Trinity College
Fire-Fighting Home Robot Contest
2017 Rules V1.0

October 16, 2016

Contents

Chapter 1

Introduction

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.trinityrobotcontest.org.

This document should be regarded as definitive. Do not use rules from previous contest years; several rules have changed for 2017. You may expect minor updates throughout the fall of 2016.

If you find an error or inconsistency, please send an email to Dave Ahlgren (david.ahlgren@trincoll.edu) with a copy to the Contest Director John Mertens (john.mertens@trincoll.edu). We will defer problems reported after noon on the Monday preceding the Contest weekend until the next year's Contest.

SUMMARY OF– CHANGES TO CONTEST RULES FOR 2017

1. Prize eligibility: Only Junior and Walking Division robots are eligible for Level 1 prizes. Robots in any Division are eligible for Level 2 and Level 3 prizes
2. Practice times: Arenas will be open for practice on Saturday April 1 and Sunday April 2. There will be no practice on Friday, March 31.
3. In the Level 3 challenge robots must use computer vision to detect Red, Green, and Blue patterns on the cradle base (Section D.3 on page 54). These patterns replace the blue LED that served as an indicator on the 2016 cradle.
4. It is now mandatory that the robot's control panel be mounted on the robot handle.

Please contact us with your questions and consult the FAQ link on the contest website.

Chapter 2

Registration and Eligibility

2.1 Mission Statement

The contest rules, spirit, setting, and tone derive from this statement of our mission:

> The Trinity College Firefighting Home Robot Contest (TCFFHRC) is an open, non-profit event that requires invention of autonomous, socially relevant robots. The contests promote creativity, teamwork, the understanding and application of STEM subjects, and the sharing of ideas.

2.2 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 single country outside the United States. This restriction applies to the contest as a whole, not at each level of the contest.

2.3 Unique and Customized Robots

In accordance with our mission, the Trinity College Fire-Fighting Home Robot Contest and the associated regional contests, encourage contestants to prepare original, unique robots 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 some design features with another robot entered in the contest.

Therefore the contest has two categories of robots, *Unique* and *Customized*, described below. Unique robots will be eligible for larger cash prizes than Customized robots.

Contest officials will examine each robot at the contest Robot Inspection Table (RIT) to verify that the robot has been registered in the correct category.

Unique robots

- Are constructed from a unique assortment of parts chosen by the design team
- May use some components from a kit, but the overall design is unique.
- Use mechanical, sensing, electrical, and software subsystems designed or chosen by the team.
- May use any commercial computer as its brain.
- Are clearly different from any other robot entered in the contest, including those entered by other teams.

Customized robots

- May be built primarily from a single retail parts collection or a kit.
- May be a modified version of a commercial robot

Teams will designate their robots as *Unique* or *Customized* when they register for the contest.

Our inspectors will examine each robot when the team checks in. The inspectors will verify the category of each robot and, at their discretion, change the category if appropriate.

Note Any robot that the inspectors determine to be an unmodified commercial robot will not be allowed in the contest.

2.4 Multiple Entries

A team may enter more than one robot by paying a separate registration fee for each robot.

In order to qualify for a *Unique* robot prize, each robot must differ visibly and significantly from all other robots in at least some aspects of electronics or mechanics.

An individual, team or school *must not register multiple identical robots* as separate entries in the same Division: the *Customized* category does not allow identical robots.

Note: Non-functional items, such as paint, stickers, and other decorations, do not affect the robot's category.

2.5 Registration

Registration for the TCFFHRC is available only on-line through the contest website `http://www.trinityrobotcontest.org`.

We will accept registration applications from 12:01 a.m. Eastern Standard Time on December 1, 2016 to 11:59 p.m. Eastern Daylight Time on March 15, 2017. News updates about registration and other contest matters will be posted on the website regularly.

The steps in the registration process are as follows:

1. Go to the contest website `http://www.trinityrobotcontest.org` and click on the Registration tab.
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.
5. Payment is by credit card only, at the time you register. We do not accept checks or cash.

2.5.1 Deadline

You must register for the contest during the registration period above. 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!

2.6 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 fees for the 2017 contest are:

- Junior - $75
  - Walking - $85
  - High School - $85
  - Senior - $85

2.7 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.

2.8 Inspection, Qualification, and Elimination Rounds

Every team must demonstrate that its robot conforms to the contest specifications. Thus, before the team begins to practice in the contest arenas its robot/s must pass inspection at the Robot Inspection Table (Section 3.8 on page 12).

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.

2.9 Contest Location, Dates, and Schedule

TCFFHRC events will be held at Trinity College in Hartford, Connecticut, USA, from Friday March 31, 2017 through Sunday April 2, 2017.

The full schedule of events for the contest will be posted on the Contest Website at http://www.trinityrobotcontest.org.

The main events are the the Firefighting contest (Section 1 on page 6), the Robotics Olympiad (Section 7 on page 38), and the Poster Competition (Section 8 on page 39).

Chapter 3

General Rules and Procedures

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.

3.1 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.

3.2 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.

3.3 Safety

Any Contest official may stop, by pulling the robot's kill power plug, 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.

3.4 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 15 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.

3.5 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*.

3.5.1 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

3.6 Practice Time

The contest arenas will be assembled and available for unscheduled test trials at the stated practice times. The practice schedule is below:

Saturday, April 1: 8 a.m. – 12 noon.

Sunday, April 2: 8 a.m. – 10 a.m.

There is no practice on Friday, March 31.

Due to the limited number of arenas and the large number of robots, waiting lines might become– long during practice times.

Robots should be built, programmed, and ready to compete on arrival at the contest site. You should use the practice time to calibrate sensors for the conditions in the gym and to troubleshoot any last minute problems.

NOTES:

1. 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.
2. 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.

3.6.1 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.

3.7 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.

3.8 Robot Inspection Table

Each robot must meet the specifications described in these rules, so that it will compete fairly with other robots.Each team will present its robot at the Robot Inspection Table (RIT) prior to the start of the Contest trials to verify that it meets these specifications:

- Overall size
- Extinguisher capacity
- Start Button position, label, and color (Junior Division only).
- Robot handle
- Check for arrow showing which direction the robot will move when started
- Except for Junior Division robots:
  - Microphone position, label, and color
  - Response to the Standard Sound Start Device
  - Operation with standard SPL (Sound Pressure Level)
  - Detection of 3.8 kHz tone using standard contest start device
- For robots intending to compete in Level 3, judges will check the robot's vision system if present
- General conformance to the rules

NOTES:

1. The robot's drive motors MUST be disabled before the robot is screened at the RIT (Robot Inspection Table), either by disconnecting the motor power supply or by disabling the appropriate control signal. Note that the power may be easily removed using the robot's kill power plug (Section 4.5.6).
2. If there are moving parts other than the drive motors, the fullest extension must be articulated and presented at RIT to verify that it is conforming to the rules. To prevent potential mishandling on the team representative may perform this operation.

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 E on page 57.

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

The RIT will be officially open only on Friday from 3 - 6 pm, Saturday from 9 a.m. - 4 p.m., and Sunday from 8:30 a.m. - 10:30 a.m. If your robot does not pass inspection when the RIT is officially open, the robot will not be able to compete. The competition starts on Saturday. Check the bulletin board at the Registration Table for any schedule changes.

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

3.9 Trial Sequence

Several different arena configurations will operate simultaneously during the competition. Robots will form a queue. At the time the next arena becomes available, the robot at the head of the queue will be assigned to that arena by the dispatcher judge. In this way, the assignment of robots to arenas is nearly a random process. The team will immediately proceed to the assigned arena and place the robot on the Judge's table there. Any robot that is not ready to compete will forfeit its chance at that trial and no appeals will be accepted. The robot may still compete in any remaining trials and as the best 3 of the five trials determines the score. A missed trial does not prevent an overall win.

If you are content after the 3rd or 4th trial, it is not necessary to complete 5 trials.

Remember: No robot may take more than three runs on Saturday. No robot may take more than three runs on Sunday. Exceptions will be made only for religious reasons.

3.10 Starting the Trial

The team will receive the Trial Options Sheet when they check in at the registration table. When they arrive for each of their robot's trials the team will place the robot on the Judge's table and give the Judge the Trial Options Sheet (Appendix F on page 59).

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 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 rules of the robot's Division.

3.10.1 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 5.3.3.2 on page 31, 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.

3.10.2 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.Fire-Fighting Contest Divisions, Levels, and Structure

3.11 Introduction

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. In Level 3, the most challenging level in the contest, the robot must also rescue a baby endangered by fire.

The robot must operate autonomously during all parts of the challenge, without human intervention, using its own sensors, control logic, and actuators. Each Team has the responsibility to build a robot that conforms to the rules applicable to the 2017 Contest. Additional events held during the TCFFHRC weekend provide different challenges, as described in these rules. Direct questions and comments about the contest to the Contest Director: John Mertens john.mertens@ trincoll.edu.

3.12 Divisions

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

- Junior - Grades 8 and below
- High School - Grades 9 through 12
- Senior - College/University, professionals, adult hobbyists
- Walking - Any age

Teams or individuals may also demonstrate their robotics knowledge by taking the Robot Olympiad exam (Part 7 on page 38).

3.12.1 Division Criteria

Each team must register in one of the Divisions listed in Section 3.12.

The following rules apply to registration.

- Teams that meet the criteria for a particular Division must register in that Division. Teams with mixed membership must register in the division appropriate to the most senior member of the team; e.g., a team with one high school student and three junior students must register in the High School Division.
- If a Division is full, the robot will be placed on a waiting list.
- No single robot may be entered in more than one contest Division.
- Robots will compete only in the Division in which they are registered.
- In order to change Divisions, the team must re-register the robot and pay an additional registration fee. Teams may not change Divisions after the registration deadline.
- The Contest Judges may reclassify robots entered in an incorrect Division.
- Entry fees will not be refunded.

3.13 Firefighting Contest Description

3.13.1 Competition Levels

The 2017 FireFighting Competition will take place at three levels of challenge: Level 1, Level 2, and Level 3. Each level presents a greater challenge than the

level below. Robots in any Division are invited to compete at any Level.

Level 1 will take place in the former Junior/Walking arena. The Level 1 competition rules are based on the Junior Division rules used in past contests.

Level 2 will take place in the former High School/Senior arena. The Level 2 rules are based on the 2015 High School/Senior rules. .

The greatest challenge will be posed by Level 3, a new event, which will take place in two connected Level 2 mazes. Level 3 combines firefighting and search and rescue tasks.

The overarching goal for teams is to complete as many levels as possible, starting at Level 1 and proceeding to Level 2 and Level 3, with the lowest total final score.

3.13.2 Schedule

All robot performance events will take in the Oosting Gymnasium on theTrinity College campus.

The Level 1 and Level 2 events will start on Saturday, and the competition will proceed at all three levels on Sunday.

Practice time is provided on Saturday and Sunday (see Section 3.6).

3.13.3 General Requirements

Before competing at any level each robot must pass inspection at Robot Inspection Table. For details, see Section 3.8 on page 12).

A robot must have at least one successful run at Level 1 to qualify for competition at Level 2 . A successful run at Level 1 is a run during which the robot extinguishes the flame within the 3-minute time limit.

A robot must have at least one successful run at Level 2 to qualify for competition at Level 3. A successful run at Level 2 is a run during which the robot extinguishes the flame within the 4-minute time limit.

Each robot has a maximum of five runs total over all levels.

No robot may take more than three runs on Saturday, andno robot may take more than three runs on Sunday. We allow exceptions to this only for religious reasons.

Robots that have three successive Level 1 runs without success are disqualified from further competition.

Robots that have three successive Level 2 runs without success are disqualified from further competition.

Once a robot competes at Level 2 it may not return to Level 1, and once a robot has competed at Level 3 it may not return to Level 2 or Level 1.

3.14 Level 1 Competition

The Level 1 competition is the entry level for the 2017 TCFFHRC. All robots must start at Level 1. Robots may choose to compete only at Level 1 or may use a successful Level 1 run as a springboard to Level 2.– Level 1 trials take place in the basic firefighting arena shown in Figure 4.1.3 on page 18. Level 1 procedures are presented in Section 3.9 on page 13, and scoring for Level 1 is presented in Section5.1.1.

