Ahlgrendavid.ahlgren@trincoll.edu.

Chapter 3

Fire-Fighting Contest Structure

3.1 Divisions

In order to make the contest accessible to persons of all ages and skill levels the TCFFHRC offers prizes in several Divisions:

- Junior Grades - 8 and below
- High School - Grades 9 through 12
- Senior - College/university and other adults
- Walking - Any age

Teams or individuals may also demonstrate their robotics knowledge by taking the Robot Olympiad exam (Part V on page 81) and entering the Poster Contest (Part VI on page 85).

3.1.1 Division Criteria

Participants who meet the criteria for a particular Division may, at their option, decide to enter their robot in a *higher* Division, however, they may not enter in a *lower* Division.

See Section 1.5 on page 14 for a discussion of how the Contest Judges may reclassify robots entered in an incorrect Division.

When registering for the contest, each team must specify the robot's Division. If that Division is full, the robot will be placed on a waiting list.

In order to change Divisions, the team must re-register the robot and pay the appropriate registration fee.

Division entry fees will *not* be refunded after registration.

No single robot may be entered in two Divisions.

Chapter 4

Scoring and Awards

The scoring system emphasizes reliability by grouping robots according to the number of successful trials.

Within each reliability group robots are ranked according to score. To earn a cash award a robot must complete at least two successful trials. Within any contest Division only one prize will be given to any winning robot. However, a robot may win a prize in a contest Division and win one or more special prizes (Cost Effective, etc).

The TCFFHRC awards cash prizes provided by our contest sponsors and non-cash prizes provided by contest supporters. All prizes are described on the Contest Website at http://www.trincoll.edu/events/robot/.

Each team participating in the contest will receive a Certificate of Achievement and *one* official contest T-shirt.

4.1 World Champion Prize for Best Unified Robot Performance

The World Champion BURP Prize recognizes the best overall performance by an individual or team in the Junior, High School, Senior, or Walking Divisions. We will compute each team's or individual's BURP score by weighing

- Its relative standing in its Division
- Its ranking on the Olympiad exam
- The team's Poster Contest score

A team or individual must participate in the Contest, Olympiad, and Poster events to be eligible for the BURP award.

NOTE The BURP Prize does not include robots competing in the Expert or Assistive Robotics Divisions.

4.1.1 BURP Score Weighting

The ranking of the robots and teams within their respective Divisions determines their total BURP score. The actual contest scores are not used, only the rankings within the respective Divisions.

This weighting applies to the rankings:

- Performance = 50%
- Olympiad = 25%
- Poster = 25%

4.1.2 BURP Scoring Example

Junior Division: Team 1

- 15 robots compete in the Junior Division. This robot wins 4th place. Score is (4/15) * 0.50 = 0.133
- 8 teams present posters; this team wins 2nd place. Score is (2/8) * 0.25 = 0.0625
- 4 teams take part in Olympiad; this team wins 1st place. Score is (1/4) * 0.25 = 0.0625

Total BURP score = 0.133 + 0.0625 + 0.0625 = 0.258.

High School Division: Team 2

- 45 robots compete in the High School Division. This robot wins 8th place. Score is (8/45) * 0.50 = 0.089
- 22 teams present posters; this team wins 6th place. Score is (6/22) * 0.25 = 0.068
- 12 teams take part in Olympiad; this team wins 7th place. Score is (7/12) * 0.25 = 0.146

Total BURP score = 0.089 + 0.068 + 0.146 = 0.303.

BURP Ranking

Team 1 has a lower score than Team 2, so its BURP ranking is better.

4.2 Special Awards

4.2.1 Spirit of an Inventor

Once Upon A Time, a creative engineer developed a unique two-legged firefighting robot. Even though the robot was not the fastest in the contest and and had no chance to win first prize, it made its way through the arena and extinguished a candle.

We were so impressed that we created a special award to recognize this engineer's achievement: The Spirit of the Inventor Award. This award will be given in addition to any other prizes that the robot may win.

To qualify for The Spirit of the Inventor award, the robot must:

- be entered in any Contest Division *and*
- show unique concept and design features *and*
- navigate through the arena *and*
- extinguish a candle

The robot need not successfully complete a trial run according to the rules of its Division.

4.2.2 Cost-Effective Robot

Robotics does not have to be expensive: spending more money does not guarantee success. In fact, some of the very best robots have been some of the least expensive. To award financial efficiency there will be a special prize for the best performing robot built with the lowest amount of money in material cost.

If you put in $50,000 in labor and destroyed $5,000 in parts finally getting it to work, but your final robot has less than $200 in actual parts in it, then it is a good contender for this prize.

It does not matter what you paid for the parts, but only what they are worth. A motor that originally cost $50, but is now for sale in a surplus catalog for $5 is now a $5 motor. However, if you got a $50 motor for free from a friend, then it's still a $50 motor even though you got it for free. On the other hand, if you destroyed three $50 motors in building the robot, you only have to account for the one motor that is actually on the robot.

Evaluation Method:

1. As part of the on-line registration process teams will indicate in a check box on the registration form whether they wish to be considered for the Cost-Effective Prize (CEP).
2. Participating teams will prepare an inventory for their robot that lists all parts and their prices. You must submit an itemized record of your receipts and copies of the receipts to the Judges. If you do not have that material your robot is not eligible for the cost effective prize.
3. Two Judges will inspect the robot and verify the inventory.
4. Each robot will be put into a cost category (CC)
   - CC1: under $100 U.S.
   - CC2: $100-$150 U.S
5. Robots will be ranked as follows:
   (a) Compute Total Final Score (TFS) for only the two best trials using the scoring method described below.
   (b) If any robots in CC1 were successful, the winner will be the robot with the best TFS.
   (c) If no CC1 robots had successful trials, the winner will be the robot in CC2 with the best TFS.

4.2.3 Tiny Robot Award

Although the contest rules for each Division require robots to fit into a specified maximum volume, there is no *minimum* size. We challenge teams to build the smallest robot able to successfully complete at least one of its three trials. The robot may compete in any Contest Division.

Size will be determined by measuring the area of the robot's projection on the arena floor - the smallest rectangle enclosing its chassis and all of the projecting sensors, wires, and appendages.

The size of an Expert Division robot swarm will be the smallest rectangle enclosing all the robots arranged in their starting position. These robots may be stacked if that's how they will start during their trials.

The Judges will measure all robots competing for this prize.

Chapter 5

Specifications

5.1 Arenas

The arena dimensions and specifications listed below are not *exactly* what will be encountered at the contest: they are provided as general aids. See Section 2.4 on page 17.

5.1.1 Dimensions

All arenas use a common layout, with dimensions as shown in Figure 5.1. In addition to those dimensions,

- Hallway width: 46 cm
- Door opening: 46 cm
- Walls: 1.9 cm thick, 27 to 34 cm tall

The location of any given point may vary by ±2.5 cm from its nominal position. This is a non-cumulative tolerance: the distance between any two points will be within ±2.5 cm of the nominal value.

Door openings do not have doors: white tape on the floor marks each door opening. The tape is 2.5 cm wide, extends across the entire door opening, and is aligned with the walls on each side. The tape may have gaps up to 2.5 cm on each side and may not be precisely aligned with the walls.

NOTE We strongly recommend that your robot should *not* depend on precise dimensions. Our experience shows that the intensity of a protest based on arena dimensions corresponds directly with the robot's failure to operate at all. See Section 2.4 on page 17.

The location of the doors in Rooms 1 and 4 will differ on each trial, as described in Section 6.5.1.10 on page 40.

5.1.2 Materials and Finishes

The arena floor consists of plywood, painted flat black at the start of the contest. Our best efforts

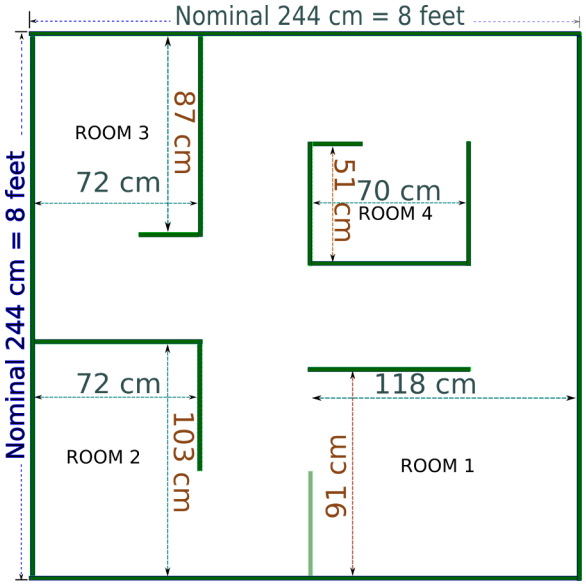


Figure 5.1: Arena Dimensions(FF Arena Dimensions.png)

will be made to clean up after each robot, but there is no guarantee that the floor will stay uniformly black throughout the entire contest (Section s 2.4 on page 17 and 2.5 on page 18). The floor may also have small (3 mm diameter) colored dots on it to indicate potential locations for candles and other objects.

Arena walls consist of medium-density particleboard, painted flat white at the start of the contest. Angle brackets supporting a wall may extend about 4 cm into the hall or room, with screws into the wall and floor.

The white tape marking the doorways has a semi-gloss finish. It will become scuffed and discolored during the contest: your robot must detect the difference between a black floor and a white tape line regardless of their cleanliness.

NOTE Remove your shoes before stepping into the arena! Shoes produce hard-edged dust marks on the floor that may be mistaken for white tape. Stockings produce soft-edged marks that

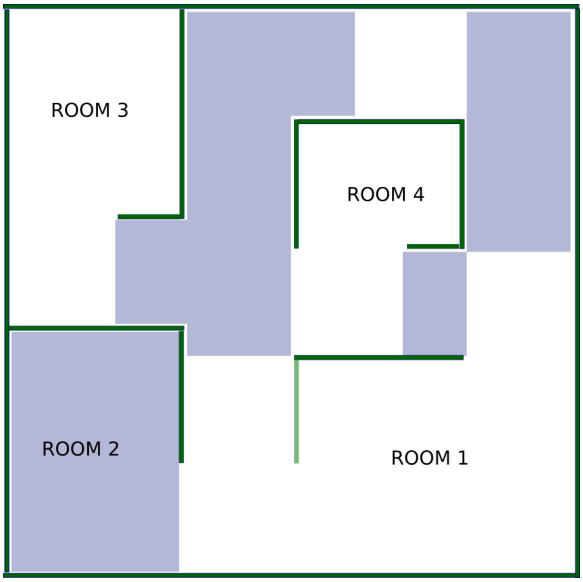


Figure 5.2: Allowed Rug Locations (FF Rug Locations.png)

reduce the overall floor contrast. In either case, the arena will be as clean as you leave it.

5.1.3 Basic Arena

The Basic Arena presents a simplified model of a typical house, with high-contrast walls and floors, for the Junior and Walking Divisions.

5.1.4 Standard Arena

The Standard Arena Layout represents a decorated home that presents a more realistic fire-fighting environment for the High School & Senior Divisions. The Standard Arena has the same dimensions as the Basic arena, with these differences:

1. Rugs will be placed in some or all of the rooms and hallways. There will be no shag rugs, but robots must navigate across 1 cm thick rug edges. The shaded areas in Figure 5.2 mark the allowed rug locations: not all rugs will be present and the locations and colors will be different in each arena.

2. Wall decorations, including pictures, tapestries, and mirrors, will be hung from the walls of rooms and hallways. These will not protrude more than 1 cm from the wall. The walls may also have wallpaper in various patterns and colors, as well as painted surfaces in any color.

   Mirrors will not appear in the room where the candle is located.

5.1.5 Arbitrary Start Orientation

Except in Arbitrary Start Location Mode (Section 6.5.1.4 on page 39), the robot will start at the Home Circle location marked by the H in Figure 5.3 on the facing page: a 30 cm diameter solid white circle, without the H, centered in the halls intersecting at the corner. The robot may begin motion in any direction it chooses.

NOTE The Home Circle is *not* anchored to the arena floor and may be dislodged by an accelerating robot. There is no penalty for this (and the crowd likes it), but the loss of traction may misalign the robot in the hallway.

The Judge will place the robot on the Home Circle so that the central axis of the robot body is aligned within ±10° of *either* hallway axis and the robot's front is directed toward the hallway The A and B arrows in Figure 5.3 on the next page show the possible orientations. The Judge will randomly choose the orientation for each trial.

NOTE In previous contests, the Judge always aligned the robot so that it faced toward the center of the arena, shown as Orientation A in Figure 5.3 on the facing page.

Other than the ±10° limit, there is no specification for the actual angle with respect to the hallway axis. The robot must start and operate correctly when oriented at any angle within each 20° range.

The robot must determine which hallway it faces in order to navigate correctly; a single wall sensor may suffice. The robot may touch the wall to activate the sensor, but see Section 6.5.4 on page 43 for the penalty applied for continuous wall contact.

NOTE Magnetic compasses do not produce reliable heading information. See Section 2.5.1 on page 18.

NOTE A robot in Orientation B may be directly adjacent to and facing the Dog Obstacle. See Section 5.1.6.

NOTE Teams *must not* request a different orientation after the Judge places the robot.

5.1.6 Dog Obstacle

A large Dog will block one corridor of each arena. The robot must not move the Dog or continue along the blocked corridor.

The robot may contact the Dog to sense its presence, but must not move it more than 1 cm. A

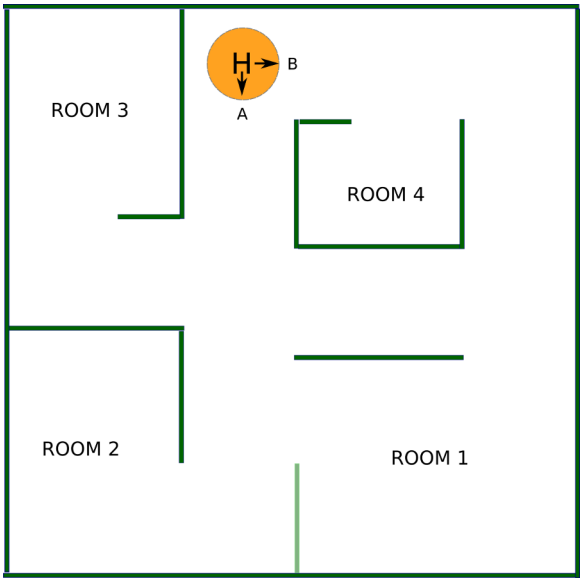


Figure 5.3: Starting alignments in Home Circle (FF Home Circle and Start Orientations.png)

Figure 5.4: Sample Dog Obstruction (Dog Obstacle - Doggie261.jpeg)

robot that moves the Dog more than 1 cm will incur 50 Penalty Points (Section 6.5.4 on page 43).

A robot that goes past the Dog, even without moving the Dog, and continues along the hall will fail the trial.

Figure 5.4 shows a typical Dog. The Dog weighs approximately 500 g. It blocks between 50% and 75% of the hallway width.

The location of the Dog will change from trial to trial. Figure 5.5 shows the possible locations for the Dog. The Dog's long axis will always be perpendicular to the hall; the picture and figures indicate only the locations.

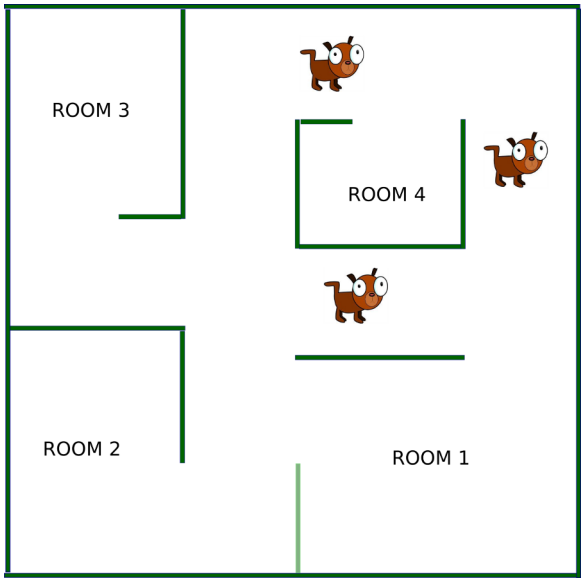


Figure 5.5: Possible Dog locations (FF Dog Obstacle Locations.png)

5.2 Robot

The robot dimensions, hardware requirements, and performance specifications are absolute and will be enforced by the Judges.

5.2.1 Operation

Once turned on, the robot must be autonomous: self-controlled without any human intervention. Fire-fighting robots must not be manually controlled.

Robot swarms may communicate with each other, but must not receive commands from outside the arena.

A robot may bump into or touch the walls of the arena as it travels, but it cannot mark, dislodge, or damage the walls in doing so. The robot must not leave anything behind as it travels through the arena. It must not make any marks on the floor of the arena that aid in navigation as it travels. Any robot that, in the Judge's opinion, deliberately damages the contest arena (including the walls) will fail that trial. This does not include any accidental marks or scratches made in moving around.

NOTE Although a robot may bump the arena walls as it moves, it should not repeatedly crash into the walls at high speed. "Navigation by crashing" would not be acceptable in an actual house and is discouraged in this contest. If the robot crashes hard enough to move the arena walls, it will fail that trial.

5.2.2 Dimensions

The robot must fit in a Bounding Box with a base 31 x 31 cm square and 27 cm high. If the robot has feelers to sense an object or wall, the feelers will be counted as part of the robot's total dimensions.

Robots competing in the Walking Division may be up to 46 cm long. The width and height remain as described above. *The robot must not exceed the maximum height limit with its legs at full extension.*

NOTE A "walking" robot must support its weight on non-wheeled legs that are also used for locomotion.

NOTE Although a one-legged hopping robot is permitted, no part of the robot may exceed the maximum height limit during any part of its trajectory.

Robots must not exceed the maximum dimensions at any time, including while extinguishing the candle. This rule prohibits swinging snuffers, extending arms, and other devices that protrude beyond the allowable base or height dimensions while in operation. Team members must demonstrate the maximum extent of any extending devices to the satisfaction of the Judges prior to their first trial.

The robot cannot separate into multiple parts. Robot swarms may compete in the Expert Division (Part III on page 47).

Contestants may add a flag, hat, or other purely decorative, non-functional items to the robot as long as the item has absolutely no effect on the operation of the robot. The item may exceed the maximum height limit.

Unlike the arena specifications, the robot size limits are *not* approximate: robots *must not* exceed the given dimensions.

There are no restrictions on robot weight or materials.

5.2.3 Start Button

All robots, including those using Sound Activated Mode, *must* have exactly one Start Button switch that starts the robot.

The Start Button *must* have these characteristics:

- Momentary push-to-operate action: not a toggle switch.
- Located on the top surface of the robot and accessible from above.
- Above the highest fan blade tip (the highest point the fan can reach)

Figure 5.6: Sample Start Buttons. (Sample Start Buttons.jpg)

- Less than 2 cm below any other mechanical part.
- A green actuator or background. You may color the button with a marker, surround the button with a colored area, or use a colored label.
- The word START printed in a contrasting color on or adjacent to the button.

NOTE If a robot does not have a Start Button meeting these requirements, *it will be disqualified.*

Figure 5.6 shows sample Start Buttons. You must provide a green background even if the switch is located on a green circuit board.

You may use a mechanical linkage from an actuating button located above all the other parts, as shown in Figure A.1 on page 95, leading to an electrical switch inside the robot body. The actuator must meet all of the specifications described above and will be considered the Start Button.

See Appendix A on page 95 for examples of acceptable and unacceptable Start Button locations.