The run time limit for Level 1 is 3 minutes.

3.15 Level 2 Competition

The Level 2 competition is the intermediate level in the 2016 TCFFHRC. Robots are eligible to compete at Level 2 if they have at least one successful run at Level 1. Level 2 trials take place in the arena described in Section 4.1.4 on page 18. Level 2 procedures are presented in Section 3.9 on page 13, and scoring for Level 2 is presented in Section 5.1.1 on page 28.

The run time limit for Level 1 is 4 minutes.

3.16 Level 3 Competition

The most challenging event in the 2017 TCFFHRC, the Level 3 competition presents a combined firefighting and search-and-rescue mission.

The Level 3 robot mission is to find and rescue a sleeping baby, represented by a doll and to put out all active flames within the 5-minute Level 3 time limit. The search and rescue task has highest priority and must be accomplished first.

The Level 3 arena consists of two Level 2 arenas (denoted as sub-arenas A and B) separated by a distance of 1 m and connected by a hallway having the same width as the arena hallways.

At Level 3 robots can expect the presence of dog obstacles (Section 4.3 on page 20), furniture (Section 5.3.1.7), and rugs (Section 4.6 on page 19).

There are two possible configurations of the hallway: (1) the standard configuration, which is a flat surface, 1 m in length, painted flat black, or (2) an optional up-and-down inclined hallway. This inclined hallway is divided into three segments of approximately equal length. The maximum pitch angle of the up and down ramp sections of the hallway is 15 degrees. See Appendix D.2 on page 52 for more information about the inclined hallway. Robots that succeed in traversing the inclined hallway on a run will receive a 10% decrease for that run.

See Section 5.3.6 on page 33 for detailed descriptions of the Level 3 options.

The baby is represented by a small doll lying in a cradle (Appendix D.3 on page 54).

3.16.1 Level 3 Runs

The robot's goal is to rescue the baby in shortest time and then to put out all fires present in the two halves of the arena.

The robot will start at a position determined by the judges at the start of the run. The start position will be marked by a circular white marker, or Start Circle of the kind shown in Figure 4.7 on page 20. The sub-arena in which the robot starts will be called "Arena A" and the other "Arena B".

The baby will be placed somewhere in Arena B.

In standard mode the robot must find and retrieve the baby and transport the baby back to the start position in Arena A. This start position is the primary rescue safe zone.

The robot will improve its score if it can use computer vision to locate an optional secondary safe zone where it can place the baby (Section 5.3.6.1 on page 33).

Initially there will also be one lit candle in Arena B. Two additional candles, initially not lit, will be placed within a room or rooms in Arena A. One of these Arena A candles will be lit 90 seconds after the robot starts. The second will be lit 120 seconds after the robot starts.

The robot must pick up the baby and bring it back to the chosen safe zone. The time needed to complete the rescue task (the Actual Time for the run) is recorded.

The additional time it takes to put out all of the lit candles is added to the Actual Time. This sum must not exceed the limit of 5 minutes.

Chapter 4

Specifications

4.1 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 3.4 on page 10.

4.1.1 Dimensions

The arenas are based on a common layout, with dimensions as shown in Figure 4.1. The Level 3 arenas are composed of two such arenas with those dimensions. In addition to those dimensions,

- Hallway width: 46 cm
- Door opening: 46 cm
- Walls: 1.9 cm thick, 27 to 34 cm tall, as measured from the arena floor.

The location of any given point may vary by as much as 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 emphasize 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 3.4 on page 10.

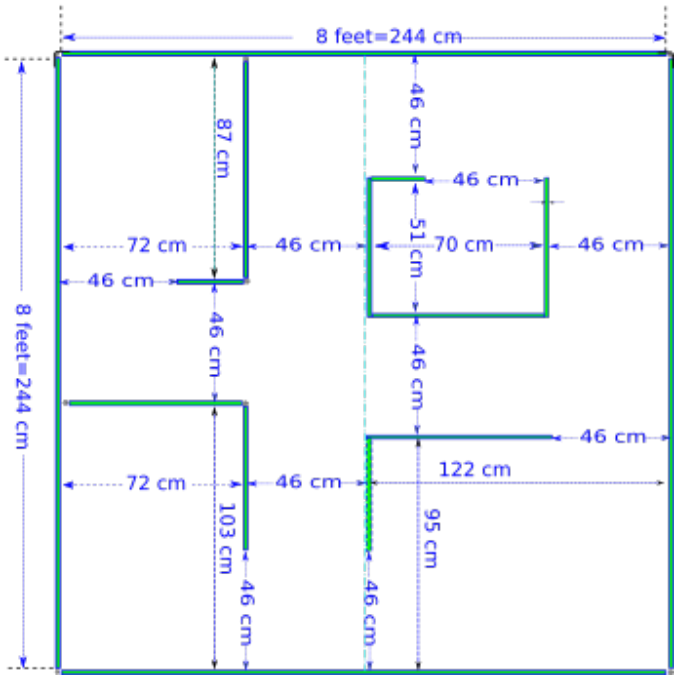

Figure 4.1: Level 1 Arena Showing Dimensions (figure5.1C.png)

4.1.2 Materials and Finishes

The arena floors consist of plywood, painted flat black at the start of the contest. Our best efforts 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 3.4 on page 10 and 3.5 on page 11). 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 or wood, 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.

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

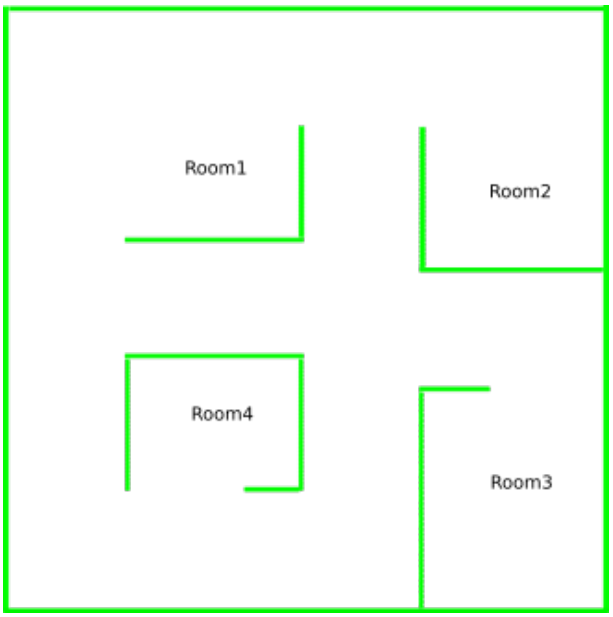

Figure 4.2: Level 2 Arena Configuration A

4.1.3 Level 1 Arena

The Level 1 arena presents a simplified model of a typical house, with high-contrast walls and floors (Figure 4.1 on the previous page). The Basic Arena is not decorated with such items as rugs and wall hangings.

4.1.4 Level 2 Arenas

There are four possible configurations of the Level 2 arena, shown by Figures 4.2, 4.3, 4.4, and 4.5. Each configuration represents the floor plan of a different decorated model home. The Level 2 Arenas have the same dimensions as the Level 1 arena. On each run robots will be assigned to the four layouts in a random fashion.

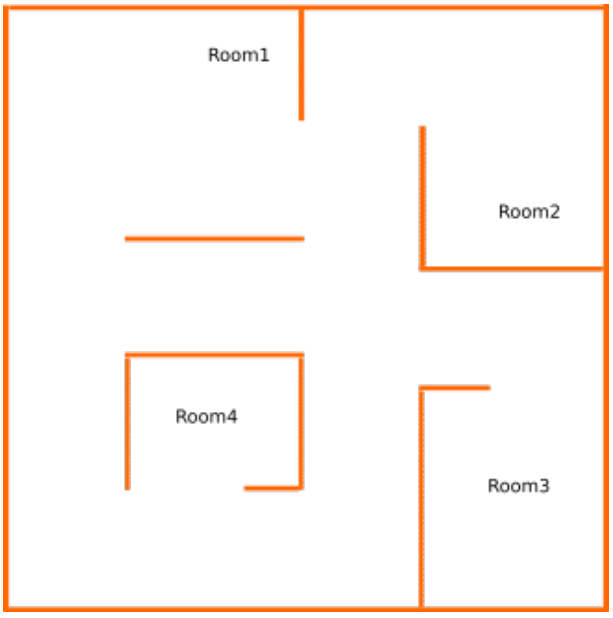

Figure 4.3: Level 2– Arena Configuration B

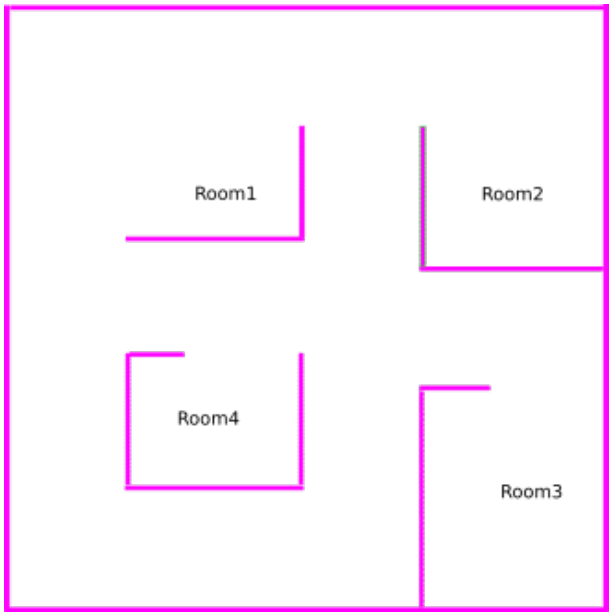

Figure 4.4: Level 2 Arena Configuration C

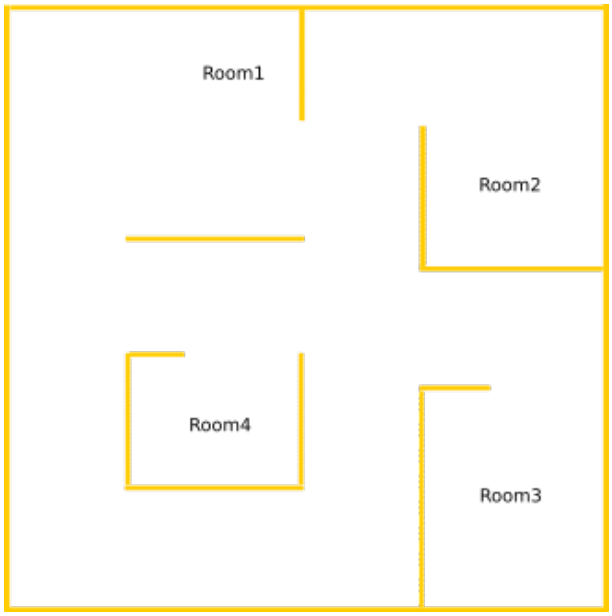

Figure 4.5: Level 2 Arena Configuration D

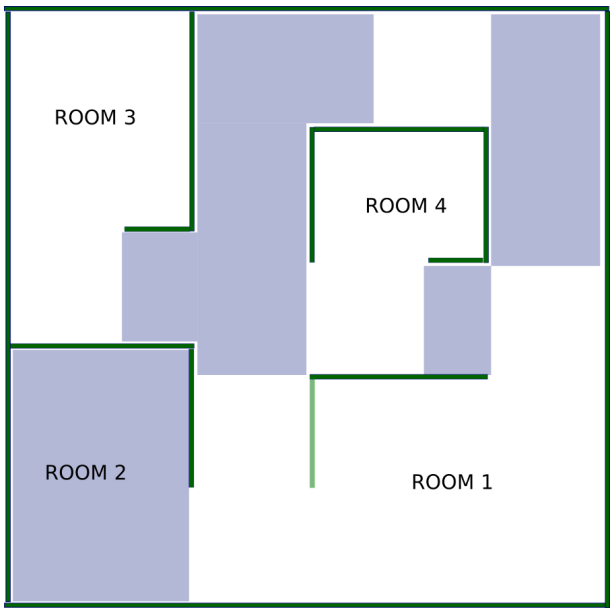

Figure 4.6: Allowed Rug Locations (FF Rug Locations.png)

4.1.4.1 Room Decoration

In order to make the Level 2 arenas realistic depictions of a real home, they are decorated as follows:

- 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 4.6 mark the allowed rug locations: not all rugs will be present and the locations and colors will be different in each arena.
- 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.