You *must* verify that your robot's Start Button meets these requirements at the Checkout Table before the contest begins. See Section 2.8 on page 19.

5.2.4 Sound Activation

As described in Section 6.5.1.3 on page 39, the robot may operate in Sound Activated Mode: it will start when it detects a sound of a specific frequency and amplitude.

The robot's microphone must have these characteristics:

- Located on the top surface of the robot and accessible from above.
- Above the highest fan blade tip (the highest point the fan can reach)
- Less than 2 cm below any other mechanical part.

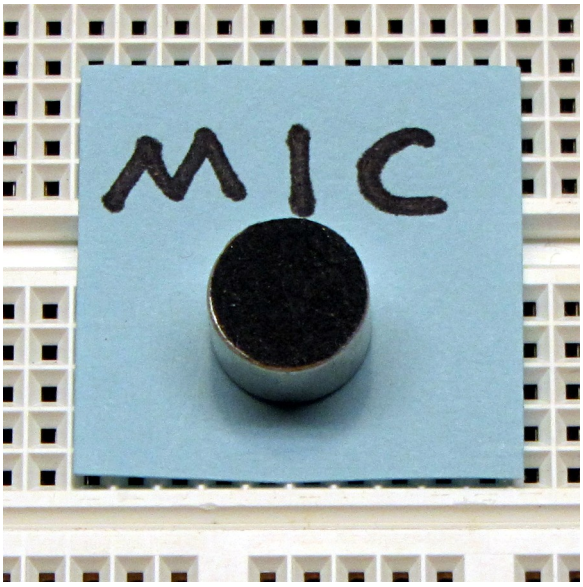


Figure 5.7: Sample Microphone with blue background (img_2247 - Sample Microphone.jpg)

- A blue background
- The abbreviation MIC printed in a contrasting color adjacent to the microphone

The Judge will position the Sound Start Device (Appendix B on page 97) approximately 25 mm away from the microphone and will attempt to align it perpendicular to the microphone's entrance port. Teams may *not* request any particular orientation or distance.

Figure 5.7 shows a sample Microphone with optional labeling. You must provide a blue background even if the microphone is located on a blue circuit board.

The pictures in Appendix A on page 95 showing acceptable Start Button locations also indicate acceptable Microphone locations.

NOTE Experience has shown that robots detecting only the peak amplitude of the sound will start prematurely due to crowd noise or mechanical shock. See Section 6.5.1.3 on page 39 for the scoring rules that apply to incorrect operation in Sound Activated Mode.

You must verify that your robot responds to the Standard Sound Start Device at the Checkout Table before the contest begins. See Section 2.8 on page 19.

Firefighting robots using Sound Activation Mode *must* also have a Start Button as described in Section 5.2.3 on the facing page.

NOTE Junior Division *robots must not* use Sound Activation Mode.

5.2.5 Power Switch

The robot may also have a Power Switch that disconnects the robot's batteries.

The team may turn the robot on using the Power Switch after placing the robot on the Judge's table at the arena, but the robot *must not* move as a result.

We recommend that robots be turned on and ready to start before being placed on the table, unless that would cause an unsafe condition. Please discuss your robot's operation with the Judges if you anticipate a problem.

NOTE The Power Switch *cannot* be the Start Button, because activating the Start Button causes the robot to begin operation.

5.2.6 Sensors

There is no restriction on the type of sensors that may be used as long as they do not violate any of the other rules or regulations. The robot must not extend any sensors beyond the dimensions specified in Section 5.2.2 on the preceding page.

Robots using laser-based devices must take measures to prevent eye damage to team members and to observers. The Judges may require the team to remove the laser device from the robot if, in the opinion of the qualification Judges, effective safety measures have not been taken. The robot will be permanently disqualified from competing if the laser cannot be either removed or made safe.

Contestants are not allowed to place any markers, beacons or reflectors on the walls or floors, whether inside or outside of the arena, to aid in the robot's navigation.

5.2.6.1 Sensor Interference

Ambient lighting in the contest room is a mixture of IR, visible, and UV light. During the course of the contest, sunlight may come into the contest room through open outside doors. The sunlight will not shine directly on the arenas, but may be detectable by very sensitive sensors.

During the course of the contest, Judges at other arenas will be lighting candles or lighters. These incidental flames will be above the arena and further away than the candle, but still may be detectable by an undiscriminating sensor. In setting up the arena, contest officials may put their arms into the arena and some very sensitive sensors may mistake that IR emission as the flame.

Many video and still cameras transmit infrared light as part of their automatic focusing systems. Flash

units produce bursts of UV that may trigger the popular Hamamatsu UVTron flame sensor. The gymnasium will have many, many cameras at all times: verify that your robot will operate correctly when it's being photographed.

If a robot uses light sensors to find the candle or detect walls or furniture, the robot designer must prevent unintended UV, visible and IR sources from interfering with its operation. Part of the challenge of this contest is to design a robot that can find the flame and ignore everything else.

5.2.7 Power

AC power is not available in the arena area.

See Section 2.7 on page 19.

5.3 Fires

For obvious reasons of safety and economy, fires will be simulated by small candle flames.

The candle flame will be from 15 cm to 20 cm above the nominal floor level. The candle thickness normally will be between 2 cm and 3 cm. The exact height and size of the flame will change throughout the contest depending upon the condition of candle and its surroundings. The robot is required to find the candle no matter what the size of the flame is at that particular moment.

The candle will be placed at random in one of the rooms in the arena. The candle has an equal chance of being in any of the 4 rooms in each of the robot's 3 trials. It is possible for the candle to be in the same room on two of the robot's three trials. If it happens that the candle is placed in the same room for both the 1st and 2nd trials, then the contest officials will make sure that it is a different room for the third and last trial. Thus every robot will have the candle in at least 2 rooms and possibly 3, during its 3 trials.

The candle will not be placed in a hallway, but it might be placed just inside a doorway of a room. The Candle Circle will not touch the doorway line and this means that the front of the robot will be able to move at least 33 cm into the room before it encounters the candle.

NOTE The Candle Circle is *not* anchored to the arena floor and may be dislodged by a decelerating robot. There is no penalty for this, but the moving paper may knock the candle over and there *is* a penalty for that.

The contestants cannot measure or touch the candle before it is used. Violation will result in immediate disqualification of the team and the robot from the competition.

The candle will be mounted on a small wooden base painted semi-gloss yellow. This base prevents the candle from tipping over easily, but a robot can knock the candle over by bumping into it. Judges will give penalty points if that occurs (Section 6.5.4 on page 42).

NOTE The Expert Division uses different candles and placement rules. See Section 7.2 on page 54.

5.3.1 Extinguishing the Candle

The robot must, in the opinion of the Judges, have found the candle before it attempts to put it out. For example, the robot cannot just flood the arena with CO_2 thereby putting the flame out by accident.

The robot must not use any destructive or dangerous methods to put out the candle.

The robot may extinguish the candle by blowing air or other oxygen-bearing gas. However, this is not a practical method of extinguishing a fire in the real world, so robots that do *not* use air streams to blow out the candle can operate in Non-Air Extinguisher Mode for an improved score. See Section 6.5.1.6 on page 39 for details.

The robot must come within 30 cm of the candle before it attempts to extinguish the flame. There will be a white 30 cm radius solid circle (or circle segment, if the candle is near a wall) on the floor around the candle, and the candle will be placed in the center of the circle. The robot must have some part of its body over the circle before it extinguishes the candle flame.

Candle Location Mode omits the candle circle and minimum distance requirement. See Section 6.5.1.11 on page 40. The robot need not be within 30 cm of the candle, but must demonstrate that it has detected the candle before extinguishing it. This may be by a distinctive action, an illuminated LED, or other means.

Robots that touch a lit candle with either the robot chassis or a sensor will incur a penalty as specified in Section 6.5.4 on page 42.

5.3.1.1 Methods of extinguishing the flame

Robots may extinguish the flame using air, inert gas, water mist/spray, or mechanical means. The use of powders of any type is not allowed.

1. Air

   A fan is an example of an air-based extinguisher.

2. Carbon dioxide (CO_2)

   Robots may use a single CO_2 capsule containing up to 16 grams to extinguish the candle on each trial; larger CO_2 containers are prohibited. The Judges will verify that CO_2 is the extinguishing material.

3. Water mist or spray

   Water is the only liquid allowed in this contest. You may not add foaming or gelling agents.

   The water tank volume must be no larger than 50 ml. Judges will verify the tank volume.

   Water must be applied only as a mist or spray, not a jet.

   Exception: We will allow a robot to extinguish the flame with no more than three accurately aimed water "bullets". This would be a water jet with an extremely short pulse, not a continuous stream: think *rifle* rather than *machine gun*. Contact us before you register to verify that your design will be accepted.

   Any robot that floods the room will fail that trial.

4. Mechanical means

   A wet sponge or snuffer.

   The size limits described in Section 5.2.2 on page 32 apply to mechanical extinguishers: the robot's moving parts *must not* exceed the maximum size at any time.

Carbon dioxide, water mist, and mechanical means qualify for the non-air extinguisher deduction. See Section 6.5.1.6 on page 39.

5.4 Trial Procedures

The robot must perform certain operations during each trial in the arena. This section describes the overall requirements for each Division. Other sections of this document provide further details.

The robot may use any of the available Operating Modes (Section 6.5.1 on page 38) to improve its score for the trial. The robot may use different Modes in different trials, but the team cannot change Modes after a trial begins.

Each successful trial consists of the following sequence of steps.

1. The robot must start when commanded by the Judge
2. It must find the candle in one of the rooms
3. It must extinguish the candle
4. Optionally, it may return to its starting location if using Return Trip Mode (Section 6.5.1.5 on page 39)

Chapter 6

Scoring

Although the scoring system appears complex, it measures differing robot capabilities in different Divisions. The overall scoring flow follows this pattern, with some variations in each Division:

1. The team presents their Trial Options Sheet to the Judge to select the optional tasks the robot will attempt; this determines the Operating Mode factors in effect for that trial.
2. The Judge measures the Actual Time required for the robot to complete its trial.
3. The Judge records any penalties.
4. The Judge computes the Operating Score for the trial.
5. The Judge computes the Final Score from the Operating Score and the robot's Division.
6. After all three trials, the Judge computes the Total Final Score from the Final Scores of all three trials.

See Appendix E on page 107 for a sample Trial Options Sheet.

6.1 Operating Score (OS) Computation

During the trial, the Judges will:

1. Record the robot's Operating Modes (OM.x) options (Section 6.5.1 on the next page)
2. Measure the Actual Time (AT) for the trial (Section 6.5.2 on page 42)
3. Determine the Room Factor (RF) for the path used (Section 6.5.3 on page 42)
4. Record any Penalty Points (PP) incurred (Section 6.5.4 on page 42).

After the trial has completed, the Judges calculate the Operating Score (OS) from those values using this procedure:

1. Multiply all of the active Operating Mode values together to find the Mode Factor. If no OM.x factors apply, then MF = 1.0.
2. Add all of the Penalty Point (PP) values to the Actual Time (AT) to determine the Time Score: TS = AT + PP.
3. Compute the Operating Score: OS = TS x RF x MF.

Although the"units" of the Operating Score appear to be seconds, they bear little relation to actual wall-clock time.

6.2 Final Score (FS) Computation

Scoring rules convert the Operating Score into the Final Score for each trial. The Junior and Walking Divisions share one set of scoring rules; the High School and Senior Divisions share a second set of scoring rules. The Final Score becomes a component of the Total Final Score (TFS) used to rank the robots for prizes and awards.

6.2.1 Junior Division

If the robot extinguishes the candle, then the Final Score for that trial equals the Operating Score. If it did not extinguish the candle, then the robot receives a score of 600 with credit for tasks completed during the unsuccessful trial by subtracting points as described below.

Although a robot with only two successful trials can therefore have a lower Total Final Score than a robot with three successful trials, the ranking described in the next section will award higher prizes to the latter.

Sound Activation

Junior Division robots *must not* use Sound Activation Mode.

Room Searching

TASK.search = -30 x number of rooms searched

Deduct 30 points for each room searched before finding the candle. The maximum reduction is 120 points because the candle must be in the fourth room.

Candle Detection

TASK.detect = -30

The robot must correctly signal that it detected the candle by lighting an LED or making an obvious motion.

Candle Positioning

TASK.position = -30

The robot must stop within 30 cm of the candle without touching it.

6.2.2 High School

The Final Score is equal to the Operating Score: FS = OS.

6.2.3 Senior

The Final Score is equal to the Operating Score: FS = OS.

6.2.4 Walking

The Walking Division uses the same scoring rules as the Junior Division. See Section 6.2.1 on the previous page.

6.3 Total Final Score (TFS) Computation

After all robots within a Division have completed their trials, the Judges compute the Total Final Score (TFS) for each robot by adding all three of its Operating Scores together.

6.4 Ranking Within Divisions

The Trinity Home Firefighting Robot Contest rewards reliable operation by grouping the robots according to the number of successful runs, then according to their Total Final Scores within each group. As a result, a more reliable robot with a worse TFS will outrank a less-reliable robot with a better TFS and be eligible for higher prizes.

The robots in each Division will be divided into four groups based on the number of successful trials: 3, 2, 1, or 0. Within each group the robots will be ranked on the basis of their Total Final Scores. The First, Second, and Third prizes in each Division will be awarded to the three robots with the smallest TFS in the first group. If the first group has fewer than three robots, then the prizes for that Division will extend to the robots with the smallest TFS in the second group, and similarly to the third group.

In all cases, a robot must extinguish the candle in at least two trials to be eligible for a cash award.

6.5 Score Components

These sections explain how the Judges assign values that determine the Operating Score.

6.5.1 Operating Modes (OM.x)

A robot's overall performance depends on its ability to handle real-world situations. The Basic contest arena includes a level floor, high-contrast walls, and no obstructions, but additional operating modes allow you to improve your robot's score by completing more difficult tasks.

Operating modes act as multipliers to the Actual Time required for the robot to find and extinguish the candle. If no Operating Modes are in effect for a trial, the Actual Time is multiplied by the Standard Mode, which is exactly 1.0.

The team can select different Operating Modes for each of the three trials. The candle and any furniture will be placed in different locations for each trial.

The modes do not apply to an unsuccessful trial, where the robot does not extinguish the flame or fails for any other reason. The score for an unsuccessful trial is 600, regardless of any operating modes applied to that trial.

6.5.1.1 Standard

OM.standard = 1.0

The team must inform the Judge of any operating modes for the current trial *before* the trial begins. In the absence of that notification, the robot will compete in Standard Mode and the Actual Time will be multiplied by 1.0.

6.5.1.2 Tethered

Robots tethered by wires to computers, power supplies, or other devices are not permitted, so there is no Tethered Mode.

Robots may communicate through a wireless link, but must operate autonomously. Remote control by a human operator is not permitted!

6.5.1.3 Sound Activated

OM.sound = 0.80

NOTE Junior Division robots *must not* use Sound Activated Mode.

The robot begins operation when it detects a sound signal of 3.8 kHz.

The Judges will begin timing the trial when the sound signal begins, not when the robot begins moving. The sound will last 5 seconds and *will not be repeated.*

The robot *must not* start until the Judge activates the sound signal. If the robot mistakenly detects ambient noise (even an activation sound from a different arena) and begins to move, then the trial will have begun, but the Sound Activated Mode factor will not apply to the robot's score.

If the robot does not start in response to the sound signal it will *not* be given a second chance to use Sound Activated Mode for that trial. The Judge will attempt to activate the robot by pressing its Start Button, but the delay will be included in the robot's Actual Time for the trial.

See Section 2.10 on page 20 for a discussion of the starting procedure and penalties for incorrect starts.

Judges will use *only* Standard Sound Start Devices as described in Appendix B on page 97 during the Contest. Teams should build their own Sound Start Devices and use them during practice, but may not present them to the Judge during the contest.

NOTE The robot's circuitry should detect the correct frequency and should not rely only on sound amplitude. We *strongly* recommend using an analog bandpass filter tuned to the starting frequency: the arenas are *very* noisy and a robot that detects only amplitude (triggered by whistling or clapping) *will* start prematurely during its trial.

6.5.1.4 Arbitrary Start Location

OM.start = 0.80

The Judge will place the robot in an arbitrary location and orientation within any room that does not have the candle, as determined by the toss of a die.

The robot may be facing a wall or pointed into a corner, but will not be trapped by furniture.

NOTE Teams *must not* request any particular orientation or position.

There is no "Home Circle" in Arbitrary Start Location Mode.

The starting room does not count as a *searched* room for the Room Factor calculation (Section 6.5.3 on page 42). When the robot leaves the starting room, the *next* room it encounters is its first searched room.

6.5.1.5 Return Trip

OM.return = 0.80

The robot must return to its starting location after extinguishing the flame.

In Standard Mode, the robot must return to the Home Circle. It must stop with any part of its chassis within the 30 cm white Home Circle, but need not be in the same position or orientation as when it started the trial.

In Arbitrary Start Location Mode, the robot must return to the room it started from. It must stop with all parts of its chassis within the starting room, but need not be in the same position or orientation as when it started the trial. See Section 6.5.1.4.

The robot's Actual Time (AT) recorded for the trial will include only the time required to find and extinguish the candle, not the time for the return trip.

The robot must return its starting location within 2 minutes; if not, then the Return Mode factor is not in effect.

The robot need not retrace its path in returning to the starting location or take the most efficient route, but it must not enter any other rooms along the way.

6.5.1.6 Non-air Extinguisher

OM.extinguisher = 0.75

The robot must extinguish the candle using inert gas, water, or mechanical means. See Section 5.3.1.1 on page 34

Robots that use an air stream of any kind do not operate in Extinguisher Mode.

NOTE OM.extinguisher is now 0.75, down from 0.85 in 2010.

6.5.1.7 Furniture

OM.furniture = 0.75

Every room will have one or more pieces of furniture. This includes the room where the robot starts in Arbitrary Start Location Mode.

Furniture consists of semi-gloss yellow cylinders 11 cm in diameter, 30 cm high, and weighing more than 1 kg.

Furniture will always be placed to allow at least one path to the candle that is at least 31 cm wide. The furniture will not block the doorway and a maximum-size robot will be able to come into a room at least halfway before it encounters furniture. Furniture may block the robot's view of the candle, so it must move to different locations to see the candle and plan a path to reach it.

The robot may have to go around the furniture to extinguish the candle or exit from the room. It may touch the furniture, but it cannot push it out of the way. Robots that push the furniture away lose the Furniture Mode deduction for that trial.

NOTE The Expert Division Furniture Mode is entirely different and subject to different rules. See Section 7.1.2 on page 51.

6.5.1.8 Coat Tree

OM.coattree = 0.80.

A small coat tree, shown with dimensions in Figure 6.1, may be placed in any room or hallway. Clothing items with various cloth textures and colors will hang on the coat tree.

The robot must not move the Coat Tree. Robots that move the Coat Tree lose the Coat Tree Mode deduction for that trial.

The Coat Tree will not block the robot's passage through a hallway.

A Coat Tree within a room will follow the placement guidelines in Furniture Mode (Section 6.5.1.7).

The coat tree has a hardwood base and an upright made from a wooden dowel 1.6 cm in diameter. Four 3.5 cm clothes pegs are inserted into the dowel at a 45 degree angle 3.5 cm from the top. The tree is 25 cm high.

6.5.1.9 Uneven Floor

The 2013 Contest does not include the Uneven Floor Mode in any Division.

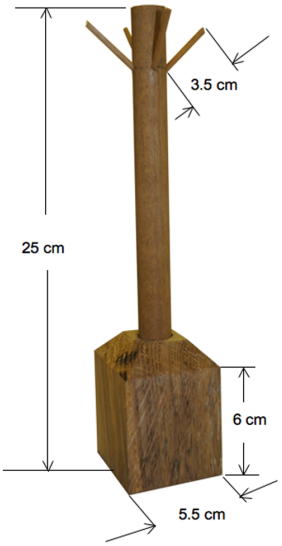


Figure 6.1: Coat Tree (CoatRACKDIMS.png)

6.5.1.10 Variable Door Locations

OM.variabledoor = 0.45

NOTE Senior Division robots *must* use Variable Door Location Mode, so the Mode Factor does not apply in that Division.

This option changes the locations of the doors in Rooms 1 and 4, so that dead reckoning will not suffice to navigate the arena and search the rooms.

At the start of a trial the arena Judge will determine the door locations by tossing a die or using a computer-assisted method. Therefore, the robot may encounter a different door location on each trial.

Figures 6.2 on the facing page, 6.3 on the next page, 6.4 on the facing page, and 6.5 on the next page show all possible door locations.

NOTE Room 1 now has an additional door in the wall closest to Room 4. This door will remain open at all times and robots may use it to improve their route planning.

6.5.1.11 Candle Location

OM.candle = 0.75

This option challenges robots to find candles without a candle circle. The Judge will place the candle at a randomly chosen location within a room for each trial.

The candle may be in any location within the room that does not block the doorway. A maximum-size robot can enter the room at least halfway before

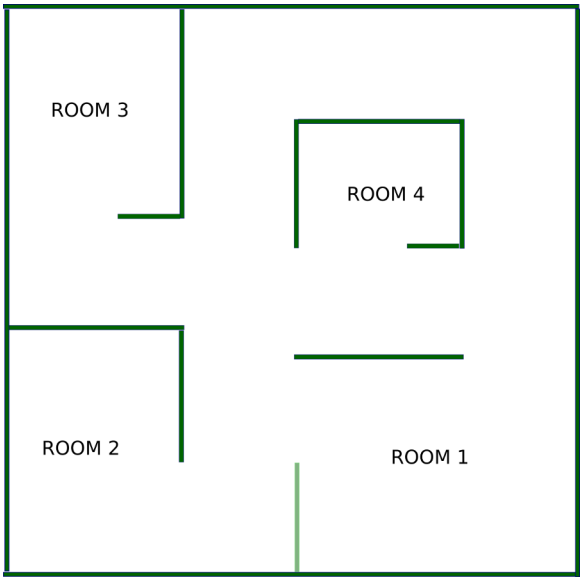


Figure 6.2: Variable Door - Configuration 1 (FF Variable Door - Config 1.png)

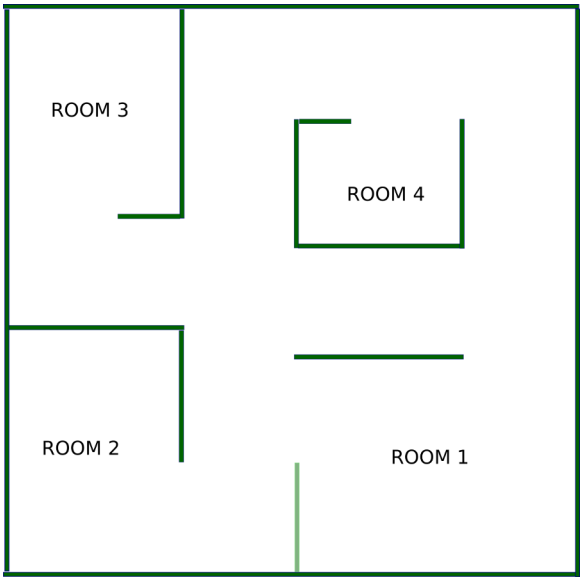


Figure 6.4: Variable Door - Configuration 3 (FF Variable Door - Config 3.png)

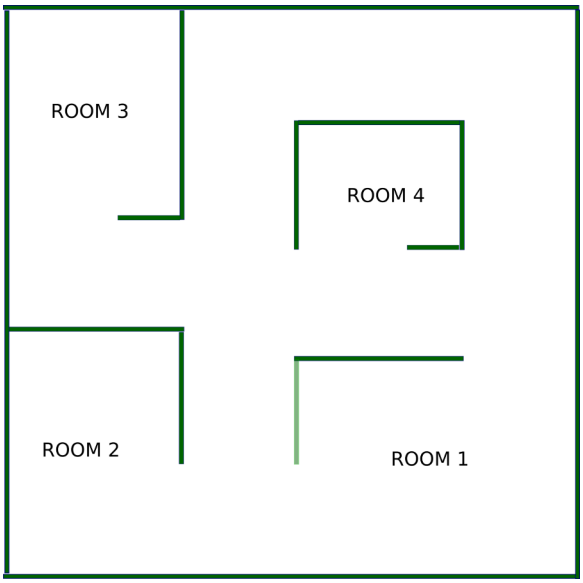


Figure 6.3: Variable Door - Configuration 2 (FF Variable Door - Config 2.png)

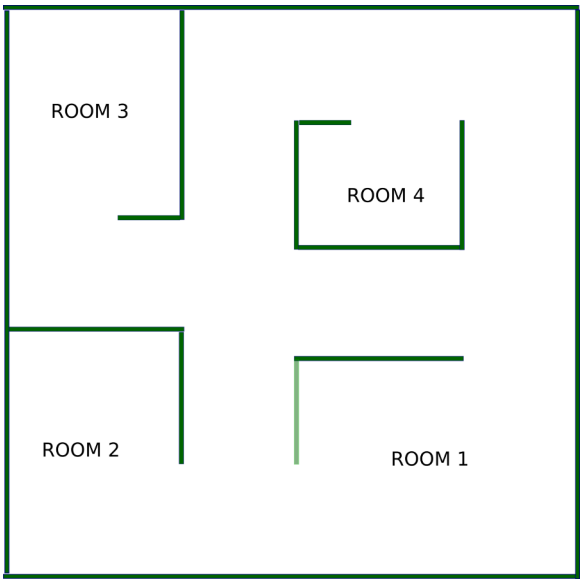


Figure 6.5: Variable Door - Configuration 4 (FF Variable Door - Config 4.png)

encountering the candle and there will be at least a 31-cm wide path around the candle.

The candle won't be directly adjacent to a wall, to reduce the chance of damaging the wall by overheating. There is no specification for the exact distance from the wall.

NOTE There are no other restrictions on the candle location in this Mode.

The Fire rules in Section 5.3 on page 34 will be followed except that:

- The method of choosing the candle location is different
- There will be no candle circle, just a candle in a standard holder
- The robot need not be within 30 cm of the candle, but it *must* demonstrate (by a distinctive action, an illuminated LED, or other means) that it has detected the candle *before* extinguishing the flame. You *must* tell the Judge how the robot will comply with this rule *before* the trial begins.

The Furniture Mode rules in Section 6.5.1.7 on page 40 also apply in Candle Location Operating Mode. In particular:

- Furniture may block the view of the candle from the door
- Although the candle will not block the doorway, the robot may have to maneuver within the room to detect and extinguish the flame.

6.5.2 Actual Time (AT)

If the robot extinguishes the flame the Actual Time is the number of seconds elapsed from robot activation to flame disappearance. The maximum Actual Time for such a *successful* trial is AT = 300. If the robot does not extinguish the flame within the limits set below, the Judge will terminate the *unsuccessful* trial and assign AT = 600.

6.5.2.1 Time Limits

The maximum time allowed for a robot to find the candle is 5 minutes, after which the Judge will stop the trial and assign AT = 600.

A robot operating in Return Trip Mode must return to the Home Circle within 2 minutes after extinguishing the candle, after which the Judge will stop the trial. The AT equals the time required to extinguish the candle.

6.5.2.2 Loops and Stalls

If a robot gets stuck in a loop and performs the same (or a similar) movement 5 times in a row without progress, the Judge will stop the trial and assign AT = 600.

Any time the robot does not move at all for 30 seconds, the Judge will stop the trial and assign AT = 600.

6.5.2.3 Functionality

A robot that fails at both of its first two trials will not receive a third trial.

6.5.3 Room Factor (RF)

The Room Factor (RF) adjusts the elapsed time based on the number of rooms searched. The more rooms a robot searches before it finds the candle, the lower the Room Factor for that trial.

When the candle is in:

First room searched RF = 1.0

Second room searched RF = 0.85

Third room searched RF = 0.50

Fourth room searched RF = 0.35

It does not matter in which order the robot searches the rooms. The only thing that matters is how many rooms the robot has searched before it finds the candle.

When the robot searches the room with the candle, whether or not the robot extinguishes it, the Judge records the Room Factor for that trial. The room factor will not change regardless of how many more rooms the robot searches.

Because some robots can detect the candle by looking in the doorway without entering the room to search it, when the robot passes a doorway for the first time the Judge will count that room as searched. If the robot has already searched a room and then goes past the doorway again on its way to a different room, that room will not be counted twice.

6.5.4 Penalty Points (PP.x)

Penalty Points (PP) will be added to the Actual Time (AT) of any robot that exhibits the behaviors described in this section.

Touching the Candle

PP.candle = 50

Any robot that touches the candle or its base, either deliberately or accidentally, while the candle is lit will have 50 penalty points added to its Time Score each time the candle is hit.

There is no penalty for a touch that occurs as part of the actual extinguishing process, i.e., smothering the flame with a wet sponge, or after the candle is extinguished.

Touching refers only to any part of the robot's body, including feelers or probes, and does not include the water, air or other material that the robot might use to extinguish the candle.

Although there is no penalty for touching or knocking the candle over after the robot has extinguished the candle, we *strongly* recommend that your robot avoid doing that. The Judges may not agree with your opinion of whether the candle was extinguished *before* it began falling.

Continuous Wall Contact

PP.slide = (contact cm) / 2

Any robot that slides along a wall will have 1 point added to its Actual Time score for each 2 cm of wall it touches.

A robot may still touch a wall to orient itself, as long as the contact is not sliding.

There is no penalty for touching or sliding along the wall on the return trip to the Home Circle.

See the Note in Section 5.2.1 on page 31 regarding"Navigation by Crashing".

Kicking the Dog

PP.dog = 50

Any robot that moves the Dog more than 1 cm will have 50 penalty points added to its Time Score.

The robot may touch the Dog with a sensor probe, as long as the probe does not move the Dog.

NOTE A robot that bypasses the Dog and continues along the hall will fail the trial.

6.6 Scoring Examples

These examples illustrate how to calculate the Total Final Score under specific conditions for each Division. The Actual times, Mode Factors, and Penalty Points come from random number generators that exercise the entire range of possible choices, so any particular combination may not make sense for an actual competition.

Any disagreement between these examples and the rules given above will be decided by reference to the rules!

6.6.1 Junior Division

First example

```
---Example  13 Trial 1 Junior--------------------
Actual Time
  AT = 63.314 Sec
Modes used:
  (1) OM.extinguisher = 0.75.......No Air
     Extinguisher
  (2) OM.furniture = 0.75..........Furniture Mode
  (3) OM.coattree = 0.80...........Coat Tree
  (4) OM.candle = 0.75.............No candle
     Circle
  (5) OM.variabledoor = 0.45.......Variable door
     location
Room Factor:
  RF =   1.00   1 room was searched
Reason for Termination:Time Score
  TS = (AT + PP)
Operating Score
  OS = TS x OM.extinguisher x OM.furniture x OM.
     coattree x OM.candle
  TS =  63.314 + 0.00
  OS =  63.314  x 0.75 x 0.75 x 0.80 x 0.75 x
     0.45
Final Score
  FS = 9.616 <===
---Example  13 Trial 2 Junior--------------------
Actual Time
  AT = 183.792 Sec
Modes used:
  (1) OM.start = 0.80..............Arbitrary
     Start
  (2) OM.extinguisher = 0.75.......No Air
     Extinguisher
  (3) OM.coattree = 0.80...........Coat Tree
  (4) OM.candle = 0.75.............No candle
     Circle
  (5) OM.variabledoor = 0.45.......Variable door
     location
Room Factor:
  RF =   0.50   3 rooms were searched
Reason for Termination:Time Score
  TS = (AT + PP)
Operating Score
  OS = TS x OM.start x OM.extinguisher x OM.
     coattree x OM.candle x RF
  TS = 183.792 + 0.00
  OS = 183.792  x 0.80 x 0.75 x 0.80 x 0.75 x
     0.45 x 0.50
Final Score
  FS = 14.887 <===
---Example  13 Trial 3 Junior--------------------
Actual Time
  AT = 160.904 Sec
Modes used:
  (1) OM.extinguisher = 0.75.......No Air
     Extinguisher
  (2) OM.variabledoor = 0.45.......Variable door
     location
Room Factor:
  RF =   0.50   3 rooms were searched
Penalty Points:
  PP.slide =  4   robot contacted wall for 9 cm.
  Total PP = 4 points
Reason for Termination:Time Score
  TS = (AT + PP)
Operating Score
  OS = TS x OM.extinguisher x RF
  TS = 160.904 + 4.00
  OS = 164.904  x 0.75 x 0.45 x 0.50
Final Score
  FS = 27.828 <===

TFS = [FS(trial.1) + FS(trial.2) + FS(trial.3)]
TFS = [  9.616 +  14.887 +  27.828]      =
   52.330
```

Second example

```
---Example  35 Trial 1 Junior--------------------
Actual Time
  AT = 38.005 Sec
```



```
Modes used:
  (1) OM.start = 0.80.............Arbitrary
     Start
  (2) OM.return = 0.80.............Return Trip
  (3) OM.extinguisher = 0.75.......No Air
     Extinguisher
  (4) OM.coattree = 0.80...........Coat Tree
  (5) OM.candle = 0.75.............No candle
     Circle
Room Factor:
  RF =   0.85   2 rooms were searched
Penalty Points:
  PP.slide =  2   robot contacted wall for 4 cm.
  Total PP = 2 points
Reason for Termination:Time Score
  TS = (AT + PP)
Operating Score
  OS = TS x OM.start x OM.return x OM.
     extinguisher x OM.coattree x OM.candle x RF
  TS =  38.005 + 2.00
  OS =  40.005  x 0.80 x 0.80 x 0.75 x 0.80 x
     0.75 x 0.85
Final Score
  FS = 9.793 <===
---Example  35 Trial 2 Junior--------------------
Actual Time
  AT = 196.755 Sec
Modes used:
  (1) OM.extinguisher = 0.75.......No Air
     Extinguisher
  (2) OM.furniture = 0.75..........Furniture Mode
  (3) OM.candle = 0.75.............No candle
     Circle
  (4) OM.variabledoor = 0.45.......Variable door
     location
Room Factor:
  RF =   0.85   2 rooms were searched
Penalty Points:
  PP.candle = 50   robot touched a candle 1 times
     .
  PP.dog = 50      robot kicked a dog.
  Total PP = 100 points
Reason for Termination:Time Score
  TS = (AT + PP)
Operating Score
  OS = TS x OM.extinguisher x OM.furniture x OM.
     candle x RF
  TS = 196.755 + 100.00
  OS = 296.755  x 0.75 x 0.75 x 0.75 x 0.45 x
     0.85
Final Score
  FS = 47.887 <===
---Example  35 Trial 3 Junior--------------------
Actual Time
  AT = 98.797 Sec
Modes used:
  (1) OM.start = 0.80.............Arbitrary
     Start
  (2) OM.coattree = 0.80...........Coat Tree
  (3) OM.candle = 0.75.............No candle
     Circle
Room Factor:
  RF =   1.00   1 room was searched
Penalty Points:
  PP.slide =  5   robot contacted wall for 11 cm.
  Total PP = 5 points
Reason for Termination:Time Score
  TS = (AT + PP)
Operating Score
  OS = TS x OM.start x OM.coattree x OM.candle
  TS =  98.797 + 5.00
  OS = 103.797  x 0.80 x 0.80 x 0.75
Final Score
  FS = 49.823 <===


TFS = [FS(trial.1) + FS(trial.2) + FS(trial.3)]
TFS = [  9.793 +  47.887 +  49.823]      =
   107.503
```

6.6.2 High-School Division

First example

```
---Example   5 Trial 1    HS --------------------
Actual Time
  AT = 112.430 Sec
Modes used:
  (1) OM.sound = 0.80.............Sound
     Activated
  (2) OM.return = 0.80.............Return Trip
  (3) OM.extinguisher = 0.75.......No Air
     Extinguisher
  (4) OM.furniture = 0.75..........Furniture Mode
  (5) OM.coattree = 0.80...........Coat Tree
  (6) OM.candle = 0.75.............No candle
     Circle
  (7) OM.variabledoor = 0.45.......Variable door
     location
Room Factor:
  RF =   1.00   1 room was searched
Reason for Termination:Time Score
  TS = (AT + PP)
Operating Score
  OS = TS x OM.sound x OM.return x OM.
     extinguisher x OM.furniture x OM.coattree x
     OM.candle x OM.variabledoor
  TS = 112.430 + 0.00
  OS = 112.430  x 0.80 x 0.80 x 0.75 x 0.75 x
     0.80 x 0.75 x 0.45
Final Score
  FS = 10.928 <===
---Example   5 Trial 2    HS --------------------
Actual Time
  AT = 147.002 Sec
Modes used:
  (1) OM.sound = 0.80.............Sound
     Activated
  (2) OM.start = 0.80.............Arbitrary
     Start
  (3) OM.furniture = 0.75..........Furniture Mode
  (4) OM.coattree = 0.80...........Coat Tree
  (5) OM.candle = 0.75.............No candle
     Circle
  (6) OM.variabledoor = 0.45.......Variable door
     location
Room Factor:
  RF =   0.35   4 rooms were searched
Time Score
  TS = (AT + PP)
Operating Score
  OS = TS x OM.sound x OM.start x OM.furniture x
     OM.coattree x OM.candle x OM.variabledoor x
     RF
  TS = 147.002 + 0.00
  OS = 147.002  x 0.80 x 0.80 x 0.75 x 0.80 x
     0.75 x 0.45 x 0.35
Final Score
  FS = 6.668 <===
---Example   5 Trial 3    HS --------------------
Actual Time
  AT = 209.509 Sec
Modes used:
  (1) OM.start = 0.80.............Arbitrary
     Start
  (2) OM.candle = 0.75.............No candle
     Circle
  (3) OM.variabledoor = 0.45.......Variable door
     location
Room Factor:
  RF =   0.35   4 rooms were searched
Time Score
  TS = (AT + PP)
Operating Score
  OS = TS x OM.start x OM.candle x OM.
     variabledoor x RF
  TS = 209.509 + 0.00
  OS = 209.509  x 0.80 x 0.75 x 0.45 x 0.35
Final Score
  FS = 19.799 <===


TFS = [FS(trial.1) + FS(trial.2) + FS(trial.3)]
TFS = [ 10.928 +   6.668 +  19.799]      =
   37.395
```