4.1.5 Level 3 Arenas

Arena: The Level 3 arena consists of two Level 2 arenas (A and B) separated by a distance of 1 m and connected by a hallway having the same width as the arena hallways. Appendix E on page 50 describes the arena layout.

On each run, the robot team will choose one of two configurations of the hallway: (1) the standard configuration, which is a flat surface, 1m in length, painted flat black; or (2) an optional up-and-down-ramp. The ramp is divided into three segments of approximately equal length. The maximum pitch angle of the up and down ramp sections of the hallway is 15 degrees. Robots that elect the up-and-down ramp on any run will receive a 10% decrease for that run.

The arena layout may be switched by the judges at any time during the competition.

Normally the robot can expect the presence of dogs, furniture, and rugs in both arenas.

4.2 Definition of Arbitrary Start Orientation

Arbitrary Start is an option for Level 1 and Level 2. Arbitrary Start is mandatory in Level 3.

Except in Arbitrary Start Location Mode (Section 5.3.1.4), the robot will start at the Start Circle location marked by "START"– in Figure 4.7. The start circle is a 30 cm diameter solid white circle (colored green in Figure4.7) centered in the halls intersecting at the corner.

NOTE The Start 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 Start Circle so that the central axis of the robot body is aligned within ±10 degrees of *either* hallway axis and the robot's front is directed toward the hallway The A and B arrows in Figure 4.7 show the possible orientations. The Judge will randomly choose the orientation for each trial. The figure also shows approximate locations and directions that will be used by judges in assigning arbitrary start positions.

Other than the ±10 degree 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 degree 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 5.3.5 on page 32 for the penalty applied for continuous wall contact.

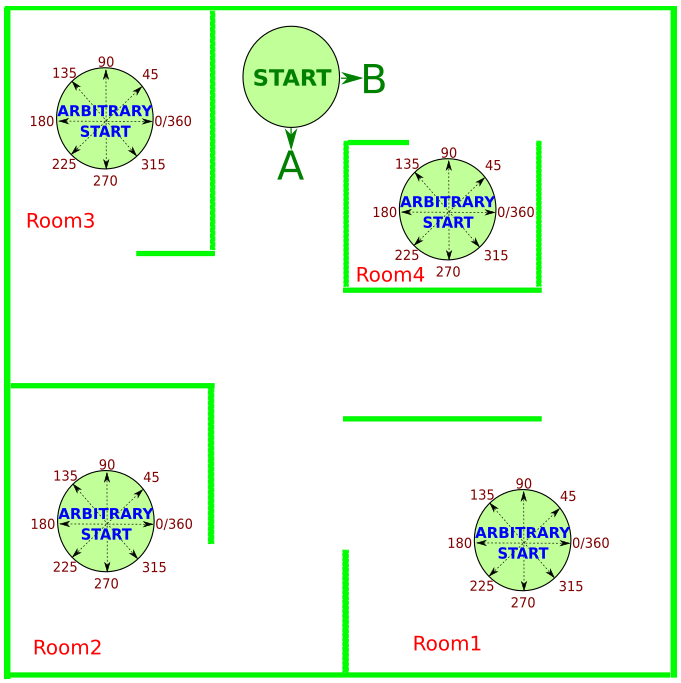

Figure 4.7: Starting alignments in Start Circle Including Arbitrary Start Locations (larger-start-circle-figure5.7.png)

NOTE Magnetic compasses do not produce reliable heading information. See Section 3.5.1 on page 11.

NOTE A robot in Orientation B may be directly adjacent to and facing the Dog Obstacle. See Section 4.3.

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

4.3 Dog Obstacle

The Dog Obstacle is mandatory for Level 1, Level 2, and Level 3 (all levels).

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 robot that moves the Dog more than 1 cm will incur 50 Penalty Points (Section 5.3.5 on page 33).

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

Figure 4.8: Sample Dog Obstruction (Dog Obstacle - Doggie261.jpeg)

NOTE A robot operating in Return Trip mode must not move or pass by the Dog.

Figure 4.8 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 4.9 shows the possible locations for the Dog in the Level 1 arena (also one of the configurations used in Level 2). In all arenas the Dog will not block the doorways in Room 1 or 4, but it may be directly adjacent to the edge of the doorway.

The Dog's long axis will always be perpendicular to the hall; the picture and figures indicate only the locations.

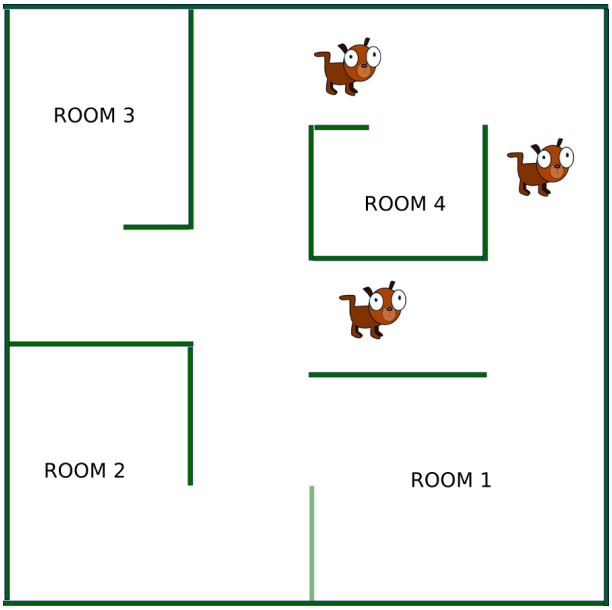

Figure 4.9: Possible Dog locations (FF Dog Obstacle Locations.png)

4.4 Robot

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

4.4.1 Operation

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

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.

4.4.2 Dimensions

All robots, including Walking Division robots, 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.

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. This rule prohibits swinging snuffers, extending arms, and other devices that protrude beyond the allowable base or height dimensions while in operation. In addition, the robot's actuators must be unable to move legs and other devices beyond the Bounding Box.

The exception is that robots competing in Level 3 may need temporarily to extend a device (e.g.,– arm and gripper to pick up the baby. However, any such device must be retracted fully to within the bounding box prior to any robot motion. Team members must demonstrate the maximum extent of any extending devices at the Robot Inspection Table as part of the inspection procedure.

The robot may not separate into multiple parts.

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 only the maximum height limit, not the width or length.

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.

4.5 Robot Control Panel

Every robot must have a control panel. The elements on the control panel are described in sub-sections below.

The control panel must be located on the robot's handle. See Section 4.6 below.

4.5.1 Start Button

IMPORTANT NOTE:

Junior Division robots must have exactly one Start Button. The judge will use the Start Button to start the robot. The Start Button, with green background, must be on the handle.

Walking, High School, and Senior Division robots may have a Start Button for testing, but (a) the button must not be located on the control panel or handle assembly, and (b) judges cannot be asked to start the robot if the robots sound activation system fails.

The Start Button *must* have the following characteristics:

Figure 4.10: Sample Start Buttons. (Sample Start Buttons.jpg)

- Momentary push-to-operate action: not a toggle switch.
- Junior Division robots only: The start button will be part of the robot's handle assembly (Section 4.6 on page 24).
- Above the highest fan blade tip (the highest point the fan can reach)
- 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 Junior Division robot does not have a Start Button meeting these requirements, *it will be disqualified*.

Figure 4.10 shows sample Start Button. You must provide a green background even if the switch is located on a green circuit board or if the pushbutton itself is green. NOTE: All Start Buttons–on robots from any Division–must be labeled in this manner.

You may use a mechanical linkage from an actuating button, located above all the other parts, which leads to 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.

You *must* verify that your robot's Start Button meets these requirements at the Robot Inspection Table before the contest begins. See Section 3.8 on page 12.

4.5.2 Sound Activation and Sound Activation LED

4.5.2.1 Sound Detection System

As described above, Junior Division robots must use a Start Button.

Robots in the Walking, High School, and Senior Divisions must must be sound activated. A sound activated robot will start when it detects a sound of a specific frequency and amplitude, as described in this Section, Section 5.3.1.3, and Appendix C .,

To accomplish sound activation, the robot will be equipped with an appropriate microphone, which must have the following 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.
- A blue background
- The abbreviation MIC printed in a contrasting color adjacent to the microphone

4.5.2.2 Sound Detect LED

Every Walking, High School, and Senior Division robot must include a sound-detect LED indicator as part of the control panel. See Figure 4.13 on page 27. When the robot detects sound activation, it must turn on the LED. The LED must not be turned on under any other condition.

4.5.2.3 Sound Activation Operation

Sound activation operates as follows during the contest.

The Judge will position the Sound Start Device (Appendix C on page 47) 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 4.11 shows a sample Microphone with optional labeling. You must provide a blue background even if the microphone is located on a blue circuit board.

Please note the following:

1. 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 5.3.1.3 on page 30 for the scoring rules that apply to incorrect operation in Sound Activated Mode.

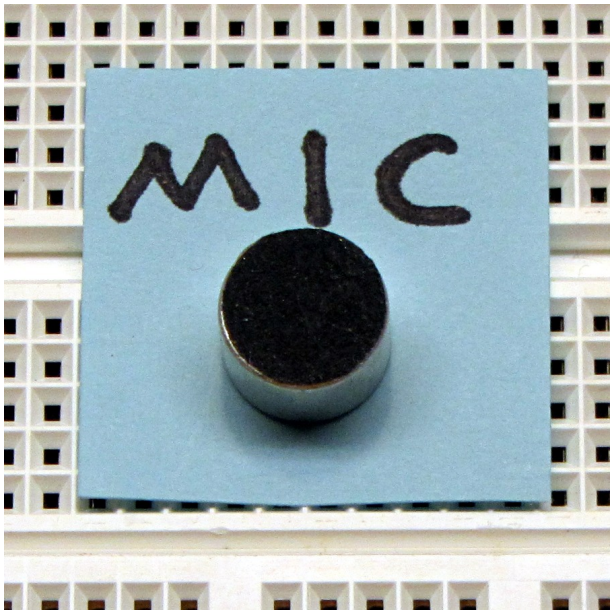

Figure 4.11: Sample Microphone with blue background (img_2247 - Sample Microphone.jpg)

2. A robot that can be started with a hand clap, or a knock on the arena wall, or out-of-band frequency will be disqualified.
3. We require that the microphone be part of the handle assembly (Section 4.6).
4. Remember: Only Junior Division robots must have a start button. Walking, High School,. and Senior Division robots may have a start button for testing, but (a) such a button must not be located on the control console, and (b) judges cannot be asked to use such a button when sound activation fails.
5. As part of the Robot Inspection process, you must verify that your robot responds to the Standard Sound Start Device. Remember that inspection takes place at the Robot Inspection Table before the contest begins. See Section 3.8 on page 12.

4.5.3 Power Switch

The robot must– 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.

Please note the following:

1. The Power Switch *cannot* be the Start Button, because activating the Start Button causes the robot to begin operation.
2. We recommend that the Power Switch be part of the handle assembly (Section 4.6).

4.5.4 Flame Detect LED

Every robot must have a bright red flame detect LED on a white background. This LED must located on the control panel in such a way that it can be seen from all directions. The Flame Detect LED must be part of the handle assembly (Section 4.6).

The robot will turn on Flame Detect LED as soon as the flame is detected and turn off the LED when the flame is extinguished.

4.5.5 Video Detect LED

Robots that will compete at Level 3 must also have a video detect LED on the control panel. Robots that intend to compete at Levels 1 and 2 may incorporate this LED in their design if they will use computer vision.