Second example

```
---Example   9 Trial 1    HS --------------------
Actual Time
```



```
  AT = 64.437 Sec
Modes used:
  (1) OM.sound = 0.80.............Sound
     Activated
  (2) OM.start = 0.80.............Arbitrary
     Start
  (3) OM.extinguisher = 0.75.......No Air
     Extinguisher
  (4) OM.furniture = 0.75.........Furniture Mode
  (5) OM.coattree = 0.80...........Coat Tree
  (6) OM.candle = 0.75.............No candle
     Circle
  (7) OM.variabledoor = 0.45.......Variable door
     location
Room Factor:
  RF =   0.85   2 rooms were searched
Penalty Points:
  PP.slide =  8   robot contacted wall for 16 cm.
  Total PP = 8 points
Reason for Termination:
  AT=600 because robot repeated same pattern 5
     times.Time Score
  TS = (AT + PP)
Operating Score
  OS = TS x OM.sound x OM.start x OM.extinguisher
      x OM.furniture x OM.coattree x OM.candle x
     OM.variabledoor x RF
  TS =  64.437 + 8.00
  OS =  72.437  x 0.80 x 0.80 x 0.75 x 0.75 x
     0.80 x 0.75 x 0.45 x 0.85
Final Score
  FS = 5.985 <===
---Example   9 Trial 2    HS --------------------
Actual Time
  AT = 146.881 Sec
Modes used:
  (1) OM.sound = 0.80.............Sound
     Activated
  (2) OM.return = 0.80............Return Trip
  (3) OM.furniture = 0.75.........Furniture Mode
  (4) OM.coattree = 0.80...........Coat Tree
  (5) OM.variabledoor = 0.45.......Variable door
     location
Room Factor:
  RF =   0.85   2 rooms were searched
Penalty Points:
  PP.candle = 200   robot touched a candle 4
     times.
  PP.slide =  8   robot contacted wall for 17 cm.
  Total PP = 208 points
Reason for Termination:Time Score
  TS = (AT + PP)
Operating Score
  OS = TS x OM.sound x OM.return x OM.furniture x
      OM.coattree x OM.variabledoor x RF
  TS = 146.881 + 208.00
  OS = 354.881  x 0.80 x 0.80 x 0.75 x 0.80 x
     0.45 x 0.85
Final Score
  FS = 52.125 <===
---Example   9 Trial 3    HS --------------------
Actual Time
  AT = 97.919 Sec
Modes used:
  (1) OM.sound = 0.80.............Sound
     Activated
  (2) OM.start = 0.80.............Arbitrary
     Start
  (3) OM.return = 0.80............Return Trip
  (4) OM.extinguisher = 0.75.......No Air
     Extinguisher
  (5) OM.candle = 0.75.............No candle
     Circle
  (6) OM.variabledoor = 0.45.......Variable door
     location
Room Factor:
  RF =   0.85   2 rooms were searched
Reason for Termination:Time Score
  TS = (AT + PP)
Operating Score
  OS = TS x OM.sound x OM.start x OM.return x OM.
     extinguisher x OM.candle x OM.variabledoor x
     RF
  TS =  97.919 + 0.00
  OS =  97.919  x 0.80 x 0.80 x 0.80 x 0.75 x
     0.75 x 0.45 x 0.85
Final Score
  FS = 10.787 <===

TFS = [FS(trial.1) + FS(trial.2) + FS(trial.3)]
TFS = [  5.985 +  52.125 +  10.787]      =
   68.896
```

6.6.3 Senior Division

First example

```
---Example   1 Trial 1 Senior--------------------
Actual Time
  AT = 35.213 Sec
Modes used:
  (1) OM.sound = 0.80.............Sound
     Activated
  (2) OM.start = 0.80.............Arbitrary
     Start
  (3) OM.return = 0.80............Return Trip
  (4) OM.extinguisher = 0.75.......No Air
     Extinguisher
  (5) OM.furniture = 0.75.........Furniture Mode
  (6) OM.coattree = 0.80...........Coat Tree
  (7) OM.candle = 0.75.............No candle
     Circle
Room Factor:
  RF =   0.85   2 rooms were searched
Time Score
  TS = (AT + PP)
Operating Score
  OS = TS x OM.sound x OM.start x OM.return x OM.
     extinguisher x OM.furniture x OM.coattree x
     OM.candle x RF
  TS =  35.213 + 0.00
  OS =  35.213  x 0.80 x 0.80 x 0.80 x 0.75 x
     0.75 x 0.80 x 0.75 x 0.85
Final Score
  FS = 5.172 <===
---Example   1 Trial 2 Senior--------------------
Room Factor:
  RF =   0.50   3 rooms were searched
Reason for Termination:
  AT=600 because robot search exceeded 5 minutes.
  FS = OS = 600 <<<<<
Final Score
  FS = 600.000 <===
---Example   1 Trial 3 Senior--------------------
Actual Time
  AT = 264.012 Sec
Modes used:
  (1) OM.return = 0.80............Return Trip
  (2) OM.extinguisher = 0.75.......No Air
     Extinguisher
  (3) OM.coattree = 0.80...........Coat Tree
  (4) OM.candle = 0.75.............No candle
     Circle
Room Factor:
  RF =   1.00   1 room was searched
Penalty Points:
  PP.dog = 50      robot kicked a dog.
  Total PP = 50 points
Time Score
  TS = (AT + PP)
Operating Score
  OS = TS x OM.return x OM.extinguisher x OM.
     coattree x OM.candle
  TS = 264.012 + 50.00
  OS = 314.012  x 0.80 x 0.75 x 0.80 x 0.75
Final Score
  FS = 113.044 <===


TFS = [FS(trial.1) + FS(trial.2) + FS(trial.3)]
TFS = [  5.172 + 600.000 + 113.044]      =
   718.216
```

Second example

```
---Example   9 Trial 1 Senior--------------------
Actual Time
  AT = 171.161 Sec
Modes used:
```



```
   (1) OM.sound = 0.80.............Sound
      Activated
   (2) OM.start = 0.80.............Arbitrary
      Start
   (3) OM.extinguisher = 0.75.......No Air
      Extinguisher
   (4) OM.furniture = 0.75..........Furniture Mode
   (5) OM.coattree = 0.80...........Coat Tree
   (6) OM.candle = 0.75.............No candle
      Circle
Room Factor:
  RF =   0.85   2 rooms were searched
Time Score
  TS = (AT + PP)
Operating Score
  OS = TS x OM.sound x OM.start x OM.extinguisher
       x OM.furniture x OM.coattree x OM.candle x
      RF
  TS = 171.161 + 0.00
  OS = 171.161  x 0.80 x 0.80 x 0.75 x 0.75 x
      0.80 x 0.75 x 0.85
Final Score
  FS = 31.425 <===
---Example   9 Trial 2 Senior--------------------
Actual Time
  AT = 227.495 Sec
Modes used:
  (1) OM.extinguisher = 0.75.......No Air
      Extinguisher
  (2) OM.furniture = 0.75..........Furniture Mode
  (3) OM.coattree = 0.80...........Coat Tree
  (4) OM.candle = 0.75.............No candle
      Circle
Room Factor:
  RF =   0.50   3 rooms were searched
Penalty Points:
  PP.candle = 50   robot touched a candle 1 times
     .
  PP.dog = 50      robot kicked a dog.
  Total PP = 100 points
Time Score
  TS = (AT + PP)
Operating Score
  OS = TS x OM.extinguisher x OM.furniture x OM.
      coattree x OM.candle x RF
  TS = 227.495 + 100.00
  OS = 327.495  x 0.75 x 0.75 x 0.80 x 0.75 x
      0.50
Final Score
  FS = 55.265 <===
---Example   9 Trial 3 Senior--------------------
Actual Time
  AT = 55.857 Sec
Modes used:
  (1) OM.sound = 0.80.............Sound
      Activated
  (2) OM.start = 0.80.............Arbitrary
      Start
  (3) OM.candle = 0.75.............No candle
      Circle
Room Factor:
  RF =   1.00   1 room was searched
Time Score
  TS = (AT + PP)
Operating Score
  OS = TS x OM.sound x OM.start x OM.candle
  TS =  55.857 + 0.00
  OS =  55.857  x 0.80 x 0.80 x 0.75
Final Score
  FS = 26.811 <===


TFS = [FS(trial.1) + FS(trial.2) + FS(trial.3)]
TFS = [ 31.425 +  55.265 +  26.811]      =
   113.502
```

6.6.4 Walking Division

Scoring in the Walking Division follows the same algorithm as in the Junior Division. See Section 6.6.1 on page 43.

Part III

TCFFHRC: Expert Division

The TCFFHRC Expert Division extends the contest presented in the Senior Division to include more realistic situations, configurations, and challenges.

Three challenges will have a major effect on robot design:

- Multiple fires
- Multiple robots
- Realistic furniture

Unless otherwise noted in this Part, all of the rules and requirements in Part I on page 9 apply to the Expert Division.

Chapter 7

Specifications

7.1 Arenas

The Expert Division contest takes place in a modified TCFFHRC Standard Arena. See Section 5.1.4 on page 30 for the Standard Arena configuration. This section describes the differences from that configuration.

7.1.1 Doorways

The doorway locations to two of the four rooms will change for each trial: the robot will encounter a different door configuration on each of its three trial runs.

Therefore, the robot must run in Variable Door Locations Mode, as described in Section 6.5.1.10 on page 40. There is no corresponding Operating Mode factor.

7.1.2 Furniture

Every room will contain *at least one* and not more than three Furniture items, consisting of scale-sized furniture normally found in a house: Chairs, Tables, Couches, Ottomans, and Beds, as shown in Figures 7.1 on the next page through 7.5 on the following page.

NOTE Wastebaskets, Wall Sconces, and Coat Trees are *not* Furniture items. They appear *in addition* to the Furniture in a room.

The furniture may block a view of the fire from the doorway and may block a robot's path into or through the room.

Furniture will be positioned with one side against a wall and will not be an island in the room. Items such as the Ottoman and Small Chairs will be positioned no more than 2 cm from the nearest furniture item.

A Furniture item may be located directly below a wall sconce, blocking the robot's approach.

A Furniture item may block the robot's approach to the Wastebasket from either (or both) sides.

The robot may move the Furniture without penalty, although it *must not* touch or move the flame container before extinguishing the flame.

NOTE Furniture used in other Divisions is entirely different and subject to different rules. See Section 6.5.1.7 on page 40.

7.1.2.1 Furniture Details

The following pictures provide detailed views of the furniture.

Figure 7.6 shows the Chair, which is 15 cm long, 17.5 cm wide, and 17 cm high.

Figure 7.7 on page 53 shows the Chair and Ottoman from above. The Ottoman is 12 cm square and 8 cm high.

Figure 7.8 on page 53 shows the Small Chair. The seat is 18 cm square and the back is 18 cm high.

Figure 7.9 on page 53 shows the Couch (also known as the Love Seat: a small, cozy couch), which is 15 cm long, 31 cm wide, and 17 cm high.

NOTE The Chair, Couch, and Ottoman cushions consist of Styrofoam slabs.

Figure 7.10 on page 53 shows the Table. The top is 18 cm square and 15 cm high.

Figure 7.11 on page 53 shows the Bed. The Bed is about 32 cm long and 21.5 cm wide. The headboard is 21 cm high and the footboard is 12.5 cm high. The cloth color and material will vary from that shown in the Figure.

7.1.3 Coat Tree

The arena will have a Coat Tree as described in Section 6.5.1.8 on page 40.

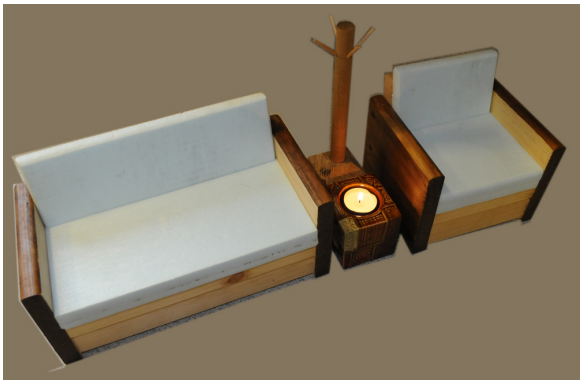


Figure 7.1: Expert Division Couch, Coat Tree, Wastebasket, and Chair (Chair+LoveSeat.jpg)

Figure 7.2: Expert Division Couch, Sconce, Chair, and Small Chair. (Couch Sconce Chair Small-Chair - Expert_Div_2011-09-07_3.jpg)

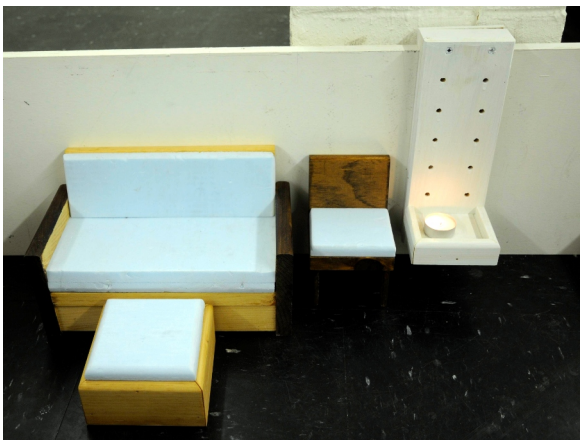


Figure 7.3: Expert Division Couch, Ottoman, Small Chairs, and Sconce. The Ottoman will be positioned no more than 2 cm from the Couch. (Couch Ottoman Small-Chair Sconce - Expert_Div_2011-09-07_4.jpg)

Figure 7.4: Expert Division Sconce, Bed, and Table (Sconce Bed Table - 2011-09-07_7.jpg)

Figure 7.5: Expert Division Table, Chairs, Sconce, Coat Tree (Expert CoatTree Sconce Table Chairs.jpg)

Figure 7.6: Expert Division Chair (ExpertEasyChairScaled2011.jpg)

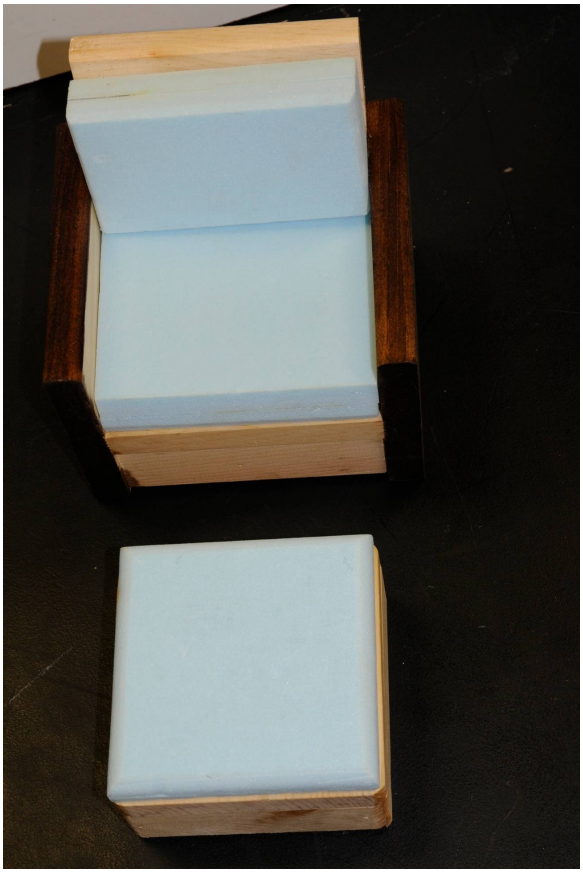


Figure 7.7: Expert Division Chair and Ottoman. The Chair will be located against the wall, with the Ottoman no more than 2 cm from it. (Chair&Ottoman2010-12-0321.jpg)

Figure 7.8: Expert Division Small Chair (Small_Chair2010-12-0325.jpg)

Figure 7.9: Expert Division Couch (LoveSeat.jpg)

Figure 7.10: Expert Division Table (Small_TableSide2010-12-0327.jpg)

Figure 7.11: Expert Division Bed (Bed.jpg)

The Coat Tree will be at least 30 cm away from a Wall Sconce (Section 7.2.4.2 on the facing page).

The robot *must not* move the Coat Tree while traversing the hallway or extinguishing an adjacent Wall Sconce fire. Unlike the other Divisions, if an Expert Division robot moves the Coat Tree, the robot *fails that trial.*

7.2 Fires

The Expert Division simulates a major house fire by using multiple fires in different locations. The robot will encounter fires in hallways, as well as inside rooms, and must extinguish all the fires *in the order it encounters them* to have a successful trial.

7.2.1 Finding and Extinguishing Fires

Because the robot will not know the number or location of the fires before starting the trial, it must search every room and hallway to verify that all fires have been discovered and extinguished. Therefore, the scoring formula does not include a Room Factor.

NOTE Even if the robot has extinguished four candles (and therefore knows it has located all possible fires), it must still search all four rooms.

The robot need not extinguish the closest fire before proceeding in a different direction. For example, upon entering the middle of a hallway with fires at each end, the robot may choose either fire. However, the robot must not pass by a fire without extinguishing it: if the robot passes a doorway to a room containing a fire, it must extinguish the fire in the room before continuing along the hallway.

If a robot passes by the doorway to a room containing a fire or passes a fire in a hallway without extinguishing it, the Judges will record that the robot has missed a fire and the robot will fail the trial. This applies even if the robot returns to the missed fire and successfully extinguishes it.

A robot swarm may dispatch several "seeker" robots to search many rooms simultaneously. However, any "extinguisher" robot capable of putting out a fire *must* do so in the order it encounters the flames.

For example, the seekers may search all rooms and hallways for fires so that the extinguisher robot can compute an optimal path before it starts moving. The extinguisher robot must not pass a room or hallway fire without extinguishing it.

The robot may extinguish a fire from any distance; there is no requirement to be within 30 cm of the flame. The other rules in Section 5.3.1 on page 34 remain in effect; we commend your attention to the Water Rifle Exception (3 on page 35).

7.2.2 Locations of Fires

Fires may occur in any part of the arena, including the hallways.

Hallway fires will be contained in wall Sconces (Section 7.2.4.2 on the next page).

Room fires may be contained in either Sconces or Wastebaskets (Section 7.2.4.1 on the facing page).

NOTE Room fires may not be visible from the hallway directly outside the doorway, due to either geometry or furniture.

NOTE Furniture items may block the robot's approach to a room fire. The robot may move the obstacle, maneuver around it, or extinguish the fire from a significant distance.

7.2.3 Number of Fires

The arena will contain two, three, or four fires for each trial, with at least one fire in a hallway and one in a room. The third and fourth fires, if present, may be in any locations.

NOTE A room may have more than one fire!

The robot will encounter any possible fire configuration only once in its three trials.

Robots may be able to see multiple fires from a single location. Examples:

- A fire in a room and a fire in a hallway
- Two or more hallway fires
- Two or more room fires

NOTE Fires will be at least 30 cm from the robot's starting position.

7.2.4 Fire Containers

The fires will be flames produced by small candles within containers.

NOTE The candles are *not* the same as those used in other Divisions.

Figure 7.12: Expert Candle Size - millimeter scale (TeaCandle_1K.jpg)

The candles are commonly known as "tea candles", as shown in Figure 7.12. For more information, see http://en.wikipedia.org/wiki/Tealight.

The aluminum container is approximately 4 cm in diameter and 1.5 cm tall. The height of the flame will vary depending on the amount of wax remaining in the container and the length of the wick.

NOTE There are no specifications for the flame height or the amount of flame visible above the container rim.

7.2.4.1 Wastebasket

A candle in a small container simulates a wastebasket fire, as shown in Figure 7.13.

The ceramic container is approximately cubical: 7 to 8 cm on each side.

Although some part of the flame will be visible above the container's rim, Furniture may block the robot's view of the flame from some parts of the room. In addition, Figure 7.14 shows that the container may obscure the flame from sensors located below the container's upper rim.

7.2.4.2 Wall Sconce

A candle in a wall Sconce simulates a fire in a window curtain or wall hanging. Figure 7.15 on the following page shows a sample Sconce containing a Candle in a low position.

The Sconces have shallow candle holders, as shown in Figure 7.13, with the candle containers secured to the brackets to prevent spilling.

The flame will be between 3 cm and 200 cm *below* the top of the arena wall. Section 5.1.3 on page 30

Figure 7.13: Wastebasket Fire (fire 001 - scaled.jpg)

Figure 7.14: Wastebasket Flame Visibility (Expert-Candle2.jpg)

Figure 7.15: Sample Sconce with Candle in low position (Sconce with small candle - 2011-09-07_1.jpg)

Figure 7.16: Sample Sconce with Candle in low position (Sconce with small candle - 2011-09-07_1.jpg)

defines the arena wall height, which may vary from arena to arena.

Figure 7.16 shows a sample Sconce holding a Candle in a high position.

Although at least part of the flame will be above the edge of the sconce, a robot with a flame sensor far below the top of the Sconce may not be able to see the flame. See Figure 7.14 on the preceding page for an illustration of the geometry with a different container.

NOTE The robot's flame sensor and its mounting hardware *must not* exceed the maximum height specified in Section 5.2.2 on page 32 at any time.

Figures 7.17 and 7.18 on the next page show details of the Sconce construction. The platform supporting the candle container can be inserted into any of the holes to adjust the flame height.

Figure 7.17: Wall Sconce Construction Detail - Front View (Hanger12010-12-0322.jpg)

7.3 Robots

Because the Expert Division arena may have multiple fires, a team may deploy multiple robots. There is no limit to the number of robots, subject to the restrictions in this section, and a swarm of small robots is perfectly acceptable. The robots may be identical or different, however,

Figure 7.18: Wall Sconce Construction Detail - Rear View (Hanger_Back2010-12-0324.jpg)

see Section 7.2 on page 54 for the requirements imposed on different robots while extinguishing fires.

All of the robots must fit together within the maximum dimensions described in Section 5.2.2 on page 32. The robots may be arranged in any manner within that Bounding Box, including being stacked, but must meet these requirements:

- Robots must start from their position within the Bounding Box
- No part of any robot may exceed the Bounding Box when packed inside
- All robots must simultaneously fit inside the box when expanded to their maximum dimensions

7.4 Operating Modes

Robots *must* use these Operating Modes. There are *no* optional Operating Modes.

- Sound Activated - See Section 6.5.1.3 on page 39
- Arbitrary Start Location - See Section 6.5.1.4 on page 39

  The Judges will place the robot(s) in a single location. The team may specify, in writing, the position and orientation of each robot within the starting array (which must fit within the Bounding Box), but not the position or orientation of the array with respect to the arena walls or features. If the robots do not all face in the same direction, some of them may be aimed directly at a wall.
- Arbitrary Start Orientation - See Section 5.1.5 on page 30
- Return Trip - See Section 6.5.1.5 on page 39

  All robots in a swarm must return to the starting location, but need not park in their starting arrangement.
- Non-air Extinguisher - See Section 6.5.1.6 on page 39

  The water tank volume of all robots may be distributed in any manner, but must not exceed 50 ml for any single robot and 100 ml total. For example:

  – two robots may each have a 50 ml tank
  – four robots may each have a 25 ml tank
  – one robot (the extinguisher) may carry 50 ml and the other (the fire finder) carries no water at all

- Expert Furniture - See Section 7.1.2 on page 51

  Furniture may be moved without incurring a penalty.

- Variable Door Locations - See Section 6.5.1.10 on page 40

- Coat Tree - See Section 7.1.3 on page 51

  The robot *must not* move the Coat Tree.

The Expert Division Operating Modes do not have Mode Factors, because the robots must use all of the Modes. As a result, Expert Division scores will be numerically equal to the total elapsed time for the trials.

Chapter 8

Scoring

The Expert Division scoring procedure follows this general outline:

1. The Judge measures the Actual Time required for the robot to complete its trial and the number of tasks completed.
2. The Judge computes the Operating Score for the trial.
3. The Judge computes the Final Score.
4. After all three trials, the Judge computes the Total Final Score from the Final Scores of all three trials.

Most of the Operating Modes and Penalties are identical to those used in the Senior Division, with exceptions as noted below.

8.1 Operating Score (OS) Computation

During each trial, the Judges will:

1. Verify compliance with the required Operating Modes (OM.x). See Section 6.5.1 on page 38.
2. Measure the Actual Time (AT) for the trial (Section 8.5.1.1 on the next page)

After the trial has completed, the Judges calculate the Operating Score (OS) from those values using this procedure:

1. Compute the Time Score, which is equal to the Actual Time for the run: TS = AT.
2. Compute the Operating Score: OS = TS.

8.2 Final Score (FS) Computation

Scoring rules convert the Operating Score into the Final Score for each trial, which then becomes a component of the Total Final Score used to rank the robots for prizes and awards.

If the robot extinguishes all the flames, then the Final Score for that trial equals the Operating Score. If it did not extinguish all the flames or otherwise fails the trial, then the robot receives a score of 600 with credit for tasks completed during the unsuccessful trial by subtracting points as described below.

Although a robot with only two successful trials can therefore have a lower Total Final Score than a robot with three successful trials, the ranking described in the next section will award higher prizes to the latter.

Flames Extinguished

TASK.flames = -30 * 4 * (number extinguished / total flames)

The Task Count is weighted to compensate for the variable number of flames.

Rooms Visited

TASK.search = -30 * number of rooms searched

The robot must search all four rooms, even if it has already found all four possible flames.

Return Trip

Task.return = -30 if the robot returns to the starting position

At least one robot from a swarm must return. If more than one returns, they need not be arranged in their starting positions.

8.3 Total Final Score (TFS) Computation

After all robots have completed their trials, the Judges compute the Total Final Score (TFS) for each robot by adding all three of its Operating Scores together.

8.4 Ranking

Expert Division Ranking follows the same algorithm as for the other Divisions. See Section 6.4 on page 38 for details.

8.5 Score Components

The Expert Division uses the same scoring components as the other Divisions, as described in Section 6.5 on page 38. However, the Expert Division has more stringent requirements for some components and does not apply Mode Factors. This section describes those differences.

8.5.1 Operating Modes (OM) and Mode Factors

See Section 7.4 on page 57 for the list of mandatory Operating Modes in the Expert Division. Expert Division scoring does not use Mode Factors, because all Operating Modes are required.

8.5.1.1 Actual Time (AT)

The Actual Time is measured as described in Section 6.5.2 on page 42, with the AT equal to the time until the last flame is extinguished.

Robot swarms have additional requirements:

- At least one member of the swarm must return to the starting point within 2 minutes after extinguishing the final flame. If not, the Judge will assign AT = 600.
- If *any* member of the swarm enters a loop or a stall, the Judge will stop the trial and assign AT = 600.

8.5.1.2 Room Factor (RF)

The Room Factor *does not apply* to the Expert Division, because the robot must search all four rooms on each trial.

8.5.2 Penalty Points (PP)

Penalty Points *do not apply* to the Expert Division. Those infractions that would trigger Penalty Points in the Senior Division cause the robot to fail the trial.

8.6 Example

```
Trial 1:
The arena has three candles.  The  robot
   exinguishes all of them all in 2 minutes and 10
    seconds.
AT = 130
FS = 130

Trial 2:
The arena has four candles.  The robot visits
   three rooms, extinguishes three candles, but
   runs out of time and does not return to start.
TASK.flames = -120 * (3/4) = -90
TASK.search = -30 * 3 = -90
TASK.return = 0
FS = 600 - 90 - 90 = 420

Trial 3:
The arena has four candles.  The robot visits two
    rooms, extinguishes one candle, but runs into
   the wall and stalls.
TASK.flames = -120 * (1/4) = -30
TASK.search = -30 * 2 = -60
TASK.return = 0
FS = 600 - 30 - 60 = 510


Total final score is TFS = 130 + 420 + 510 = 1060
```


Part IV

Trinity College Assistive Robotics Contest: RoboWaiter

The RoboWaiter Contest challenges teams to create a robot that can retrieve a plate of food and transport it to a table in a reliable and efficient manner. The arena simulates a home kitchen with the usual fixtures and a pair of dolls representing humans served by the robot.

The Assistive Robotics Contest (a.k.a RoboWaiter) was founded with support from the Connecticut Council on Developmental Abilities.

Chapter 9

Contest Structure

9.1 General Setting and Task

The competition presents a situation where Grandpa, a person with a disability, wants a plate of food from the Refrigerator. He sits at the kitchen table in his wheelchair. The arena represents a household kitchen, with Grandma, a second chair, a sink, and the refrigerator.

In the Standard Division, a simple shelf represents the refrigerator. The Advanced Division arena refrigerator consists of an enclosed box with an automatic door and two shelves, one of which will contain the food.

When directed by a signal from the Judge, the robot will move to the refrigerator, pick up the plate, and place it on the Table, while avoiding obstacles within the kitchen. Optional tasks include returning to the starting point and moving the plate from the Table to the Sink.

As in all Trinity Robotic Contests, the robot's action must be fully autonomous.

The Judge will measure and record the time from the start signal until the robot places the plate on the table. Various Operating Modes reward successful completion of more challenging tasks by improving the overall score.

9.2 Divisions

The RoboWaiter Contest has two Divisions.

Standard Division presents a simplified challenge:

- Obstacles in fixed positions
- Open shelf holding the plate

Advanced Division robots must use precision navigation and accurate timing:

- Obstacles appear in variable positions
- Refrigerator has automatic door and two shelves

Appendix C on page 101 presents details of the refrigerator hardware. The Contest Website at `http://www.trincoll.edu/events/robot/` may have additional details.

NOTE The same rules apply to all robots in each Division. Walking robots compete on the same basis as wheeled or tracked robots.

9.3 Eligibility and Registration

RoboWaiter is open to any team registered in the TCFFHRC. To register for RoboWaiter, check the box on the registration form. Teams may enter kit or unique robots.

A team may enter a robot into the RoboWaiter contest without entering a robot in the TCFFHRC.

See Section 1.3 on page 13 for registration and fee information.

9.4 Prizes

Cash prizes for first, second, and third place will be awarded, plus a special prize for the most successful walking robot in either Division of the RoboWaiter competition.

Separate prizes will be awarded in the Kit and Unique robot categories.

Chapter 10

Specifications

10.1 Arenas

The competition takes place in a square arena that simulates a kitchen. The arena is 2.5 m on each side, with a black floor and white walls that are 30 cm high.

A Home Circle marks the robot's starting point for the trial. The circle is white and 30 cm diameter. It will *not* be secured to the arena floor.

The Judges will position the robot on the Home Circle with its front surface (the end with the plate grippers) facing the shelf or refrigerator. There is no specification for the exact orientation.

NOTE Teams should identify the front surface, but may not specify an exact position or orientation.

NOTE The Home Circle is *not* anchored to the arena floor and may be dislodged by an accelerating robot. There is no penalty for this (and the crowd likes it), but the loss of traction may misalign the robot.

The starting position will vary for robots competing in Arbitrary Start Location Mode (Section 11.2 on page 76). As in Arbitrary Start Location Mode in the Firefighting Contest (Section 6.5.1.4 on page 39), there is no Home Circle.

The contest may use several RoboWaiter arenas. While all of the various parts, furniture, and figures in the arenas will be within the stated tolerances, teams must assume that all arenas will be different. See the Note about tolerances in Section 2.4 on page 17.

NOTE Teams cannot request that their robot run in a specific arena.

10.1.1 Standard Division

Figure 10.1 shows the arrangement of the Standard Division arena.

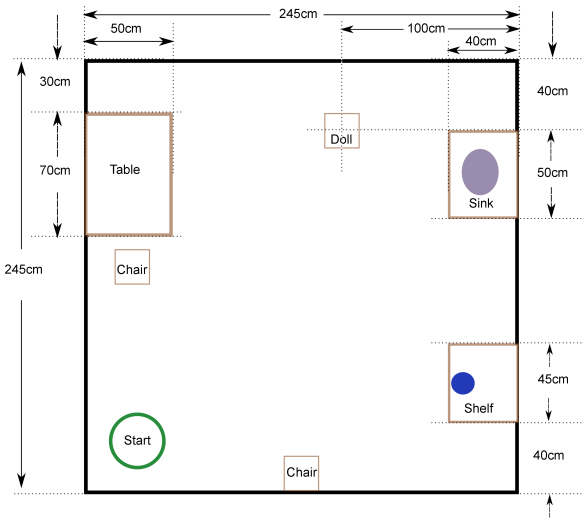


Figure 10.1: RoboWaiter Standard Division arena overview (RWStdScaled.png)

The Chair is always present. It will be located as shown in Figure 10.1, with its back against the wall, at the midpoint of the wall.

The Grandma doll is optional. If the Grandma option is selected, it will be located and oriented at the positions shown in Figure 10.1.

10.1.2 Advanced Division

Figure 10.2 on the following page shows the arrangement of the Advanced Division arena.

The Chair is required and will be located as shown in Figure 10.2 on the next page, no more than 75 cm from the wall between the Home Circle and the Refrigerator. It may be oriented at any angle.

The Grandma doll is required and will be located at a random position along the line shown in Figure 10.2 on the following page, at most 75 cm (to the doll center) from the wall. its exact location and orientation along that line will vary for each trial run. It will not block access to the refrigerator or Sensor. As mentioned in in Section 10, if the robot touches the Grandma doll, the robot fails the trial.

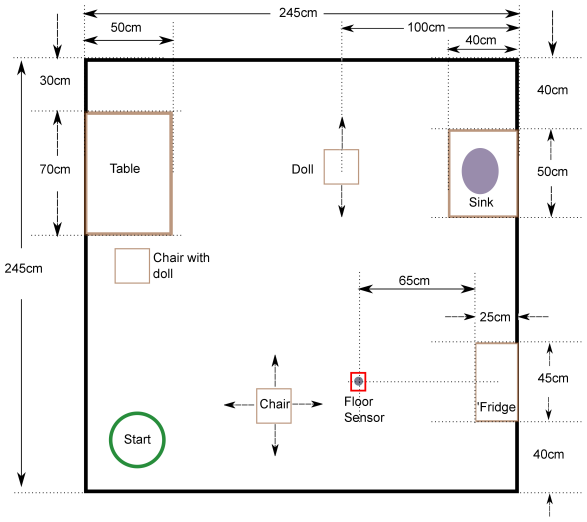


Figure 10.2: RoboWaiter Advanced Division arena layout (RWAdvanced12.png)

Figure 10.3: The Grandpa doll seated in wheelchair (GrandpaWheelchairSM.jpg)

10.1.3 Occupants

Dolls similar to these will be used in the arena. For historic reasons, we refer to the doll at the table as Grandpa and the doll standing in the arena as Grandma, but your robot should expect similar dolls of either gender at either location.

Because robots must operate safely around humans, a robot that touches any part of a doll will incur severe penalties.

10.1.3.1 Grandpa

The Grandpa doll and wheelchair (Figure 10.3) will be positioned at the table.

Figure 10.4: The Grandma doll (GrandmaSm.jpg)

10.1.3.2 Grandma

The Grandma doll (Figure 10.4) is optional in the Standard Division and required in the Advanced Division.

Grandma will be positioned on the floor in the arena as described in Section s 11.1.1 on page 75 and 11.1.2 on page 75.

10.1.4 Plate

The plate is located on a shelf as described in the Standard and Advanced sections below. Each shelf will have one plate.

The plate is round: 10 ± 0.3 cm in diameter. It is a pet-food can cover, Curtis Wagner Plastics Corp. Item #PF-4200 (`http://hometownusastores.com/product_info.php?products_id=1814`). See Figure 10.5 on the facing page.

A steel washer glued to the base of the plate adds weight. Also fixed to the bottom of the plate are four plastic feet, which help prevent slippage of the plate on the shelf. The total weight of the plate, including the steel washer and the plastic feet is 50 grams. See Figure 10.6 on the next page.

NOTE The robot *must not* include a metal detector to sense the plate.

10.1.5 Shelf

The shelf supporting the plate is 40 cm deep (front-to-back) and 45 cm wide (left-to-right). The top

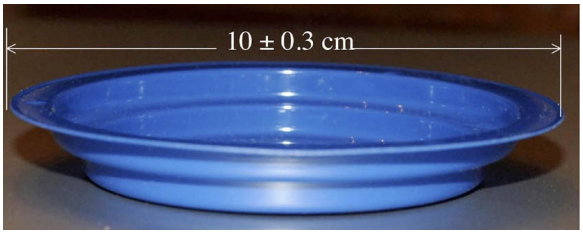


Figure 10.5: RoboWaiter Plate (RW_PlateSM.jpg)

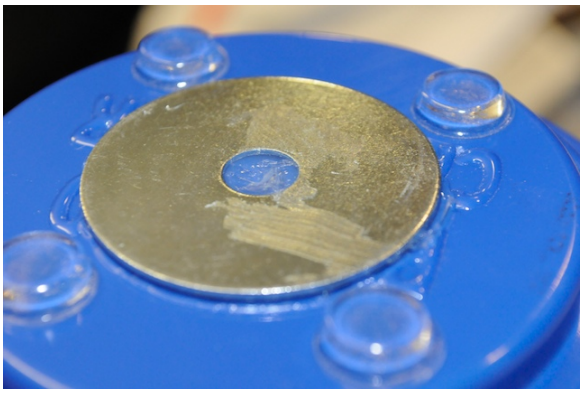


Figure 10.6: RoboWaiter Plate bottom showing weight and feet (RoboWaiter Plate 16.jpg)

of the shelf is 20 cm to 24 cm above the floor. The shelf height *will* change from trial to trial, so the robot *must* cope with an unknown shelf height! See Section 2.4 on page 17 regarding dimensional limits.

There are three bright red light-emitting diodes fixed to the edge of the shelf, separated by 2.0 ± 0.1 cm center-to-center (Figure B). The mid-point of the plate's edge is aligned with the middle LED. Figures 10.7 and 10.8 show the LED and plate arrangement.

10.1.5.1 LED data

- Everlight Part number 333-2SDRT/S530-A3
- Mouser Part # 638-333-2SDRTS5303
- current = 30 mA

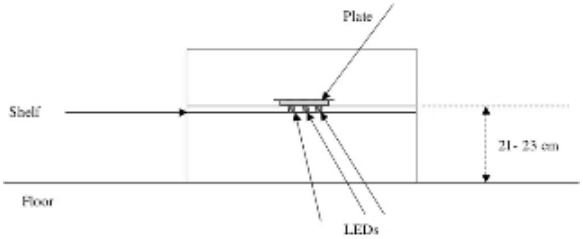


Figure 10.7: Refrigerator Shelf front view showing Plate and LED positions (ShelfFrontViewSm.jpg)

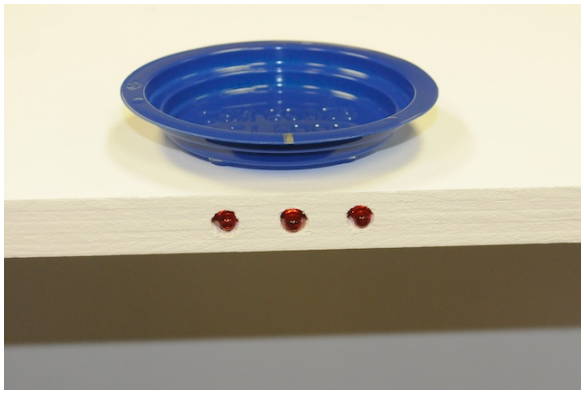


Figure 10.8: Plate on Refrigerator Shelf above LEDs (HOF Maze 8.jpg)

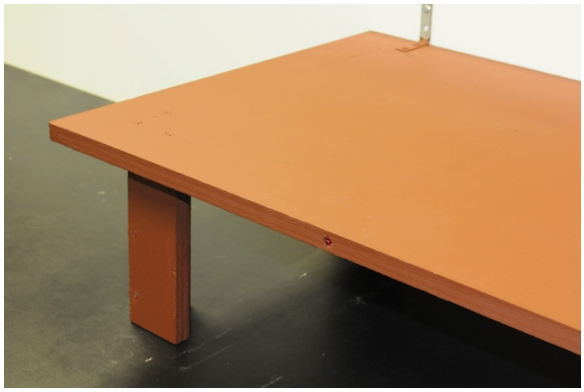


Figure 10.9: Picture of Table (HOF Maze 15.jpg)

10.1.6 Table

The table is 70 cm wide (left-to-right) and 50 cm deep (front-to-back), with one bright red LED (Section 10.1.5.1) at the center of each visible side. The top of the table is 20 to 24 cm above the floor. See Figure 10.9.