The Video Detect LED will be normally OFF. It will be activated under the following conditions:

1. The LED will be steady ON when the robot recognizes the target shown in Figure 5.1 on page 33.
2. The LED will blink when the robot recognizes any of the targets on the cradle base (see D.3.3 on page 54).

4.5.6 Kill Power Plug

Robots must be equipped with a "kill power" plug that immediately removes power from the robot's sensor, control, and drive systems. A possible design would have four pins. Two of the pins would power the robot's logic, sensing, and control circuitry, and the other two would power the drive system. When the plug is removed, all robot systems are turned off.

For example, a suitable Kill Power Plug may be constructed from any standard 4-pin square post header and connector with pins 1-2 short-circuited and 3-4 short-circuited. The Kill Power Plug must be mounted with a bright yellow background. Current for the robot's control and sensor circuits may be routed through the Pins 1-2 circuit, and current for the robot's drive system can be routed through the Pins 3-4 circuit. An example is shown in Figure on this page.

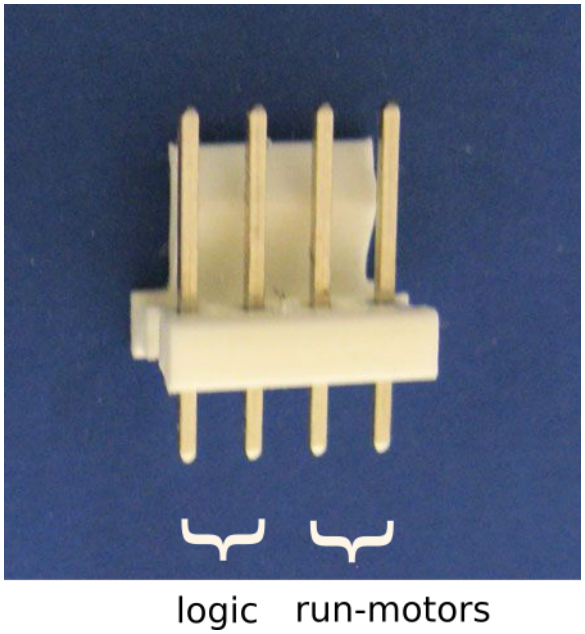

Figure 4.12: Kill Power Plug Example

NOTES:

1. The power to the drive motors MUST be removed before the robot is screened at the RIT (Robot Inspection Table) (Section 3.8 on page 12).
2. The Kill Power Plug must be part of the handle assembly (Section 4.6).

4.6 Robot Handle

To help the contest to run efficiently and to protect robots from damage, all robots must be equipped with a carrying handle. There have been several times in past contests when a robot did not perform as expected and were saved from damage by picking up the robot via the handle. Please note that the handle (and in exceptional situations, the kill power plug) is the only part of the robot that will be touched by the TCFFHRC staff during the competition. We know that many hours were spent on designing and testing

your robots and we want to assure that unintentional mechanical or electrical adjustments are avoided.

The handle be constructed from any materials including metal, wood, or plastic. The handle presents a design challenge: to design a sturdy handle, easily accessible to judges, that is integrated with the control panel described in Section 4.5.

In all designs, the handle must be:

1. Strong enough to allow the robot to be picked up by staff
2. Durable enough to allow easy operation of devices mounted on it (switches, microphone, etc.)switch/sound-activation-microphone, and kill-power plug-in by non-technical volunteers. Note that the robot's control panel will include these devices (Section 4.13 on page 27).

Junior Division robots are encouraged to place their start button, with green background, on the handle. Robots entered in the Walking, High School, and Senior Divisions must have a blue background behind the microphone so that the judge will know where to direct the output of the sound activation device. Walking, High School, and Senior Division robots must include a green or blue LED sound start indicator.

Every robot must have a bright red flame detect LED on a white background. This LED must be positioned so the it can be seen in all directions.

All robots must have an arrow somewhere on the handle that points to the front of the robot so that the judge will know in which direction to start the robot. The arrow must be conspicuous and no special instructions are to be given to the judge placing the robot in the arena.

Appendix B shows one possible arrangement of a robot handle.

4.6.1 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 4.4.2 on page 21.

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.

4.6.1.1 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.

4.6.2 Power

AC power is not available in the arena area.

See Section 3.7 on page 12.

4.7 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 trials. It is possible for the candle to be in the same room on two of the robot's trials.

The Candle Location Mode is *required* in the Level 2 and Level 3 competitions, and it is an option in Level 1. See Section5.3.1.8 below.

Additional information about candles and candle circles follows.

- 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 5.3.5 on page 32)
- The contestants may not 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 not be placed in a hallway, but it might be placed just inside a doorway of a room. When a candle circle is present it is *not* anchored to the arena floor. Consequently it can be dislodged by a decelerating robot. There is no penalty for this, but the moving circle might knock the candle over, and there *is* a penalty for that.
- A candle circle will not touch the doorway line. Thus, the front of the robot will be able to move at least 33 cm into the room before encountering the candle.

4.7.1 Extinguishing the Candle

The robot must, in the opinion of the Judges, have found a 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 5.3.1.6 on page 30 for details.

In the Level 1 competition Standard operating mode, the robot must come within 30 cm of the candle before it extinguishes 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. In Level 1 robots may choose Candle Location Mode, which omits the candle circle and minimum distance requirement. See Section 5.3.1.8 on page 31.

In the the Level 2 competition, the robot may not extinguish the candle until the robot is fully in the room where the candle is located.

In all Levels, the robot *must* turn on a bright red LED, indicating that it has detected the candle. Candle detection is the only event that will cause this LED to be turned on. The LED must stay on at least until the candle is extinguished. The LED must be mounted on the control panel in plain view so that the judge can see it clearly at all times during each trial.

NOTES:

1. It is good design to place this LED on to the control panel, which includes the start switch, sound activation microphone, and power kill device; one possible arrangement of the control panel is shown in Figure 4.13).
2. Use a different LED for each control panel indication (sound activation, candle detection, etc.). Do not use a multi-colored LED.
3. The Video LED is required if your robot will run at Level 3.

Robots that touch a lit candle with either the robot chassis or a sensor will incur a penalty as specified in Section 5.3.5 on page 32.

4.7.1.1 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.

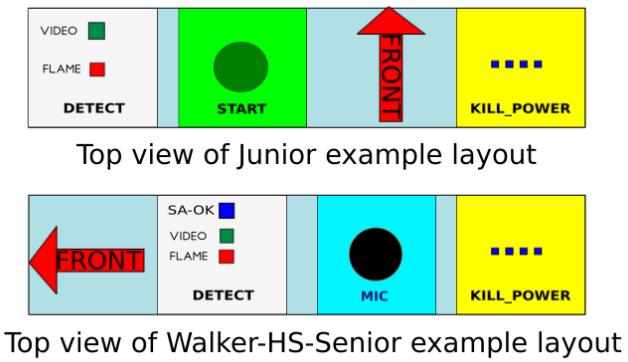

Figure 4.13: Panel with LED and Other Components (fig-5.13-2017A.png)

NOTE A robot must have *only one* type of extinguisher.

1. Air

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

   Any robot with a fan or blower cannot use Non-air Extinguisher Mode.

2. Carbon dioxide (CO_2)

   Robots may use a single metallic CO_2 capsule (of the type used to charge carbonated beverages and refill bicycle tubes) 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.

   NOTE The robot must release the CO_2 gas from the capsule when it detects the fire. It must not pre-charge a low-pressure gas system from the capsule before detection.

3. Water mist or spray

   Water is the only liquid allowed in this contest; foaming or gelling agents are prohibited.

   The water tank volume must be no larger than 50 ml. Judges will verify the tank volume. A robot using a container pressurized with air (i.e., a soda bottle), rather than a pump, must have a separate water tank of no more than 50 ml capacity.

   Any robot that floods the floor will fail that trial.

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

   Exception: A robot may aim a narrow water jet directly at the flame, with up to three water pulses containing up to 2 ml each. Contact us before you register to verify that your design will be accepted. Your design will be examined at the Robot Inspection Table.

4. Mechanical means

   A wet sponge or snuffer.

   The size limits described in Section 4.4.2 on page 21 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 5.3.1.6 on page 30.

4.8 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 5.3.1 on page 29) 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.

In Level 1 and Level 2 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 5.3.1.5 on page 30).

In Level 3 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 baby and transport the baby to a safe zone;
3. It must extinguish all lit candles;
4. It must return to its starting location.

Chapter 5

Scoring

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

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. After all five trials, the Judge computes the Total Final Score from the Operating Score of all five trials.

See Appendix F on page 59 for a sample Trial Options Sheet.

5.1 Operating Score (OS) Computation

5.1.1 Level 1 and Level 2 OS Computation

During the trial, the Judges will:

1. Record the robot's Operating Modes (OM.x) options (Section 5.3.1 on the following page)
2. Measure the Actual Time (AT) for the trial (Section 5.3.3 on page 31)
3. Determine the Room Factor (RF) for the path used (Section 5.3.4 on page 32)
4. Record any Penalty Points (PP) incurred (Section 5.3.5 on page 32).

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.

5.1.2 Level 3 OS Computation

Determining the OS in Level 3 follows the same general outline as with Levels 1 and 2. However the following apply:

1. There is no room factor.
2. There are only three elective operating modes for which deductions will apply: Hallway Ramp (Section 5.3.6.2 on page 33), Computer Vision (Section 5.3.6.1 on page 33), and All_Candles (Section 5.3.6.3 on page 33).
3. As in Levels 1 and 2, an incomplete run will receive OS = 600. However, robots will receive lower scores by completing tasks below:
   (a) For traversing the hallway between arenas A and B: OS = 500
   (b) For finding the baby: OS = 450
   (c) For picking up the baby: OS = 400.

5.2 Total Final Score (TFS) Computation

Each trial will receive an Operating Score based on the scoring rules of Level at which the trial takes place (see Section 5.3). For each contest Level the robot will receive a Lowest Operating Score. To represent these lowest scores the contest scoring system uses the notation, Lowest Operating Score (Level 1) = LS1, Lowest Operating Score (Level 2) = LS2, and Lowest Operating Score (Level 3) = LS3.

The Total Final Score is the sum of the robot's three Lowest Operating Scores:

TFS = LS1 + LS2 + LS3. TFS is a measure of the robot's overall performance in the contest.

Scoring examples in Appendix A on page 42illustrate how robot performance is scored for each Division and Level using the method described.

5.3 Level 1 Scoring–Junior and Walking Divisions

Special rules apply to determining the Operating Scores of Junior and Walking Division robots at Level 1 only. If the robot does not extinguish the candle, the robot receives a score of 600 for the trial. However, this score may be reduced if the robot completes certain tasks, as described below. *These deductions apply only to Junior and Walking Division robots at Level 1.*

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.Score Components (Levels 1 and 2) (Operating Modes)

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

5.3.1 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.A fractional multiplier is associated with each Operating Mode. The measured time (Actual Time) for each successful trial is multiplied by these fractions when computing the Operating Score (OS) for the trial. Robots able to operate with these optional modes may get scores much lower than indicated by the Actual Time. 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 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.

5.3.1.1 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.

5.3.1.2 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!

5.3.1.3 Sound Activated

The Sound_Activated deduction has been eliminated.

Walking, High School, and Senior Division robots must use sound activation.

Junior Division robots must not use sound activation (pushbutton switch starting only).

The sound-activated robot begins operation when it detects a sound signal of 3.8 kHz ± 13%. Each starting device used by the judges during the contest will meet the specification.

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 in the robot's own arena 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 be terminated.

If the robot does not start in response to the sound signal it will *not* be given a second chance for that trial. The Judge will not attempt to activate the robot by any other means.

See Section 3.10 on page 13 for a discussion of the starting procedure and penalties for incorrect starts.

Judges will use *only* Standard Sound Start Devices as described in Appendix C on page 47 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 or digital FIR 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 and be disqualified.

5.3.1.4 Arbitrary Start Location

OM.start = 0.80

Only contest judges will place the robot in arbitrary start positions. The robot will be placed at a 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 Start Circle in Arbitrary Start Location Mode.