10.1.7 Sink

The sink serves as an obstacle and has the same footprint as the table. The sink is 25 cm high. A single blue LED centered on the front edge marks the center of the sink bowl.

See Figure 10.10 on the next page.

10.1.7.1 LED Data

The blue LED is available from Mouser: 941-C503BBCNCV0Z0462 or Cree C503B-BCN-CV0Z0462.

10.1.8 Chair

The chair has a footprint of 20 cm x 20 cm. See Figure 10.11 on the following page.

Figure 10.10: Sink with blue LED (Sink&BlueLED.jpg)

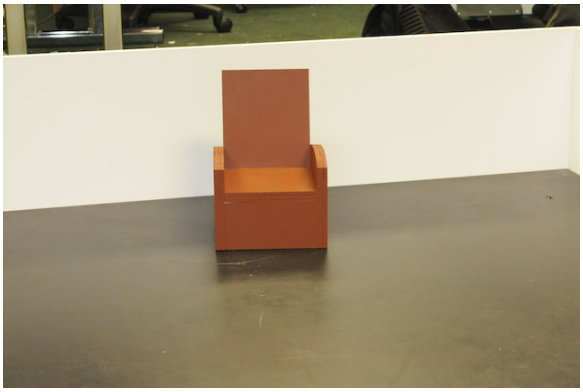


Figure 10.11: Picture of Chair (HOF Maze 12.jpg)

Figures 10.1 on page 67 and 10.2 on page 68 show the possible chair positions.

NOTE The chair orientation will vary in the Advanced Division arena.

10.1.9 Refrigerator

The RoboWaiter Advanced Division arena has a simulated refrigerator in place of the Shelf.

The refrigerator has two shelves in an enclosed box, with a door that opens and closes under the robot's control.

This section describes the refrigerator's physical dimensions and characteristics. The next section describes the sensor that triggers the door operations.

10.1.9.1 Overall Dimensions

The refrigerator exterior is 20-25 cm deep (front-to-back) x 45 cm wide (left-to-right) x 42 cm tall.

The refrigerator shelves are 16-21 cm deep (front-to-back) x 42 cm wide (left-to-right).

- The top of the upper shelf is 28 ± 1 cm above the floor.

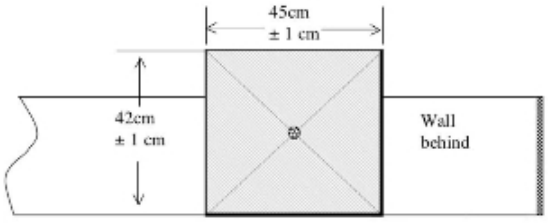


Figure 10.12: Refrigerator Door dimensions - Front View (DoorClosedFrontViewSm.jpg)

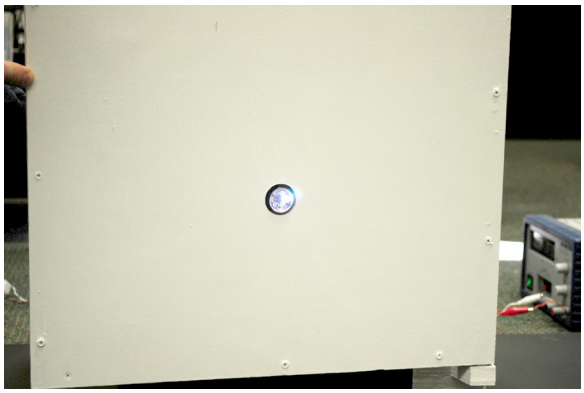


Figure 10.13: Refrigerator Door Beacon in visible light (BeaconOnDoor 218 - scaled.jpg)

- The top of the lower shelf is 14 ± 1 cm above the floor.

The shelf tolerances allow for slight variations in refrigerator construction: all refrigerators will be slightly different. If the contest has more than one Advanced arena, teams must assume the refrigerator shelves *will* be at different heights.

10.1.9.2 Refrigerator Door

A continuous, modulated infra-red LED beacon, aimed perpendicular to the face of the door, is located within 1 cm of the center of the refrigerator door. Figure 10.12 gives the dimensions and Figure 10.13 shows the beacon in visible light.

The beacon consists of five IR emitters and one visible emitter on a small circuit board taken from a 6-LED flashlight. Five of the six LEDs were replaced by IR emitters; the remaining visible LED indicates that the device is working.

The beacon emits approximately 300 mW of 880 nm IR with a beam width of approximately 30 degrees. Designers should *not* assume a uniform or Gaussian intensity distribution within the beam.

The driver circuitry modulates the beacon at 8.0 kHz ± 10%.

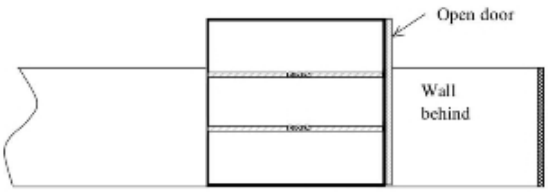


Figure 10.14: Refrigerator front view with Door open - Front View (DoorOpenFrontViewSm.jpg)

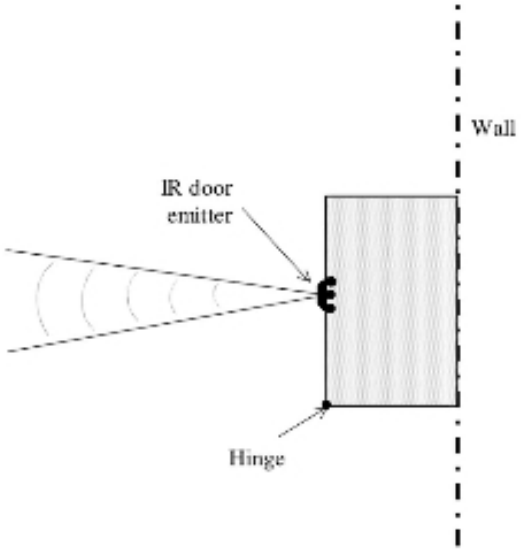


Figure 10.15: Refrigerator Door closed - Top View (FridgeTopViewShutSm.jpg)

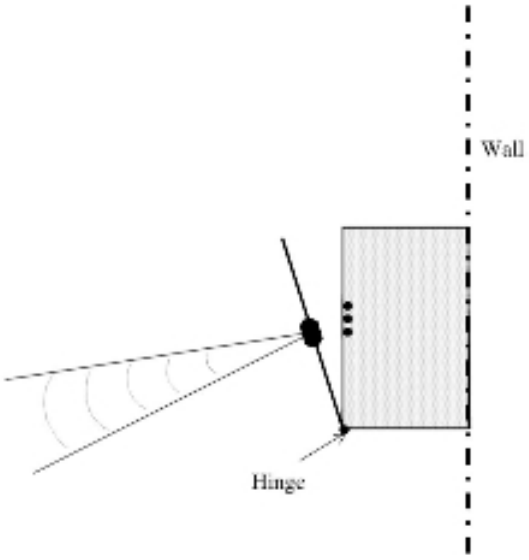


Figure 10.16: Refrigerator Door partially open - Top View (FridgeTopViewPartialSm.jpg)

A simple IR phototransistor mounted in a flashlight reflector readily detects the beacon from a distance of more than one meter.

See Appendix C.1 on page 101 for details of the beacon design.

Robots may use wall-following techniques on the open door while navigating into and out of the refrigerator, but they *must not* touch the door while doing so.

10.1.9.3 Shelves and Plates

Each shelf has three LEDs as described in Section 10.1.5.

Figure 10.14 shows the front view of the Refrigerator interior.

Figures 10.15 through 10.17 show top views of the Refrigerator with the Door in various positions.

A plate will be located on each shelf, aligned as described in Section 10 on page 67, Item10.1.5.

The robot must fetch the correct plate as part of a successful trial: if the robot takes the plate from the wrong shelf, the robot has failed that trial.

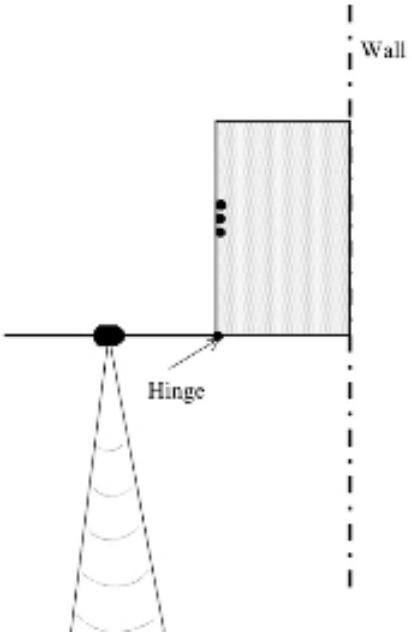


Figure 10.17: Refrigerator Door completely open - Top View (FridgeTopViewOpenSm.jpg)

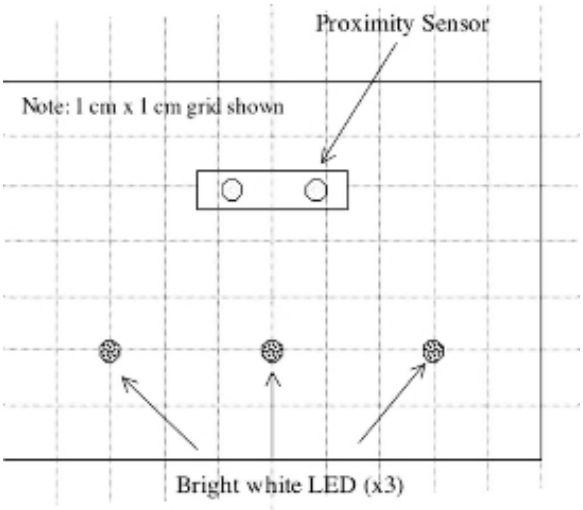


Figure 10.18: Refrigerator Door Sensor Module detail view - Top View (SensorModuleSm.jpg)

The robot may touch the shelf (but not the door!) while aligning itself to the plate's position. However, mechanical lever-action switches may not trip reliably on contact with the shelf, particularly at nearly perpendicular approach angles. If your navigation algorithms depend on switch closures, test your mechanical linkages very carefully under worst-case conditions, because that's what your robot will encounter at Trinity!

10.1.9.4 Refrigerator Door Floor Sensor

Advanced Division robots must open and close the refrigerator door by triggering a sensor module embedded in the floor directly in front of the refrigerator. The sensor module lies in the center area of the refrigerator's door beacon pattern, 65 cm from the outside surface of the closed door.

The sensor module contains three bright white visible LEDs that shine directly up from the floor and a Sharp GP2D120 IR proximity sensor. The LEDs are in a line 3 cm from the proximity sensor, parallel to the front of the refrigerator. The entire sensor module is embedded in the floor and will not impede robot motion.

NOTE The robot *must not* use a metal detector to locate the Floor Sensor.

Figure 10.18 shows the LED and GP2D120 arrangement within the sensor module. The refrigerator is located 65 cm from the upper edge of the rectangle in the figure.

See Appendix C.2 on page 101 for details of the sensor construction

The proximity sensor is connected to the refrigerator's embedded microcontroller. When the microcontroller first senses the presence of a robot, it will open the refrigerator door. When it senses the robot again, it will close the door. Therefore the sensor acts a toggle switch that controls the door's opening and closing.

A large robot or one that holds the plate in front of its main chassis may trigger the sensor before it has cleared the path of the closing door. The robot *must* avoid contact with the door, because the robot will fail the trial if the door touches it while closing.

10.1.9.5 Door Operation

The door will begin opening or closing within one second of the time the sensor detects the robot.

The door will open or close completely within five seconds from the start of motion.

The robot must move completely off the sensor module for at least 5 seconds while extracting the plate.

The refrigerator door will operate only one time during a trial. The robot must ensure that it does not trigger the door-opening sequence before it is ready to extract the plate.

10.2 Robots

10.2.1 Dimensions

The functional parts of the robot must fit into a box measuring 30 cm on a side and 50 cm tall.

A flag, hat, or other purely decorative, non-functional item may exceed the maximum height limit. The item must not be a structural part of the robot: the robot must operate correctly without the item. Judges may disallow any item if, in their opinion, it forms a functional part of the robot.

NOTE The height limit was 30 cm in previous contests.

Although the robot may deploy grippers beyond the starting envelope while transporting the plate, the "no contact" rules apply to all parts of the robot.

NOTE A robot *must not* deploy any sensors, other than plate contact sensors on the grippers, beyond the initial dimensions.

The robot need not retract its grippers after placing the plate on the table, but that would be a nice touch.

10.2.2 Starting Signal

10.2.2.1 Standard Division

All robots in the Standard Division *must* have a Start Button as described in Section 5.2.3 on page 32.

Optionally, the robot may start with the sound signal used to mark the lower shelf in the Advanced Division, as described in Section 10.2.2.2. However, there is no Sound Activated score deduction.

NOTE If a robot uses Sound Activation to start the trial, it must also use Sound Activation for the Cleanup task.

10.2.2.2 Advanced Division

Sound activation is required for robots competing in the Advanced Division. A Start Button is *not* required for robots in the Advanced Division, because (unlike in the Firefighting competition) if the robot fails to start in response to the Standard Sound Start Device, it will fail the trial.

The sound frequency indicates which plate the robot must retrieve from the refrigerator:

- If the food is located on the lower shelf, the sounder will send out an audio signal of 3.8 kHz ± 10%.
- If the food is located on the upper shelf, the sounder will send out an audio signal of 2.5 kHz ± 10%.

The starting signal will be a Standard Sound Start Device as used in the TCFFHRC (Section 6.5.1.3 on page 39), with an additional audio output at a different frequency to specify one of two plate locations. See Appendix B on page 97 for details of the Standard Device.

Chapter 11

Rules

The general rules described in Chapter 2 on page 17 apply unless otherwise noted below.

11.1 Trial Procedure

This section describes the overall procedure of a RoboWaiter contest trial.

11.1.1 Standard Division

1. The Judge will place the robot in the arena and configure any optional obstacles.
2. The Judge will start the robot and begin timing the trial.
3. The robot must fetch the plate from the shelf or refrigerator.
4. The robot must deliver the plate to the table, place it on the table surface, and completely release the plate. The plate must be entirely on the table, without overhanging the table edge, but need not be centered on the surface.
5. The Judge will record the elapsed time when the robot has stopped moving after releasing the plate.
6. In the optional Cleanup Mode, the Judge will start the robot, which will move the plate from the table to the sink.

Teams may chose optional Operating Modes to modify the challenge. See Section 11.2 on the following page for details. The Operating Mode multipliers apply to the total time required to fetch the plate and place it on the table.

11.1.2 Advanced Division

These rules apply in addition to the Standard Division rules in Section 11.1.1.

1. The robot must start in response to the Standard Sound Start Device (Appendix B on page 97). The trial timing begins when the sound signal starts, not when the robot begins to move. If the robot does not start, it will fail the trial.
2. The robot must decode the tones, as described in Section 10.2.2.2 on page 73, to know which plate must be retrieved from the refrigerator.
3. The robot must open the refrigerator door before attempting to retrieve the plate. However, as described in Section 10.1.9.5 on page 72, the door will operate only once for any trial. If the robot inadvertently opens the door, the door will close when the robot activates the sensor a second time and, consequently, the robot will fail the trial.
4. After determining that the refrigerator door is open, the robot must extract the proper plate. The robot will fail the trial if:

   - The robot touches the refrigerator door while entering the refrigerator
   - The robot extracts the wrong plate

   The robot may touch either refrigerator shelf, perhaps to align itself with the plate, without penalty. However, it must not touch the door at any time.
5. The robot must close the door and indicate that it has done so by lighting an easily visible LED. There is no penalty if robot indicates that it has sensed a closed door before the door is completely closed.
6. The robot must deliver the plate to the table as described above.
7. The Judge will record the elapsed time when the robot has stopped moving after releasing the plate.
8. In the optional Cleanup Mode, the Judge will start the robot, which will move the plate from the table to the sink.

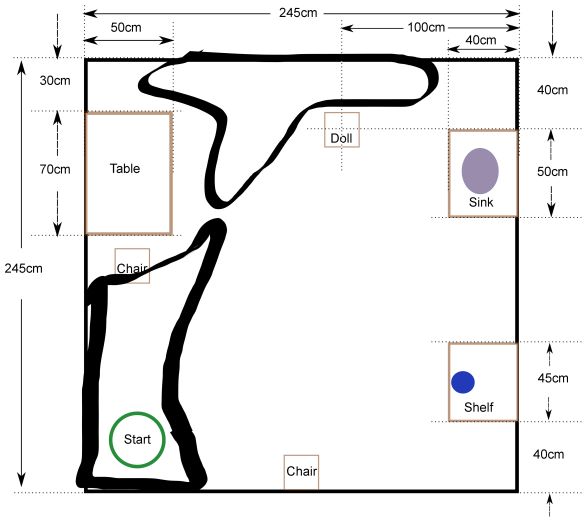


Figure 11.1: RoboWaiter Standard and Arbitrary Start Locations (RWArbStart12.png)

11.2 Operating Modes

All robots in the RoboWaiter contest may select any or all of these optional Operating Modes to improve their time scores. Each trial may use a different combination of Operating Modes.

When completed successfully the following options, available on each of the three trials, will result in reduced time scores, using the indicated multiplication factor (MF) for each of the listed premiums.

Food premium OM.food=0.8

The plate will contain a simulated food item: meat, potato, etc. Multiplier will be earned by delivering the plate to the table without dropping or spilling the food.

The food will be actual food, such as cereal or pasta, that does not stick to the plate. The food will not add any significant weight to the plate.

NOTE If the robot bumps the plate after placing it on the table and spills food on the table or floor, the Food Premium will not apply.

Arbitrary starting location OM.start = 0.85

The Judge will choose the robot's starting location and orientation at random and place the Home Circle at that position. This arbitrary starting location will not be physically closer to the plate (on the shelf or in the refrigerator) than the standard starting location. See Figure 11.1 for possible locations.

Grandma OM.grandma = 0.75

The Grandma doll is optional in the Standard Division. If this option is selected, the Grandma doll will be located as shown in Figure 10.1 on page 67. If the robot touches the Grandma doll, the Grandma Operating Mode factor will not apply to that trial.

The Grandma doll is always present in the Advanced Division, the Grandma Operating Mode does not apply. If the robot touches the Grandma doll, it fails that trial.

Return Trip OM.return = 0.80

The robot must return to the Home Circle position where it started the trial. The robot need not be in the same orientation as when it started the trial.