The starting room does not count as a *searched* room for the Room Factor calculation (Section 5.3.4 on page 32). When the robot leaves the starting room, the *next* room it encounters is its first searched room.

5.3.1.5 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 Start Circle. It must stop with any part of its chassis is within the 30 cm white Start Circle. It 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 5.3.1.4.

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. It must not move or pass by the Dog obstacle (Section 4.3 on page 20) during the return trip.

5.3.1.6 Non-air Extinguisher

OM.extinguisher = 0.75

The robot must extinguish the candle using inert gas, water, or mechanical means. See Section 4.7.1.1 on page 26

In order to use the Non-air Extinguisher Mode, the robot *must not* have a fan or blower.

See Section 4.7.1.1 on page 26 for details.

5.3.1.7 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.

5.3.1.8 Candle Location (Level 1 Only)

The Candle Location Mode is *required* in at Level 2.

The Candle Location Mode is an option in the Level 1 contest. The multiplier is OM.candle = 0.75.

The Candle Location Mode challenge is 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 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.

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

The Fire rules in Section 4.7 on page 25 will be followed except that:

- There will be no candle circle, just a candle in a standard holder.
- Before extinguishing the flame the robot *must* turn on a bright red LED, that it has detected the candle. The LED must stay on at least until the candle is extinguished. The LED must be mounted in plain view so that the judge can see it clearly at all times during each trial.
- The robot need not be within 30 cm of the candle, but the robot must be entirely within the room where the candle is located before it lights the LED.

The Furniture Mode rules in Section 5.3.1.7 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.

5.3.2 Summary of Operating Modes

See Table 5.1 on the next page

5.3.3 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.

5.3.3.1 Time Limits

The maximum time allowed for a robot to finish any trial 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 Start 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.

5.3.3.2 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

	Level 1		Level 2		Level 3	
Options (Below)/Divisions	Jr	Walk/HS/Sr	Jr	Walk/HS/Sr	Jr	Walk/HS/Sr
Sound Activation	N/A	Required	N/A	Required	N/A	Required
Furniture	Optional	Optional	Optional	Optional	Required	Required
Return Trip	Optional	Optional	Optional	Optional	Required	Required
Arbitrary Start	Optional	Optional	Optional	Optional	Required	Required
Non-Air	Optional	Optional	Optional	Optional	Required	Required
Candle Location	Optional	Optional	Required	Required	Required	Required

Table 5.1: Summary of Operating Modes

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. The kill-power plug will be pulled in case of loops or stalls.

5.3.4 Room Factor (RF) (Level 1 and Level 2 only)

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 run time limit for Level 1 is 3 minutes.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.

5.3.5 Penalty Points (PP.x) (Levels 1, 2, 3)

Penalty Points (PP) will be added to the Actual Time (AT) of any robot that exhibits the behaviors described in this section. These penalty points apply at all competition Levels.

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 Start Circle.

See the Note in Section 4.4.1 on page 21 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.

5.3.6 Level 3 Mode Factors

NOTE: There are no room factors at Level 3.

As part of their normal Level 3 operation, robots must handle the challenges of arbitrary start, return trip, non-air, and furniture modes. So, there are no score-reducing multipliers for these modes in Level 3. However, score reduction multipliers will apply for three other special mode factors described below.

5.3.6.1 Baby Placement–Computer Vision Option

As an option the robot may bring the baby to a secondary safe zone. This safe zone is always in Arena B and it is marked by the target shown in Figure5.1 below. The target consists of a square blue field measuring 10 cm x 10 cm enclosing a red circle 5 cm in diameter. The target will always be found on an outside wall of Arena B on the inside of the maze under a window, but the target position will be changed by the judge from run to run. Robots that execute this task will recognize the target, lift the baby over the edge of the arena at that position, and place the baby carefully into a safety net just over the wall.

The target must be found using computer vision with a camera. The presence of a camera and its function will be checked by judges at the Robot Inspection Table.

When the alternate target position is chosen the time for the run will be reduced by multiplying it by the Mode Factor

MF = OM.Alt_Target = 0.6.

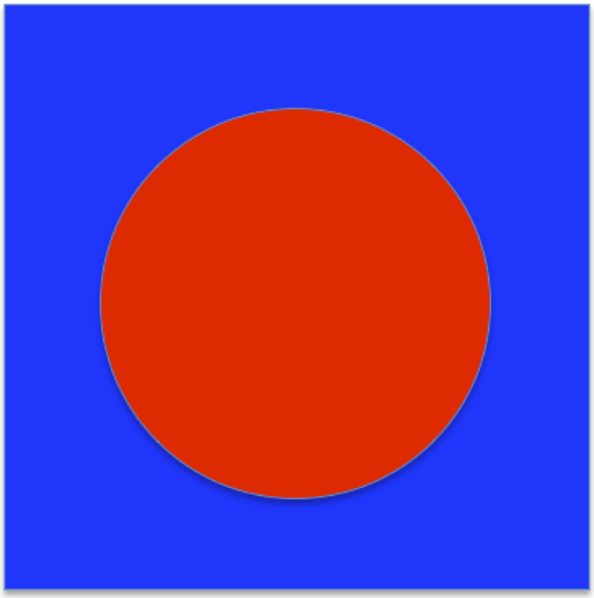

Figure 5.1: Target–Level 3 Computer Vision Option. 10 x 10 cm blue square, 5 cm diameter red circle

5.3.6.2 Hallway Option

The hallway connecting parts A and B of the Level 3 arena may take two forms: flat or ramp (see Section D.2 on page 52 for geometries). When the ramp is chosen, the actual time score will be reduced by 10%; i. e, the Mode Factor is

MF = OM.Ramp_Hallway = 0.9.

EXAMPLE: If both Computer Vision Option and Hallway Options are successful, the score for the run will be (actual time) x (OM.Alt_Target) * (OM.Ramp_Hallway) = (raw time) x 0.54.

5.3.6.3 All Candles Option

If the robot is able to put out all lit candles within the time limit, the Mode Factor OM.All_Candles = 0.6 will be applied.

EXAMPLE: If the robot successfully completed the Computer Vision Option, Hallway Option, and All Candles Option, the score for the run will be (raw time) x (OM.Alt_Target) x (OM.Ramp_Hallway) x (OM.All_Candles) = (raw time) x 0.324.

5.4 Scoring Examples

Scoring examples for– are provided in Appendix A on page 42.

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

Chapter 6

Awards and Prizes

6.1 Robot Performance Prizes

The TCFFHRC cash prizes are provided by our contest sponsors and non-cash prizes provided by contest supporters. All prizes are described on the Contest Website at http://www.trinityrobotcontest.org.

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

To be eligible for a performance cash prize the robot must:

1. Have at least three successful runs. Successful runs at any contest level will be counted. The ability to complete at least three runs demonstrates reliability in this challenging event..
2. Prepare and display a poster. See Part 8 on page 39 for technical presentation guidelines.

In addition to the robot performance prizes, a robot may win one or more of the special prizes awarded by the TCFFHRC. These include Cost Effective, Tiny Robot, and North American. See sections below for description of the special prizes.

6.1.1 Best Robot in Division Performance Prizes (BRD)

Robots in each Division with the lowest Total Final Scores will be eligible to receive the "Best Robot in Division" (BRD) prizes. First ($300), Second ($200), and Third ($100) Place BRD prizes will be awarded to Unique robots in each Division. The BRD prizes for Customized robots will be one-half these amounts.

6.1.2 Grand Performance Mastery Prize (GPMP)

The Grand Performance Mastery Prize (GPMP) will be awarded to the robot with the lowest TFS in the 2017 TCFFHRC. Only Unique robots are eligible to win the GPMP, and the team must prepare a poster. The robot that wins this award will be considered the overall champion

6.1.3 Lowest Individual Score Prizes (LISP)

There will be cash awards for the lowest individual LS1 (Level 1), LS2 (Level 2), and LS3 (Level 3) scores in the contest. For each of the three contest Levels, prizes will be: First Place: Unique, $200; Customized, $100.

Only Junior or Walking Division robots are eligible the Level 1 award.

Robots in any Division are eligible for Level 2 and Level 3 award

6.1.4 Summary of Robot Performance Awards

NOTE: Your robot must have at least three successful runs to win a robot performance prize (BRD, LISP, GPMP).

BRD and LISP awards are summarized in Tables 6.1 and 6.2 below.

6.2 Best Unified Robot Performance (BURP) Award

The BURP award has been replaced by the GPMP and will not be given in 2016.

Best Robots in Division (BRD) Awards	Unique	Customized
DIVISION	First, Second, Third	First, Second, Third
Junior	$300, $200, $100	$150, $100, $50
Walking	$300, $200, $100	$150, $100, $50
High School	$300, $200, $100	$150, $100, $50
Senior	$300, $200, $100	$150, $100, $50

Table 6.1: Summary of Best Robots in Division (BRD) Awards

Lowest Individual Score Prizes (LISP)	Unique	Customized
Level 1*	$200	$100
Level 2	$200	$100
Level 3	$200	$100
* Only Junior and Walking Division robots are eligible for Level 1 prizes		

Table 6.2: Summary of Lowest Individual Score (LISP) Awards

6.3 Special Awards

6.3.1 North American Awards

The top North American robot in each Level will receive a special cash award of $100.

"North American" countries lie north of the Panama Canal.

6.3.2 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.

6.3.3 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 at the lowest cost.

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 the robot..

   (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.

6.3.4 Tiny Robot Award

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

At the Contest inspection table the judges will determine the size of each entry by determining the smallest volume into which the robot will fit. This volume must contain all robot components as deployed during a typical contest trial including the chassis, projecting sensors, wires, appendages, etc.

6.4 Robot Olympiad Prizes

Cash prizes of $200 will be awarded for the highest score on the Robot Olympiad Exam (Chapter 7) in the following categories: Junior Individual, Junior Team, High School Individual, High School Team, Senior Individual, and Senior Team. To be eligible for an award, the score must meet minimum requirements established by the judges.

6.5 Poster Competition Prizes

Cash prizes of $200 will be awarded for the highest ranking poster in each contest division (Junior, Walking, High School, Senior).

6.6 Rookie of the Year Award

Rookie of the Year will not be awarded in 2017.

Chapter 7

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.trinityrobotcontest.org/ for the 2016 Olympiad schedule.

Questions for the 2017 Olympiad exam will be based on material presented in two introductory robotics textbooks, listed below. To prepare your team for the Olympiad exam, be sure to study these books and relate the theory to your robot project.

1. David G. Alciatore and Michael B. Histand, Introduction to Mechatronics and Measurement Systems, McGraw Hill, 2011, ISBN-13: 978-0073380230 . (Book may be viewed online here:

http://robotics.bgu.ac.il/uploads/f/f7/Introduction.to.Mechatronics.and.Measurement.Systems.pdf

2. Maja J. Mataric, The Robotics Primer, MIT Press, ISBN: 9780262633543 . (Book may be viewed online here:

http://pages.ucsd.edu/~ehutchins/cogs8/mataric-primer.pdf

Inquiries about the Olympiad exam may be directed to:

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Chapter 8

Technical Presentation Competition

Contributed by: David Pietrocola, Allison Mathis

The ability to effectively communicate technical ideas and to describe designs is an increasingly important skill for engineers and scientists. The TCFFHRC technical presentation competition aims to encourage the development of such communication skills. In 2017 the poster competition is *required* for all teams and is required to win a cash prize. We encourage all 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). Guidelines

1. The poster presents the design of the team's fire-fighting 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:
    - Judges will assess displayed posters divided into two groups: high school and below, and university and above
    - The top 5 teams from each group 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 and 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.

Chapter 9

Regional Contest Events

Starting an Official Regional Event

Trinity College's Fire-Fighting Home Robot Contest rules are published on the Contest Website at http://www.trinityrobotcontest.org/.

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.trinityrobotcontest.org/. 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

Appendix A

Scoring Examples

These examples track the progress of three robots: Jazz, Hanley, and Spazz. Jazz is a Junior Division robot, Hanley is a High School Division robot, and Spazz is a Senior Division robot.

In these examples, OS represents the Operating Score, LS1 represents the Lowest Score at Level 1, LS2 the Lowest Score at Level 2, and LS3 the Lowest Score at Level 3. TFS is the Total Final Score:

TFS = LS1 + LS2 + LS3.

A.1 Robot Jazz (Junior Division)

TRIAL 1 (Level 1)

Actual Time AT = 1555.742 Sec, less than the 180 sec (3 min) time limit.

Modes used: Standard Mode

Room Factor:

RF = 0.85: 2 rooms were searched

Operating Score OS = TS x MF x RF

Time Score:

TS = (AT + PP)

TS = 155.742 + 0 = 155.742

Mode Factor:

MF = 1 = 1.000

OS = 155.742 x 1.000 x 0.850 = 132.381Jazz decides to take another run in order to lower its Level 1 score.

TRIAL 2 (Level 1)

Actual Time AT = 132.614 Sec

Modes used:

(1) OM.candle = 0.75.....No candle Circle

Room Factor:

RF = 0.35: 4 rooms were searched

Penalty Points:

PP.dog = 50 robot kicked a dog.

PP.slide = 8 robot contacted wall for 16 cm.

Total PP = 58 points

Operating Score OS = TS x MF x RF

Time Score: TS = (AT + PP)

TS = 132.614 + 58 = 190.614

Mode Factor:

MF = 1 x OM.candle

MF = 1 x 0.75 = 0.750

OS = 190.614 x 0.750 x 0.350 = 50.036

Still hoping for a better result at Level 1, Jazz decides to take a third run. The run is not successful, but Jazz gets a deductions for searching one room. Such deductions apply only to Junior and Walking robots at Level 1.

TRIAL 3 (Level 1)

Terminated Time:

OS = 600.000 <<<<<

Completed Tasks:

Rooms searched: -30 x +1 = -30

OS = 600 + (task.search x rooms.searched)

OS = 600 -30

OS = 570.000

After the third trial, Jazz decides to go on to Level 2.

Its lowest score for Level 1 is LS1 = 50.036.<===

TRIAL 4 (Level 2)

Actual Time

AT = 150.304 Sec, less than the 240 sec Level 2 limit.

Modes used:

(1) OM.furniture = 0.75.....Furniture Mode

Room Factor:

RF = 0.35: 4 rooms were searched

Penalty Points:

PP.slide = 1 robot contacted wall for 3 cm.

Total PP = 1 points

Operating Score

OS = TS x MF x RF

Time Score:

TS = (AT + PP)

TS = 150.304 + 1 = 151.304

Mode Factor:

MF = 1 x OM.furniture

MF = 1 x 0.75 = 0.750

OS = 151.304 x 0.750 x 0.350 = 39.717

Having succeeded at Level 1 and Level 2, Jazz decides to "go for it" on Trial 5. Jazz attempts Level 3.

The Lowest Score for Level 2 is LS2 = 39.717 <===

TRIAL 5 (Level 3)

Terminated Time:

OS = 600.000 <<<<<

Completed Tasks: Did not cross hallway, find baby, or pick up baby.

OS = 600. The Lowest Score at Level 3 is LS3 = 600

Robot Jazz has the Total Final Score TFS = LS1 + LS2 + LS3 = 50.036 + 39.717 + 600 = 689.753.

A.2 Robot Hanley (High School Division)

TRIAL 1 (Level 1)

Actual Time

AT = 285.742 Sec

Modes used:

Standard Mode

Room Factor:

RF = 0.85: 2 rooms were searched

Operating Score

OS = TS x MF x RF

Time Score:

TS = (AT + PP)

TS = 285.742 + 0 = 285.742

Mode Factor:

MF = 1

MF = 1 = 1.000

OS = 285.742 x 1.000 x 0.850 = 242.881 <===

Hanley decides to go for another run at Level 1.

TRIAL 2 (Level 1)

Actual Time AT = 39.234 Sec

Modes used:

(1) OM.candle = 0.75.....No candle Circle

Room Factor:

RF = 0.5: 3 rooms were searched

Penalty Points:

PP.slide = 4 robot contacted wall for 8 cm.

Total PP = 4 points

Operating Score OS = TS x MF x RF

Time Score: TS = (AT + PP)

TS = 39.234 + 4 = 43.234

Mode Factor:

MF = 1 x OM.candle

MF = 1 x 0.75 = 0.750

OS = 43.234 x 0.750 x 0.50 = 16.21275.

Hanley moves on to Level 2.

LS1 = 16.21275<===

TRIAL 3 (Level 2)

Actual Time

AT = 150.304 Sec

Modes used:

(1) OM.furniture = 0.75.....Furniture Mode

Room Factor:

RF = 0.35: 4 rooms were searched

Penalty Points:

PP.slide = 1 robot contacted wall for 3 cm.

Total PP = 1 points

Operating Score

OS = TS x MF x RF

Time Score:

TS = (AT + PP)

TS = 150.304 + 1 = 151.304

Mode Factor:

MF = 1 x OM.furniture

MF = 1 x 0.75 = 0.750

OS = 151.304 x 0.750 x 0.350 = 39.717

Satisfied with this result, Hanley moves on to Level 3

LS2 = 39.717 <===

TRIAL 4 (Level 3)

Terminated trial, but Hanley crosses hallway and finds the baby.

OS = 450.

Hanley has one more run, which the robot must take at Level 3 since it is not allowed to go back to Level 2.

TRIAL 5 (Level 3)

Hanley rescues the baby in 58.222 seconds. Robot returns to Arena B and extinguishes the candle in an additional 22 seconds. The total time is 58.222 + 22 seconds, well within the 300 sec. time limit. Neither candle in Arena A has been lit yet so all candles have been extinguished. Score for this run is (58 sec.) x (OM.All_Candles) = 34.8 sec.

Actual time

AT = 58.222 Sec

Modes used:

OM.All_Candles = 0.6...All_Candles Mode

OS = AT x (OM.All_Candles) = 58.222 x 0.6 = 34.9332

LS3 = 34.9332 <===

TFS = LS1 + LS2 + LS3 = 16.21275 + 39.717 + 34.9332 = 90.863.<===

A.3 Robot Spazz (Senior Division)

TRIAL 1 (Level 1)

Terminated Time:

OS = 600.000 <<<<<

TRIAL 2 (Level 1)

Actual Time

AT = 85.641 Sec

Modes used:

Standard Mode

Room Factor:

RF = 0.85: 2 rooms were searched

Operating Score

OS = TS x MF x RF

Time Score:

TS = (AT + PP)

TS = 85.641 + 0 = 85.641

Mode Factor:

MF = 1

MF = 1 = 1.000

OS = 85.641 x 1.000 x 0.850 = 72.795

Spazz feels that this score is too low and goes for a third trial at Level 1.

TRIAL 3 (Level 1)

Terminated Time:

OS = 600.000 <<<<<

With three trials taken at Level 1, Spazz moves to Level 2.

LS1 = 72.795 <===

TRIAL 4 (Level 2)

Actual Time

AT = 187.638 Sec

Modes used:

(1) OM.start = 0.8.....Arbitrary Start

(2) OM.return = 0.8.....Return Trip

(3) OM.extinguisher = 0.75...No Air Extinguisher

(4) OM.furniture = 0.75.....Furniture Mode

Room Factor:

RF = 0.35: 4 rooms were searched

Penalty Points:

PP.candle = 100 robot touched a candle 2 times.

PP.dog = 50 robot kicked a dog.

Total PP = 150 points

Operating Score

OS = TS x MF x RF

Time Score:

TS = (AT + PP)

TS = 187.638 + 150 = 337.638

Mode Factor:

MF = 1 x OM.start x OM.returntrip x OM.extinguisher x OM.furniture

MF = 1 x 0.8 x 0.8 x 0.75 x 0.75 = 0.360

OS = 337.638 x 0.360 x 0.350 = 42.542

The Spazz team decides to take its last run at Level 3.

LS2 = 42.542 <===

TRIAL 5 (Level 3)

Spazz rescues the baby in 117 seconds in an arena with the hallway ramp. Using its vision system the robot finds the alternate position and it places the baby through the window to the safe zone at that position. Robot finds the candle in arena B and extinguishes it in an additional 56 seconds. Both candles in Arena A have been lit by this time, and the robot takes another 123 seconds to extinguish them. The total time is 123 + 117 = 240 sec., which is less than the run time limit of 5 minutes (300 sec.).

Actual time AT = 117 Sec

Modes used:

(1) OM.Alt_Target = 0.6...Computer Vision/Alternate Target Mode

(2) OM.Ramp_Hallway = 0.9...Ramped Hallway Mode

(3) OM.All_Candles = 0.6...All_Candles Mode

OS = AT * (OM.Alt_Target) x (OM.Ramp_Hallway) x (OM.All_Candles) = 117 x 0.324 = 42.12

The Lowest Score at Level 3 is LS3 = 42.12 <===.

The Total Final Score for Spazz is TFS = LS1 + LS2 + LS3 =72.795 + 42.542 + 42.12 = 157.457 <===.

Appendix B

Robot Carrying Handle

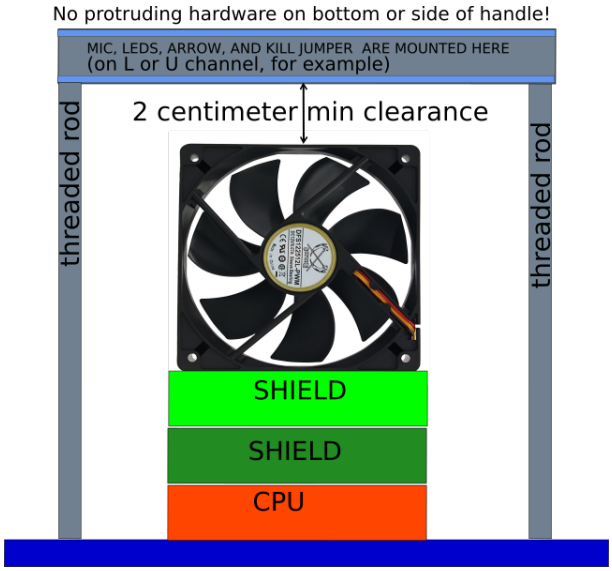

Figure B.1: Example o f Carrying Handle Design

The figure shows one possible handle design that includes power switch, kill switch, microphone, and other components. When developing your handle, be sure to consider the dimensions shown in the figure.

Appendix C

Standard Sound Start Device

Judges will use only the Standard Sound Start Device during the contest for all non-Junior-Division trials. Teams may *not* bring their own devices to the arena during trials.

C.1 Operation

Each official contest Sound Start Devices emits a tone of approximately 3.8 kHz. Judges will use a different starting device at each of the contest arenas, so the start frequency will vary from arena to arena. The start devices are based on Mallory Sonalert buzzer, model PK-20N38WQ. Your robot must respond properly to every start device.

The manufacturer's spec sheet for the Sonalert buzzer is found at this URL: http://www.mallory-sonalert.com/specifications/PK-20N38WQ.pdf. Please read the spec sheet carefully and be especially aware of the frequency range specification.

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 judge presses the Tone button to start the device. The sound lasts for approximately five seconds and will NOT be repeated.

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

C.2 Hardware

Figure C.1 shows a Standard Sound Start Device.

Schematic

Figure C.2 on the next page shows the schematic diagram of the circuitry inside the Sound Start Device.