The robot's Actual Time (AT) recorded for the trial will be the time required to transfer the plate to the table, not including the return trip. However, the robot must return its starting location within 2 minutes; if not, then the Return Mode factor is not in effect for that trial.

Clean_Up OM.cleanup = 0.70

After the robot has returned to the Home Circle and ceased all motion, the Judge will restart the robot using the 3.8 kHz Standard Starting Device tone. The robot will return to the table, pick up the plate, transfer it to the sink, then return to the Home Circle again.

The plate will remain where the robot left it on the table, with the food in place. However, the robot may inadvertently move the plate while releasing it or while backing away from the table, so the Clean Up algorithm *should not* assume an exact plate location. The judges will not reposition the plate after the robot releases it.

The plate may be dumped into the sink in any orientation, but it must remain either on the top surface of the sink or within the bowl.

If the robot is operating in Food Premium Mode, then it *must not* spill any food onto the floor while transferring the plate to the sink. Food may spill onto the surface around the sink, but not onto the floor.

NOTE If the robot spills any food while transferring the plate from the refrigerator to the sink, the Food Premium will not apply to the trial. However, the robot must not spill any remaining food on the floor while moving the plate to the sink in order to successfully complete the Clean Up operation.

The robot must complete the Clean Up operation and cease all motion within 4 minutes of the second Start Signal. That time is *not* added to the

total time: the Clean Up Mode factor is applied to the original time required to place the plate on the table. In effect, by completing the Clean Up operation, the robot receives a significant scoring advantage.

However, if the robot fails to complete the Clean Up operation, it will fail the entire trial.

NOTE Clean Up Mode requires that the robot operate in Return Trip Mode.

Chapter 12

Scoring

Each robot will compete in three trials, with the Judges recording the time required to complete the trial. Section 11.2 on page 76 describes the Operating Modes in detail. Section 12.0.1 provides examples of scoring calculations.

Robots that have successfully completed at least one trial will be eligible for First, Second, and Third prizes, with accompanying cash awards. Robots that have not successfully completed at least one trial will not be eligible for prizes or cash awards.

Successful robots will be divided into three groups, based on the number of successful runs, to ensure that the most reliable robots receive awards. The ranking within each group will be based on the robot's final score for all three runs. The groups are:

1. Most Reliable group: successful on three trials.
2. Moderately Reliable group: two successful trials.
3. Least Reliable group: one successful trial.

Winners will be taken starting with the highest-ranking robots in the Most Reliable group, then continuing with the Moderately and Least Reliable groups, until the three winners have been identified.

Examples:

- If the Most Reliable group includes three robots, they will win the First, Second, and Third prizes based on their ranking within that group.
- If the Most Reliable group includes only two robots, then they will receive the First and Second prizes based on their ranking, while the highest-ranked robot in the Moderately Reliable group will receive the Third prize.

12.0.1 Scoring Examples

You can help by creating scoring examples for various situations, using the rules as a basis, to help verify your understanding of the rules. Please send them to the Editor (Ed Nisleyed.nisley@ieee.org).

Trial 1

Robot starts at home position, finds plate and delivers it to the table. No food on plate. No mode options completed.

Measured Actual Time AT = 78 s

Score: Success = 1; Time = AT = 78 s

Trial 2

Robot starts at home position, finds plate with food on it, delivers plate to table, returns to start.

Measured Actual Time AT = 56 s

Score: Success = 1; Time = AT * OM.food * OM.return = 56 * 0.8 * 0.8 = 35.84 s

Trial 3

Robot starts at arbitrary position, delivers plate with food to table, returns to start, and completes cleanup option.

Measured Actual Time AT = 109 s

Score: Success = 1; Time = AT * OM.start*OM.food * OM.return * OM.cleanup = 109 * 0.85 * 0.8 * 0.8 * 0.7 = 41.507 s

Overall Scores

Success = 3; Time = 78 + 44.8 + 41.507 s = 182.1 s

The robot is placed in the Most Reliable group with three successful trials. Its ranking will be determined by comparing overall time scores within that group.

Part V

Robot Olympiad Exam

The TCFFHRC Olympiad exam consists of about ten questions, each presenting a real problem that might arise during robot design projects. Each question requires a solution based on theoretical background and practical experience.

The exam takes 50 minutes.

The Olympiad is open to any registered team or individual, and prizes will be awarded to teams and individuals in Junior, High School, and Senior Divisions.

Check http://www.trincoll.edu/events/robot/ for the 2013 Olympiad schedule.

Questions about the Olympiad may be directed to:

Igor Verner ttrigor@tx.technion.ac.il

David Ahlgren david.ahlgren@trincoll.edu

Part VI

Technical Presentation Competition

Contributed by David Pietrocola, Science Education Analyst, National Science Foundation

The ability to effectively communicate technical ideas and designs is an increasingly important skill for engineers and scientists. The 2013 TCFFHRC technical presentation competition aims to encourage the development of such communication skills. The competition is optional for all teams. We encourage teams to summarize and convey their efforts by designing and delivering a presentation that explains the design and functionality of the robot.

Teams will present using a traditional scientific poster format, which involves designing a poster following established scientific poster templates (see below).

Entries will count toward the team's BURP score, which allows teams to be rewarded for effective communication abilities in addition to successful engineering design (please see the BURP section for scoring examples).

Guidelines

1. The poster presents the design of the team's firefighting or assistive robot. Posters must include the following sections and components, using a traditional scientific poster template:

   - Abstract and Introduction
   - Problem description and definition
   - Design process
   - System design or schematic
   - Results
   - Conclusions and future improvements
   - Informative diagrams and photos.

   Visit http://posterhall.org/igert2012 for many examples of common scientific posters, designed by graduate students from across the United States.

2. Teams will register for the poster competition as part of our web-based registration process.

3. Maximum poster size is 1 m wide x 70 cm high. Minimum poster size is 80 cm wide x 60 cm high. Poster stands will be provided to those who register for the poster session.

4. The competition is split into two rounds:

   (a) Judges will assess displayed posters

   (b) The top 10 teams will deliver a five-minute oral presentation using the poster as a visual aid.

   A maximum of two team members may present the poster to the Judges, who are engineers and university faculty. Presentation of the physical robot to the Judges is not permitted. A two-minute question & answer period between the presenters and the Judges will follow.

5. All posters must use English. However, teams for whom English is a second language may request to have an official contest-provided interpreter who can assist during the presentation. If you wish to have an interpreter at your poster presentation, please check the appropriate box on the registration form and indicate the language. Unofficial interpreters affiliated with the team are not permitted; their presence will be grounds for immediate disqualification of the team from the robot competition.

Judging Criteria

Posters are judged based on the following criteria:

1. Content – 40%
   - Problem appropriately described with context given
   - System architecture and overview described
   - Appropriate level of detail provided
   - Appropriate usage of the English language in a scientific context
     - grammar
     - style
     - tone and cadence
2. Visuals – 30%
   - Easy to read and see
   - Obvious logical sequence of material
   - Useful and appropriate diagrams, photos, etc.
3. Presentation – 30%
   - Appropriate overview, focus, preparation, and delivery
   - Good articulation
   - Appropriate response to judges' questions

Scoring

Each criterion (content, visuals, presentation) will be judged, with each specification earning a score of 0, 5, or 10 points. The points will be summed to produce a total score up to the maximum 100 points.

The poster's final score will be the average of the individual score values determined by each Judge.

Common Mistakes

Although a *good* poster will build on the points mentioned above, you can make your poster better by following these guidelines:

1. Create a technical poster, not a personal ad for your robot.
2. Use plain backgrounds. Avoid busy patterns and bright colors.
3. Use large, simple fonts. If you cannot read every word on your poster from a distance of 2 meters, neither can the Judges.
4. Describe your robot and project, not your school, your hometown, your friends, or the funny team mascot you made.
5. Do not include large photos of you, your team, or your school. Only the robot matters.
6. Do not include inside jokes about your team. They belong within the team and have no place in a technical presentation.
7. Include technical details of your project, not just a list of robot components. Describe your unique algorithm that processes sensor data, the special wheels you built, or the mechanical innovation that distinguishes your robot from the others.
8. Do not glue robot parts to the poster. Use a camera and include only photos.

Oral Presentation Guidelines

1. Be prepared to explain your team's design decisions and how each component or subsystem functions. The Judges may ask about sensors, navigation algorithms, motor control, propulsion mechanisms, or any other feature of your robot.
2. Practice, practice, practice! If two team members will present the material, practice both the roles and the transitions between them.

Suggestion

A good way to determine whether you have made an effective poster is to hand it to someone who has never seen your work before. Leave the room for five minutes while they look at your poster. When you return, ask them to describe your project to you. If your poster effectively presents the information about your robot project, they will be able to give you a reasonable overview of your work.

Part VII

Regional Contest Events

Establishing a Regional Event

Trinity College's Fire-Fighting Home Robot Contest rules are published on the Contest Website at http://www.trincoll.edu/events/robot/.

We invite you to use these rules without charge for the limited purpose of use as the basis for a non-profit educational project or to organize your own non-profit firefighting robot contest. You acknowledge and agree by your use of these rules, whether for an official regional contest or an unofficial contest, that Trinity College assumes no responsibility or liability for such use of the contest rules by you or any third parties. These rules are provided "as is" without any warranty of any kind.

If you plan to use the Trinity rules, we request that you send a 50-100 word description of your activity to the contest Director via email.

Your use of the Trinity rules does not automatically qualify your robot to participate in the official Trinity College Fire-Fighting Home Robot Contest ("TCFFHRC") to be held at Trinity College.

Requirements

Official regional contests are public events based on the Trinity rules found on the Contest Website at `http://www.trincoll.edu/events/robot/`. The characteristics of official regional contests and Trinity's relationship to them are listed below.

In order to hold an official regional contest, the contest should meet these requirements:

- Longevity: regional contests will have a life span greater than one year.
- Open participation: regional contest organizers will publicize their contest and invite the public to participate.
- Non-profit: Regional contests are not-for-profit events.
- Qualification is not required for the TCFFHRC.
- Availability of advice: Regional contests may ask Trinity for advice regarding event organization.
- Web links: We will put a link to each regional contest that meets these requirements on our website, and vice-versa.

Procedure

In order to become an official regional contest and to obtain the benefits listed above, please send the contest director an email message indicating your interest and confirming your agreement to the requirements described above. In turn you will be sent an application form that asks such information as name and date of event, expected participation, contest Divisions that you wish to offer, and names of sponsors.

When planning your event please note that normally regional contests are held within eight weeks prior to the official Trinity College Fire-Fighting Home Robot Contest to be held at Trinity College.

Requests for new regional contests should be sent to the Director at least six months before the next Trinity contest.

Part VIII

Appendix

Appendix A

Start Button Locations

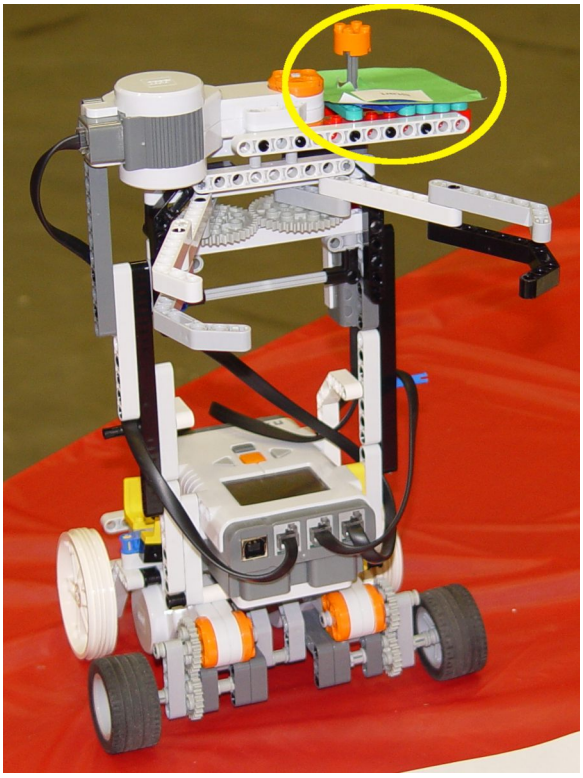


Figure A.1: Mechanical Start Button Linkage (dsc00871 - Mechanical Start Button Linkage.jpg)

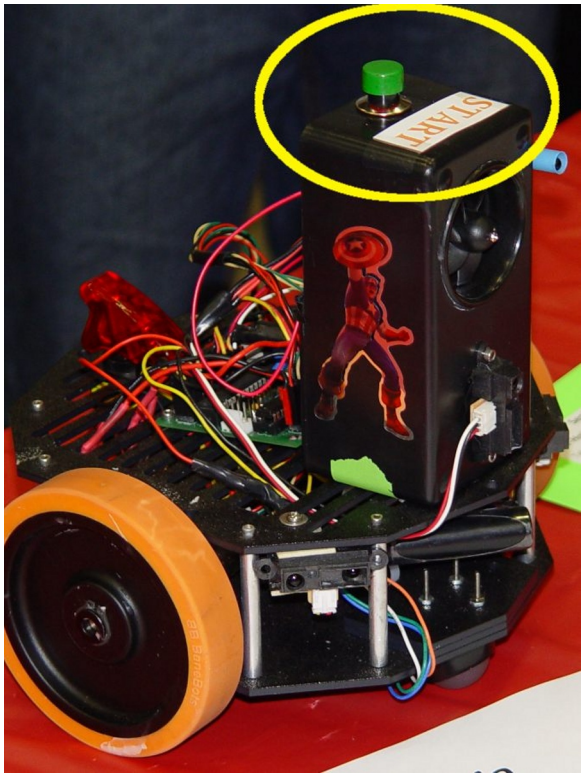


Figure A.2: Ideal Start Button Location (dsc00892 - Start Button Location 2.jpg)

Section 5.2.3 on page 32 describes the requirements for the Start Button. This Appendix provides examples of acceptable and unacceptable Start Button locations.

A.1 Mechanical Linkage

Figure A.1 shows a mechanical linkage between a Start Button at the top of a robot and an electrical switch located on the body. The top of the linkage must have a flat button-shaped actuator on the rod or shaft.

A.2 Acceptable Locations

Figure A.2 shows an ideal Start Button location on the highest part of the robot, above all other parts, with clear identification and color coding.

Figure A.3 on the following page shows an acceptable Start Button location. The white sensor housing at the front of the robot is less than 2 cm above the Start Button.

A.3 Unacceptable Locations

The Start Button in Figure A.4 on the next page will *not* be acceptable in the 2013 contest, because it is below the top of the fan blade tips and more than 2 cm below other mechanical parts.

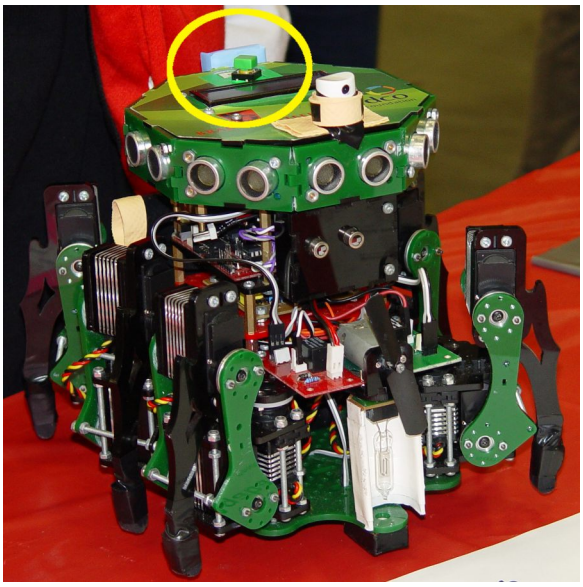


Figure A.3: Acceptable Start Button Location (dsc00884 - Start Button Location 1.jpg)

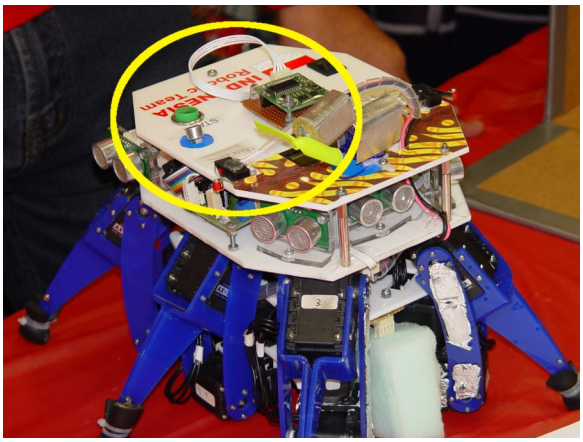


Figure A.4: Incorrect Start Button Location (dsc00887 - Unacceptable Start Button Location 1.jpg)

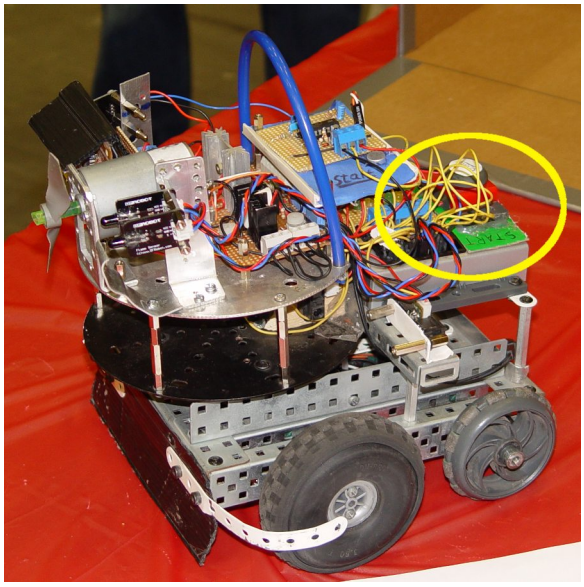


Figure A.5: Incorrect Start Button Location (dsc00933 - Unacceptable Start Button Location 2.jpg)

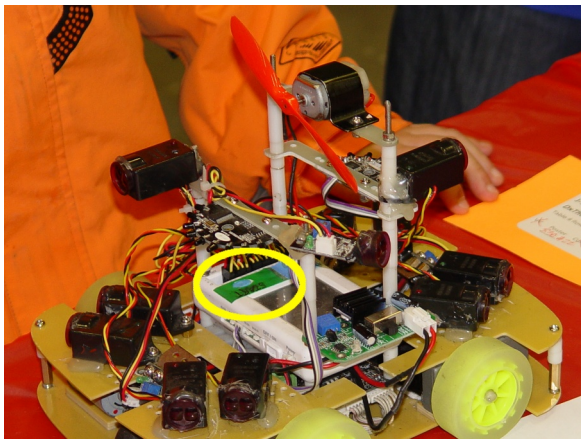


Figure A.6: Incorrect Start Button Location (dsc00913 - Unacceptable Start Button Location 3.jpg)

The Start Button in Figure A.5 will *not* be acceptable in the 2013 contest, because it is not on the top surface of the robot and more than 2 cm below other mechanical parts.

The Start Button in Figure A.6 will *not* be acceptable in the 2013 Contest, because it is below the top of the fan blade arc, not on the top surface of the robot, and more than 2 cm below other mechanical parts.

Appendix B

Standard Sound Start Device

Judges will use only the Standard Sound Start Device during the contest. Teams may *not* bring their own devices to the arena during trials.

B.1 Operation

The Sound Start Device emits two selectable tones: 3.8 kHz and 2.5 kHz.

The specified sound modules produce approximately 90 dB SPL at 1 foot. The SPL will be higher at the microphone, due to the closer distance, but there is no specification for the actual intensity.