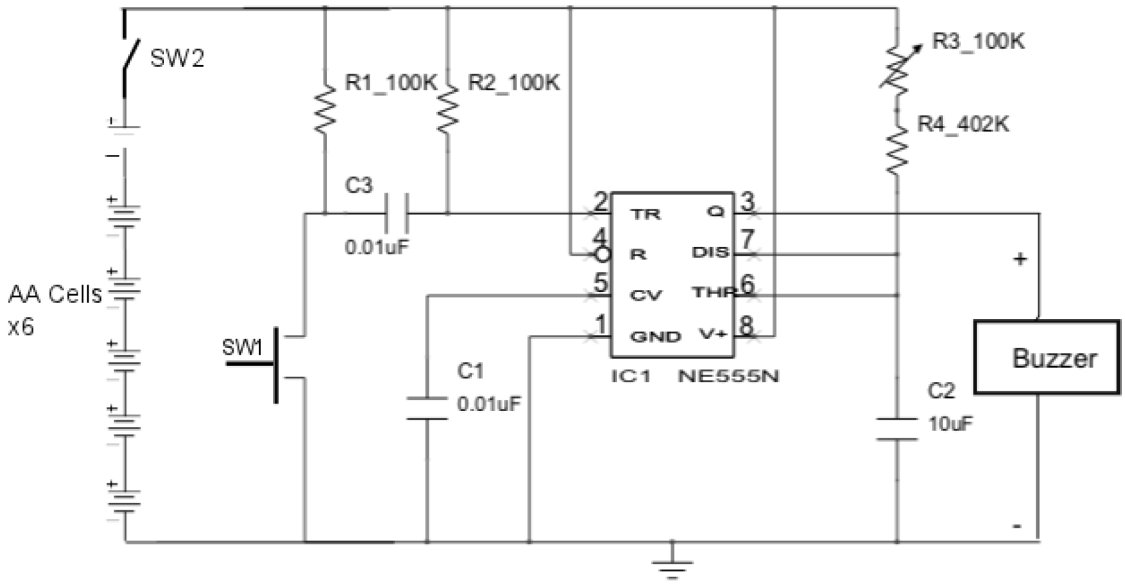

Figure C.2: Standard Sound Start Device Schematic (StartBoxSchematicBW.png)

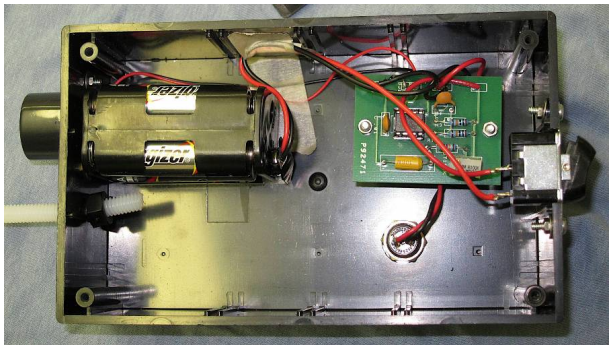

Figure C.3: Interior view of Standard Sound Start Device (Standard Sound Start Device - Interior - StartBox12_031.jpg)

Figure C.3 shows the component layout inside the case.

C.3 Parts List

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

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.

C.4 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.

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	sound271-100K-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 C.1: Standard Sound Start Device Parts List (StartBoxPartsList.ods)

Appendix D

Level 3 Arena

NOTE: Detailed carpenter's drawings of the contest arenas are available upon request. Please email John.Mertens@trincoll.edu.

D.1 Level 3 Arena Layout

Figure D.1 shows the Level 3 layout consisting of two sub-arenas, each sub-arena equivalent to a Level 2 arena. The hallway linking the sub-arenas may be the standard flat version or the optional ramped version. A starting position will be chosen by the judge. The judge will place a start circle at that position. See Section 3.16 on page 15 for further information.

Note that Figure D.1 indicates that the right side of the arena will face the bleachers where spectators will sit. That is the southerly direction in the Trinity gymnasium.

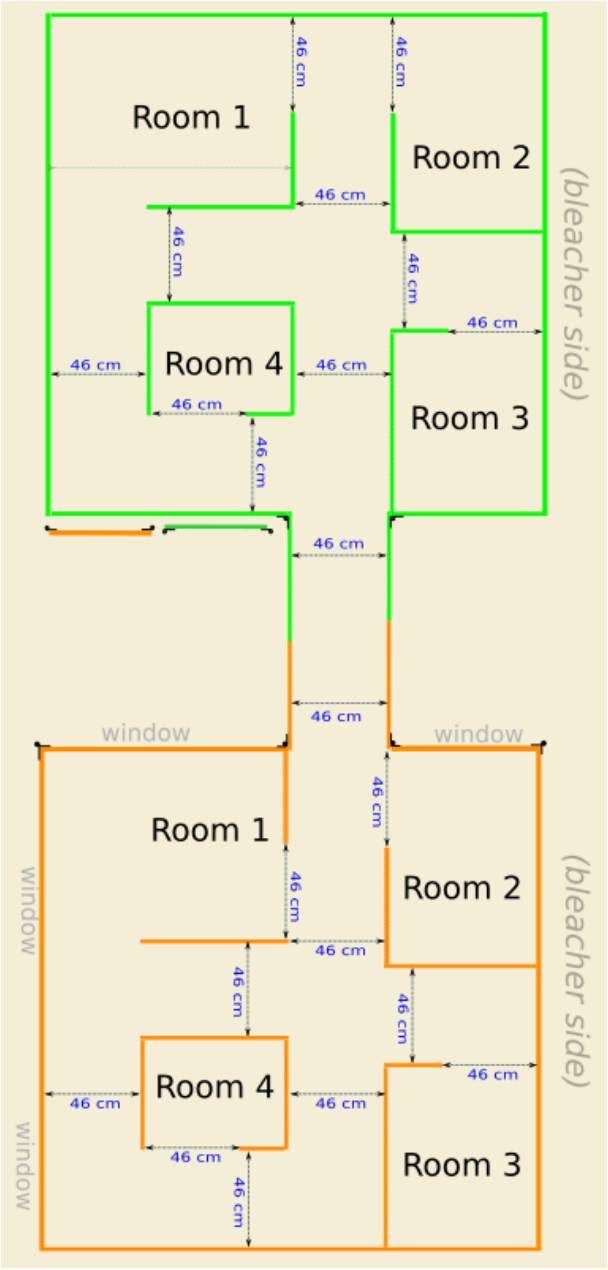

Figure D.1: Level 3 Arena Layout

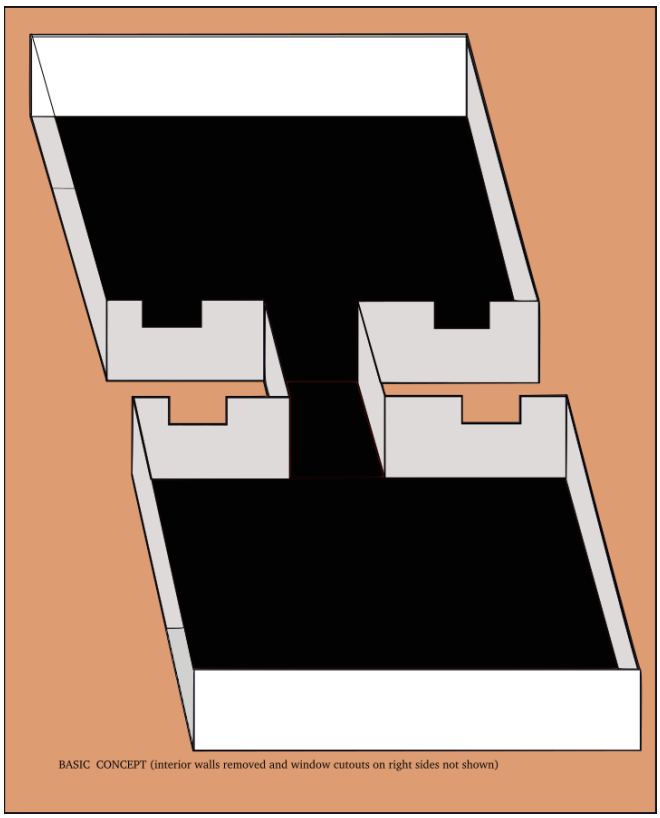

Figure D.2: 3-D Concept Drawing of Level 3 Arena Interior Walls Removed

D.2 Optional Ramped Hallway

The ramp is constructed from three 34 cm (x 46 cm wide) pieces hinged together with an 8.7 cm x 33 cm x 45 cm box under the center 34 cm section to give two 15 degree ramps in a 1 meter long stretch. The ramp is painted flat black with the same type of paint as the arena floors. The transition between the ramps and the central box will be made as smooth as possible and the gap at any point will not exceed 5 mm, a small gap that robots should be ready to traverse. Hallways will be 46 cm wide and will have walls on each side of the same nominal height as the standard arena walls (29 - 34 cm). Figure D.3 on the next page shows the geometry of the ramped hallway, excluding the central box.

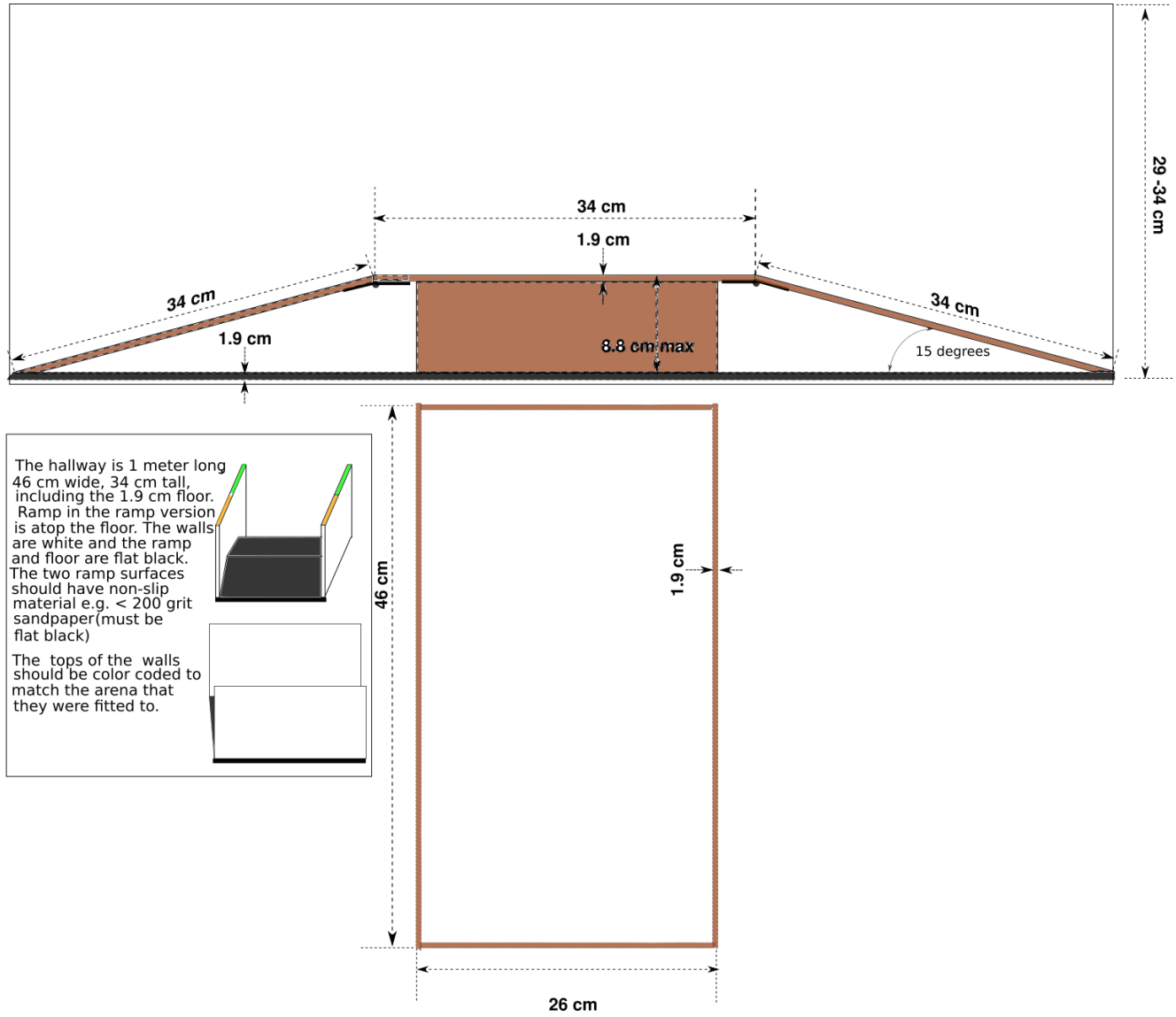

Figure D.3: Ramped Hallway Geometry– Central Box (rampAppendix06DEC2015-12-18pngA.png)

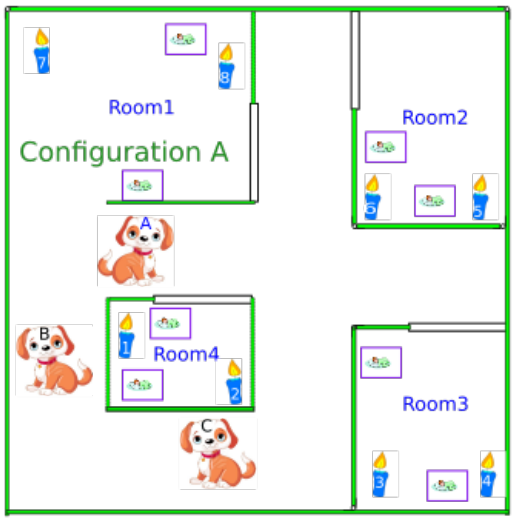

Figure D.4: Possible Dog and Cradle Positions in a Level 3 Sub-Arena (cradle-pup-candle.png)

D.3 Cradle and Baby

D.3.1 Cradle Positions

The diagram shows possible cradle and dog positions in a Level 3 sub-arena. Robots that pass the contest inspection process will have room to navigate in the arena with dog and cradle positions the contest will present.

D.3.2 Baby

The official baby doll used in the Level 3 competition is a Toysmith "My Sweet Baby" Item #65513 obtained from amazon.com (Figure D.5). The doll shown in Figure D.5 is approximately 16 cm long and weighs 32 g.

D.3.3 Cradle

The cradle consists of two parts: a basket that contains the baby and a base upon which the basket lies. An example of a cradle is shown in Figure D.9 on the next page. This cradle is constructed from from a double-thickness of 1/4" (6.35mm) foam board and assembled using hot glue. Rough edges were sanded and a single coat of white latex interior paint was applied. Complete directions for constructing the cradle are given in Figure D.12 on page 56

To ease the computer vision and navigation tasks at Level 3, three sides of the base are covered with colored patterns. The front has vertical green stripes,

Figure D.5: Level 3 Baby

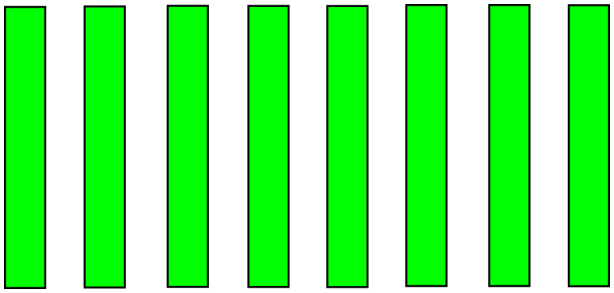

Figure D.6: Level 3 Green Target (green-0-255-0.png)

the left side patterned blue squares; and the right side patterned red squares (see Figures D.6, D.7, and D.8). These different RGB patterns may be differentiated by computer vision software. A robot's eye view from the left front corner of the base is shown in Figure D.10, and a view from the right front corner is shown in Figure D.11.

Please note the following:

1. The patterns that will be used in the contest were printed on a high quality photo matte paper on an Epson Photo R2880 printer using a color-managed workflow appropriate to high-quality photographic printing.
2. Original files, with images full size, are posted on Dropbox and may be downloaded via this link: https://www.dropbox.com/sh/ij7vvdtbyrji9tg/AADwy6G5G_
3. To avoid errors caused by color differences, teams may uses their own bases in the contest. All such bases must pass inspection at the Robot Inspection Table.

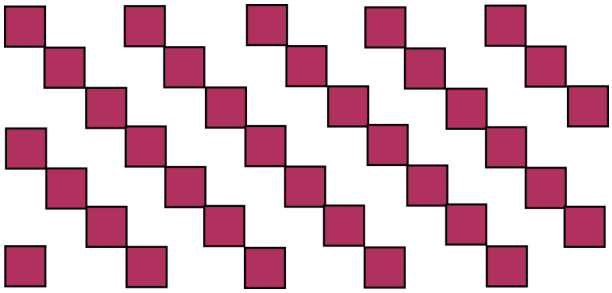

Figure D.7: Level 3 Red Target (red-255-0-0.png)

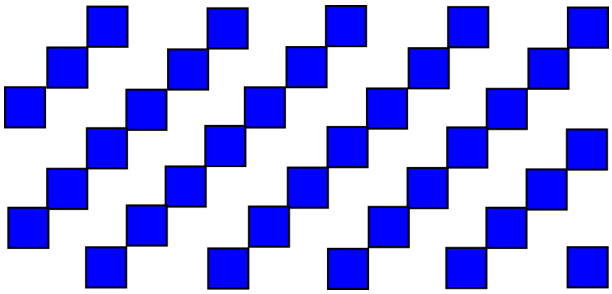

Figure D.8: Level 3 Blue Target (blue-0-0-255.png)

Figure D.9: Photo of Cradle and Baby (Baby&Cradle2017.jpg)

Figure D.10: View of Base from Left Front Corner (LeftFrontCorner17.jpg)

Figure D.11: View of Base from Right Front Corner (RightFrontCorner17.jpg)

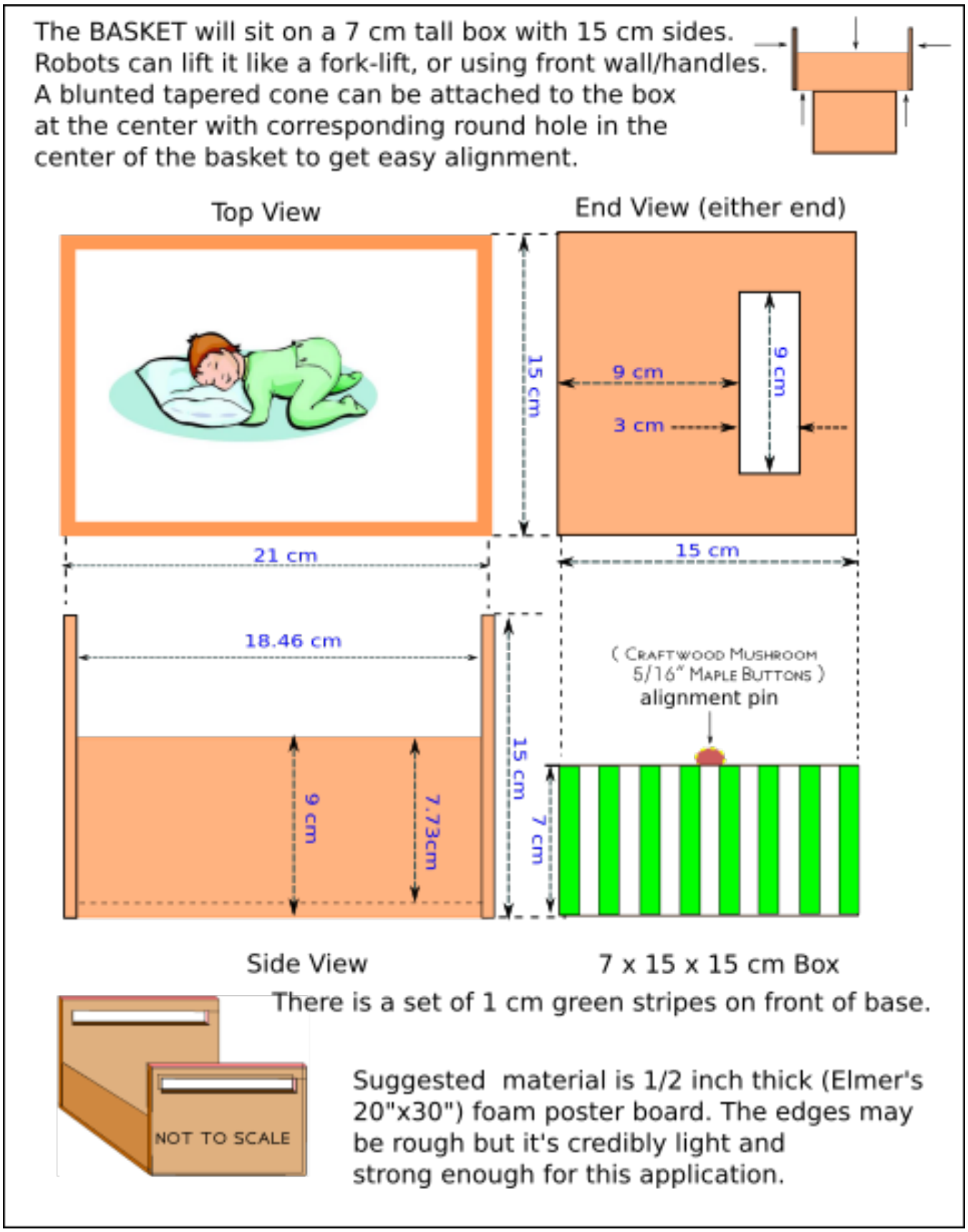

Figure D.12: Cradle Construction (Cradle13Sep2016/16/47.png)

Appendix E

Robot Inspection Table Checklist

All robots must pass an inspection at the Robot Inspection Table before competing. See Section 3.8 on page 12 for more details.

The sample RIT Checklist in this Appendix– 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
Jr/HS/SR Wheel / tread **Walking** Note: *legs extended*	31•31•27	5.2.2	❍	❍	❍	❍
TINY ROBOT (cm)	L= cm	W= cm	H= cm	V= cc	L=	

Note: Only non-functional decorations beyond Bounding Box=5.2.2

Firefighting Extinguisher & Indicator

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	Bounding Box	5.2.2				
Uses Versa valve?	Yes ❍	No ❍	In scoring system? ❑			
Red LED fire indicator visible?	Yes ❍	No ❍				

Note: Must be 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	Black	Above fan blades	5.2.4	❍	❍	❍	❍

Sound Start Response

Division		Freq kHz	Spec Section	Exam 1 Pass	Exam 1 Fail	Exam 2 Pass	Exam 2 Fail
FF	*Not* Jr, required others	3.8	6.4.1.3	❍	❍	❍	❍

Note: Junior Division robots *must not* respond to Sound Start Device=6.4.1.3

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

Etaoin Shrdlu

J-42 **Gort II**

Figure E.1: Sample RIT Checklist Form (Robot Inspection Table Checklist2016V1_0.png)

Appendix F

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 shown in this Appendix, 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.

Junior	Klaatu Tech Foundry	Esperanto
J-42	**Robot: Gort II**	**Etaoin Shrdlu**

Options - Trial 1- Level 1❍ 2 ❍ 3 ❍

Operating Mode	Selected	Section	Information
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	
Variable Door Locations	❍	6.5.1.10	Optional=Jr Mandatory=others
Candle Location	❍	6.5.1.11	Detect: LED ❍ Action ❍ Other ❍

Options - Trial 2- Level 1❍ 2 ❍ 3 ❍

Operating Mode	Selected	Section	Information
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	
Variable Door Locations	❍	6.5.1.10	Optional=Jr Mandatory=others
Candle Location	❍	6.5.1.11	Detect: LED ❍

Options - Trial 3- Level 1❍ 2 ❍ 3 ❍

Operating Mode	Selected	Section	Information
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	
Variable Door Locations	❍	6.5.1.10	Optional=Jr Mandatory=others
Candle Location	❍	6.5.1.11	Detect: LED ❍

Options - Trial 4- Level 1❍ 2 ❍ 3 ❍

Operating Mode	Selected	Section	Information
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	
Variable Door Locations	❍	6.5.1.10	Optional=Jr Mandatory=others
Candle Location	❍	6.5.1.11	Detect: LED ❍

Options - Trial 5- Level 1❍ 2 ❍ 3 ❍

Operating Mode	Selected	Section	Information
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	
Variable Door Locations	❍	6.5.1.10	Optional=Jr Mandatory=others
Candle Location	❍	6.5.1.11	Detect: LED ❍

Figure F.1: Sample Trial Options Sheet (FF_2016_Contest_Trial_OptionsRulesV1_0.png)