The selected tone will sound for at least 5 seconds after the Judge presses the Tone button.

The robot must start with the Sound Start Device approximately 25 mm from the robot's microphone. The Device has a 25 mm rod indicating this distance; the rod will not touch the robot.

Figure B.1: A Standard Sound Start Device (Standard Sound Start Device - StartBox-12_030.jpg)

B.2 Hardware

Figure B.1 shows a Standard Sound Start Device.

Figure B.2 on the next page shows the dual-frequency Standard Sound Start Device used in the RoboWaiter Advanced Division.

B.3 Schematic

Figure B.3 on the following page shows the schematic diagram of the circuitry inside the Sound Start Device.

Figure B.4 on the next page shows the component layout inside the case.

B.4 Parts List

Table B.1 on page 99 lists the parts required to construct a Standard Sound Start Device.

Figure B.2: A dual-frequency Standard Sound Start Device for the RoboWaiter Advanced Division (Standard Sound Start Device - RoboWaiter - SB_RW_Advanced033.jpg)

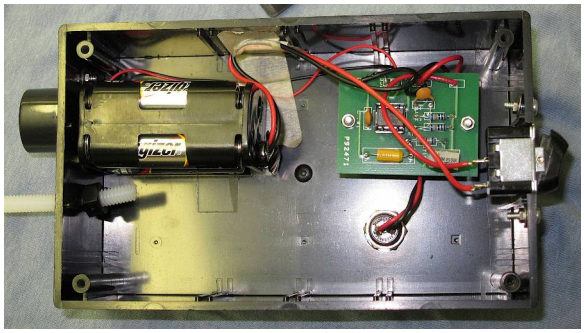


Figure B.4: Interior view of Standard Sound Start Device (Standard Sound Start Device - Interior - StartBox12_031.jpg)

The circuit can be hand wired on a prototyping board or laid out on a custom PCB to suit your enclosure; we do not provide a PCB layout.

B.5 Construction

Adjust trimpot R3 for 5 second sound duration after each press of switch SW1.

Add 25 mm nonconductive rod near the buzzer to maintain the correct standoff distance from the robot's microphone.

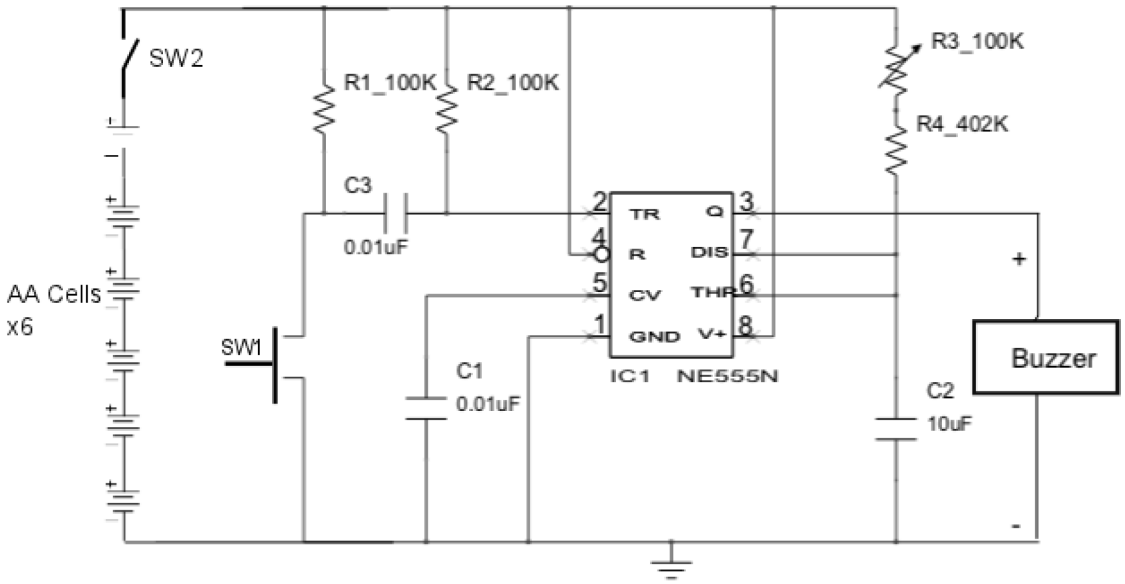


Figure B.3: Standard Sound Start Device Schematic (StartBoxSchematicBW.png)

Part	Manufacturer	Manuf. Part Number	Mouser P/N
SW1 pushbutton switch	E-Switch	PS-1040A-RED	612-PS1040A-RED
SW2 on/off switch			
Battery holder (6 x AA)	Eagle	12BH364-GR	12BH364-GR
Buzzer (2.5 kHz)	Mallory	PK-20A25WQ	539-PK-20A25WQ
Buzzer (3.8 kHz)	Mallory	PK-20N38WQ	539-PK-20N38WQ
IC1 NE555N	(various)	NE555N	511-NE555N
R3 100K 10% pot	Bi Tech	68WR100KLF	858-68WR100KLF
R1,R2 100K 1% res	Xicon	100K-RC	271-100K-RC
R4 402K 1% res	Xicon	402K-RC	271-402-RC
C1 0.01 uF/50V cap	Vishay	D103Z25Z5VF63L6R	594-D103Z25Z5VF63L6R
C2 10 uF/15V tantalum	Kemet	T322C106K015AT	80-T322C106K015AT
AA batteries x 6			
Case			
Printed circuit board			

Table B.1: Standard Sound Start Device Parts List (StartBoxPartsList.ods)

Appendix C

RoboWaiter Refrigerator Hardware

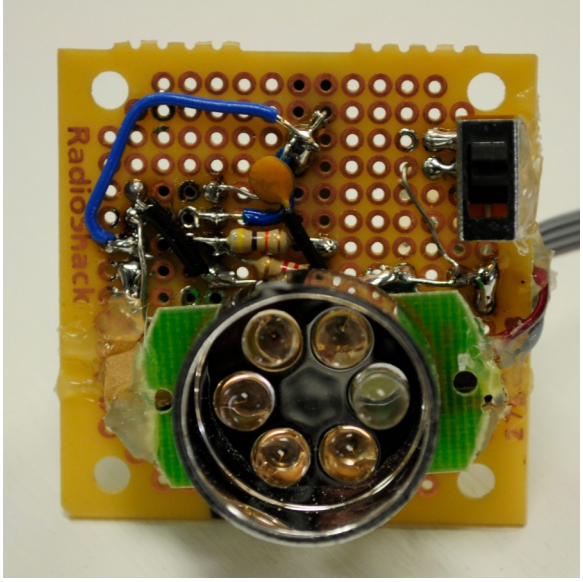


Figure C.1: Refrigerator Door LED array (Beacon-Board 216 - scaled.jpg)

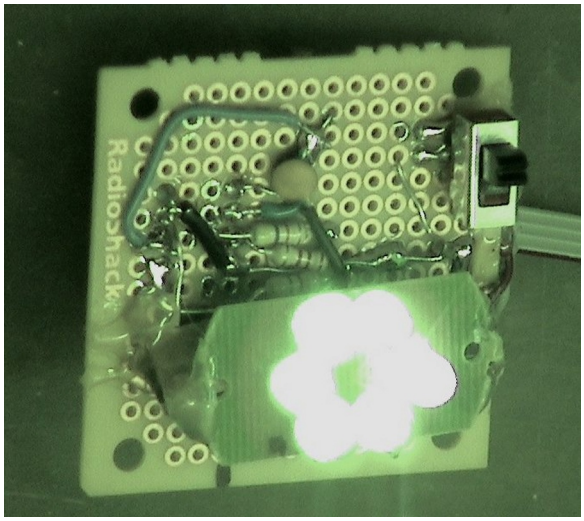


Figure C.2: Refrigerator Door LED array in IR light (BeaconIRs 217 - scaled.jpg)

C.1 Refrigerator Door Beacon

C.1.1 Hardware

Figures C.1 and C.2 show the LED array and driver circuit board.

C.1.2 Schematic

Figure C.3 on the next page gives the beacon driver schematic and parts list.

C.2 Refrigerator Door Sensor

C.2.1 Layout

Figure C.4 shows the sensor module installed in the black-painted arena floor.

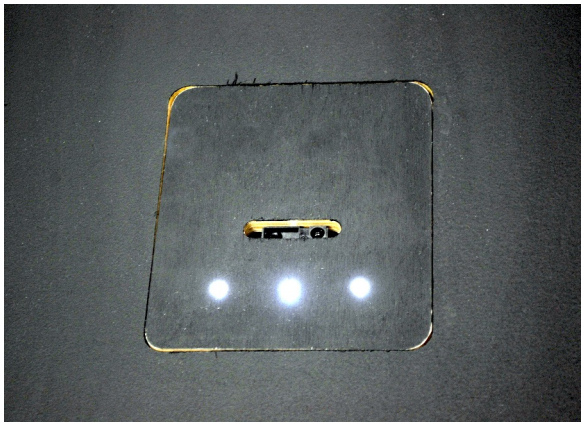
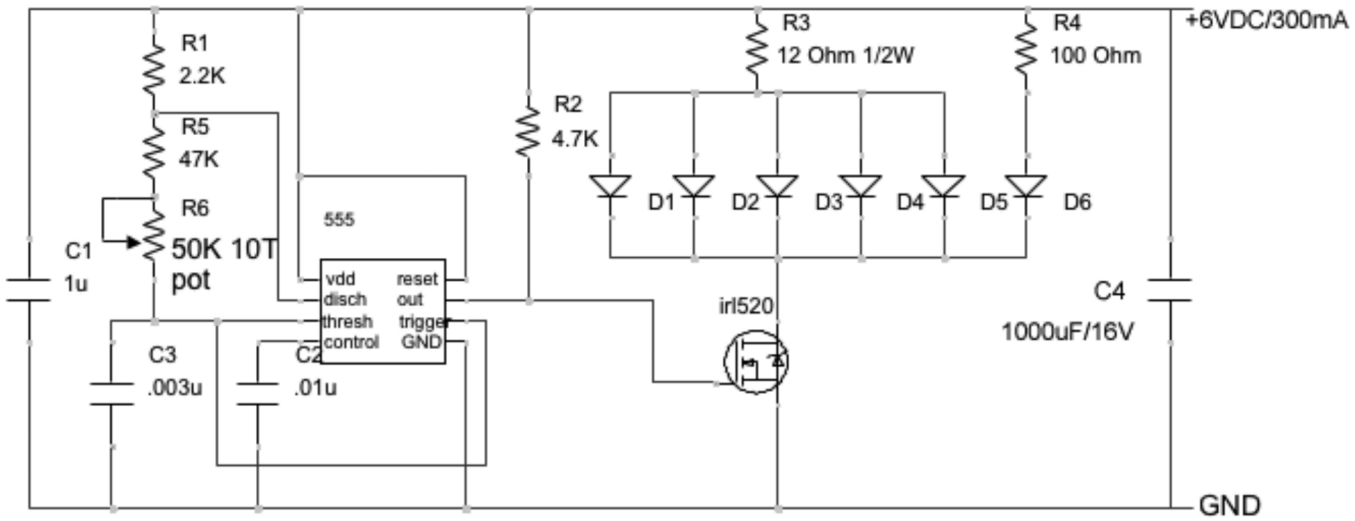
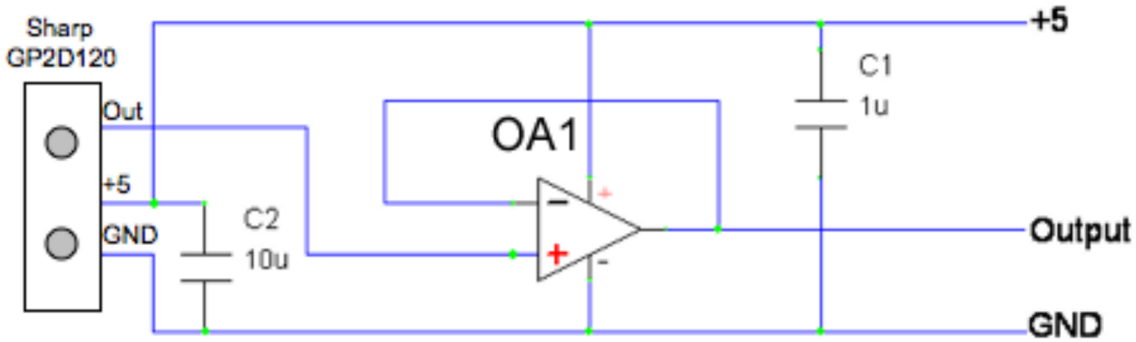


Figure C.4: Refrigerator Door sensor module (Floor Sensor 215 - scaled.jpg)



Notes: All resistors 1/4 watt except for R3
C1, C4 electrolytic
C2, C3 ceramic
D1...D5 IR emitters Fairchild QED523 or equivalent
D6 bright white visible LED from flashlight board
R6 Vishay T18503KT10 10-turn potentiometer

Figure C.3: Refrigerator Beacon Schematic and Parts List (Beacon Schematic - scaled.png)



Notes:

1. Op-Amp OA1 is Texas Instruments TLC272IP
2. C1 = 0.1 uF/16V ceramic
3. C2 = 10 uF/16V electrolytic
4. D1,D2,D3 TT Electronics/Optek Technology type OVLAW4CB7 bright white LED (or equivalent)
5. R1, R2, R3 150 Ohm 1/4 watt carbon resistor

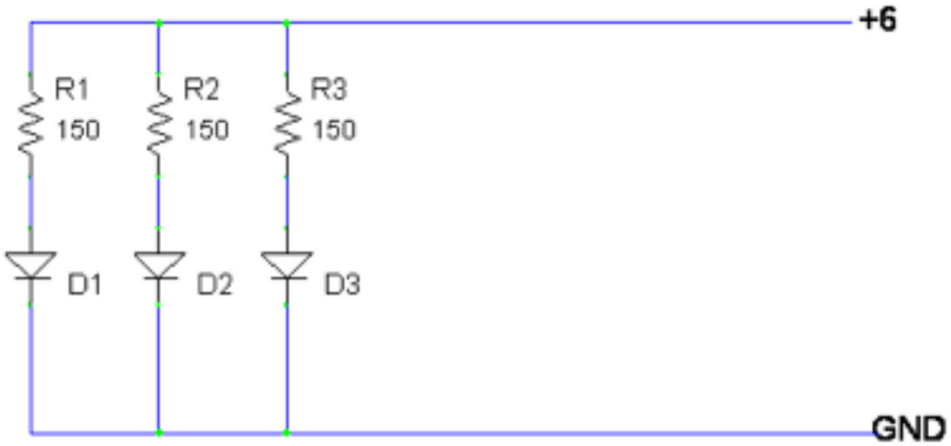


Figure C.5: (Floor Sensor Schematic - scaled.png)

C.2.2 Schematic

Figure C.5 on the preceding page shows the sensor schematic and parts list.

Appendix D

Robot Inspection Table Checklist

All robots must pass an inspection at the Robot Inspection Table before competing. See Section 2.8 on page 19 for more details.

The sample RIT Checklist on page 106 itemizes some physical and performance requirements, but your robot must comply with *all* the requirements of this rules document.

Robot Inspection Table Checklist	Photo ❍

Robot Bounding Box

Division		Max Size L•W•H	Spec Section	Exam 1 Pass	Exam 1 Fail	Exam 2 Pass	Exam 2 Fail
FF	Wheel / tread	31•31•27	5.2.2	❍	❍	❍	❍
FF	Walking - legs extended	46•31•27					
RW	All - grippers excluded	30•30•50	10.2.1				

Only non-functional decorations beyond Bounding Box=5.2.2

Firefighting Extinguisher

Method	Max Capacity	Spec Section	Exam 1 Pass	Exam 1 Fail	Exam 2 Pass	Exam 2 Fail
Water (single robot | swarm)	50 | 100 ml	5.3.1.1	❍	❍	❍	❍
CO_2 gas capsule (per robot)	16 g					
Mechanical snuffers, etc	Bound Box	5.2.2				

No extinguishing hardware beyond Bounding Box=5.2.2

Start Button & Sound Start Microphone

Label	Color	Location (Appendix A)	Spec Section	Exam 1 Pass	Exam 1 Fail	Exam 2 Pass	Exam 2 Fail
START	Green	≤2 cm below highest	5.2.3	❍	❍	❍	❍
MIC	Blue	Above fan blades	5.2.4	❍	❍	❍	❍

Button: RW Std=10.2.2, *not required* for **RW Adv**=10.2.2.2

Sound Start Response

Division		Freq kHz	Spec Section	Exam 1 Pass	Exam 1 Fail	Exam 2 Pass	Exam 2 Fail
FF	*Not* Jr, required Sr	3.8	6.5.1.3	❍	❍	❍	❍
RW Std	Only in SS mode		10.2.2.1				
RW Adv	Upper shelf	2.5	10.2.2.2				
RW Adv	Lower shelf	3.8					

Junior Division robots *must not* respond to Sound Start Device=6.5.1.3

Junior **Klaatu Tech Foundry** **Esperanto**

Etaoin Shrdlu

Gort II

Figure D.1: Sample RIT Checklist Form (Robot Inspection Table Checklist - Appendix Image.png)

Appendix E

Trial Options Sheet

The Trial Options Sheet specifies all of the Operating Modes that apply to each of a robot's Trial Runs in a Contest arena.

Teams competing in the Junior, High School, and Senior Divisions *must* present a Trial Options Sheet, similar to the sample on page 108, to the Judge at the arena when they arrive for their robot's trial. The sheet must contain the options for the current trial; teams do not need to select options for future trials.

Teams competing in the Expert division do not need a Trial Options Sheet, because the Expert Division has no optional Operating Modes (Section 7.4 on page 57).

Junior	Klaatu Tech Foundry	Esperanto

Etaoin Shrdlu

Gort II

Options - Trial 1

Operating Mode	Selected	Section	Information
Sound Activated	❍	6.5.1.3	Not allowed in Junior
Arbitrary Start Location	❍	6.5.1.4	
Return Trip	❍	6.5.1.5	
Non-air Extinguisher	❍	6.5.1.6	
Furniture	❍	6.5.1.7	
Coat Tree	❍	6.5.1.8	
Variable Door Locations	❍	6.5.1.10	Optional=Jr Mandatory=Sr
Candle Location	❍	6.5.1.11	Detect: LED ❍ Action ❍ Other ❍

Options - Trial 2

Operating Mode	Selected	Section	Information
Sound Activated	❍	6.5.1.3	Not allowed in Junior
Arbitrary Start Location	❍	6.5.1.4	
Return Trip	❍	6.5.1.5	
Non-air Extinguisher	❍	6.5.1.6	
Furniture	❍	6.5.1.7	
Coat Tree	❍	6.5.1.8	
Variable Door Locations	❍	6.5.1.10	Optional=Jr Mandatory=Sr
Candle Location	❍	6.5.1.11	Detect: LED ❍ Action ❍ Other ❍

Options - Trial 3

Operating Mode	Selected	Section	Information
Sound Activated	❍	6.5.1.3	Not allowed in Junior
Arbitrary Start Location	❍	6.5.1.4	
Return Trip	❍	6.5.1.5	
Non-air Extinguisher	❍	6.5.1.6	
Furniture	❍	6.5.1.7	
Coat Tree	❍	6.5.1.8	
Variable Door Locations	❍	6.5.1.10	Optional=Jr Mandatory=Sr
Candle Location	❍	6.5.1.11	Detect: LED ❍ Action ❍ Other ❍

Figure E.1: Sample Trial Options Sheet (FF Contest Trial Options - Appendix Image.png)