Official 2005 Rules and Regulations

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1. CONTEST OBJECTIVE

The main challenge of this contest is to build an autonomous computer-controlled robot that can find its way through an arena that represents a model house, find a lit candle that represents a fire in the house, and extinguish the fire in the shortest time. This task simulates the real-world operation of an autonomous robot performing a fire protection function in a real house. The goal of the contest is to advance robot technology and knowledge while using robotics as an educational tool.

2. DIMENSIONS AND SPECIFICATIONS

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. Therefore, the dimensions and specifications listed in the rules are not exactly what will be encountered at the contest and they are provided as general aids. However, the size limits on robots are absolute and will be enforced by the judges.

3. CASH AWARD DIVISIONS

A. Junior Division: The Junior Division is open to students in Grade 8 and below. The Junior Division competition will take place in the four-room Entry Level Arena Layout. Junior Division robots can choose any of the Basic Level Operating Modes. The 2005 rules require Junior Division robots to put out the candle in any of the arena's four rooms instead of just two rooms, as in the past.

B. Walking Division: This division is for any robot that uses only legs to move around. The number of legs does not matter. The size restriction for walking robots is 46 cm long, 31 cm wide and 31 cm high. The Walking Division will use the four-room Entry Level Arena Layout. Walking Division robots may choose any of the Basic Operating Modes.

C. High School Division: This division is open to students in high school grades 9 through 13. Prizes will be awarded for two levels of competition: The Entry Level (EL) and the 2005 Standard Level (SL).

High-School EL robots will use the Entry Level Arena Layout and may choose any of the Basic Level Operating Modes.

The 2005 High School Standard Level will use the 2005 Standard Arena Layout. SL teams may choose operating modes from the Basic Level Operating Modes and the 2005 Standard Level Operating Modes.

D. Senior Division: This division is for anyone out of high school; that is, college students and other adult contestants. The 2005 Senior Division will use the 2005 Standard Arena. Senior Division teams may choose operating modes from the Basic Level Operating Modes and the 2005 Standard Level Operating Modes (same modes as the standard level High School category).

E. Expert Division: The Expert Division is open to persons of all ages and affiliations. The 2005 Expert Division will use the 2005 TCFFHRC Expert Arena and the 2005 Expert Division Rules. The 2005 rules encourage multiple robot solutions (swarms). Note the addition of a visible beacon to the baby's crib.

4. THE HOUSE FLOOR PLANS: STRUCTURE AND FEATURES

Note: Keeping in mind the large number of original contest arenas out in the real world, we have derived the 2005 arenas by making straightforward changes to the old contest arena. For instructions about how to convert your old arena, see Appendix A. Features of 2005 arena and differences from the original arena are summarized below.

A. Entry Level Arena Layout

Click here to see a diagram of the Entry Level Arena Layout. The dimensions are given in metric units in keeping with the international scope of the contest and with scientific and technical usage. Note the following:

i. The walls of the arena are made of wood and are between 27 and 34 cm in height.

ii. The walls will be painted or decorated with finishes found in a typical home. Such finishes include wallpaper in various patterns and painted surfaces. Painted surfaces may be any color including black and white.

iii. The floor of the arena will be a smooth wood surface painted with flat black latex paint. Any seams in the floor will be taped over and painted with the same flat black latex paint. The seams in the floor section may not be perfectly flat however. Therefore, make sure that your robot can handle a discontinuity of up to 5 mm.

iv. All hallways and doorways will be approximately 46 cm wide. There will not be a door in the doorways, just a 46 cm opening. There will be a white 2.5 cm wide line made with white tape across each doorway to indicate the entrance to each room.

v. The floor of the arena will be painted black, but some robots may use foam, powder or other substances to attack the candle flame. 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. The floor may also have small (3 mm diameter) red or blue dots on it to indicate the potential locations of candles and furniture.

vi. The robot will start at the Home Circle location marked by the H in a circle on the arena floor plan. The Home Circle will be a solid white circle (without the H) on the floor. The 30 cm diameter white Home Circle will be in the center of the 46 cm hallway. There are no gaps in the outer wall of the arena.

vii. Robots may also use any placement fixtures if they help the robot initially align itself in the Home Circle. The robot must start within the Home Circle, but once started, it can go in any direction desired.

B. 2005 Standard Arena Layout

The 2005 Standard Arena Layout represents a decorated home, a more realistic fire-fighting environment. The Standard Arena and the Basic Level Arena have the same dimensions and it is straightforward to transform a single arena from Basic Level to Standard Level and vice-versa. The differences between the Standard Arena and the Entry Level Arena are listed below.

i. There is a staircase in the Standard Arena. The staircase is a fixed component of the Standard Arena Layout and is not an option.

ii. Rugs will be placed in some or all of the rooms and hallways. There will be no shag rugs.

iii. Wall hangings, including pictures, tapestries, and/or mirrors, will be hung from the walls of rooms and hallways. These will not protrude more than 1 cm from the wall.

iv. A mirror will not be placed in the room where the candle is located but may be placed anywhere else in the arena.

v. Small household objects (clutter) may be placed in the arena. The Clutter Operating Mode may be elected (time multiplier = 0.8) in the High School Standard Level and Senior Division.

vi. As noted in the arena floor plans, all hallways and doorways to room will be approximately 46 cm wide. There will not be a door in the doorways, just a 46 cm opening. There will be a white tape, approximately 2.5 cm wide, stuck to the floor across each doorway to indicate room entrances. The carpeting will not cover up the white tape. However the floor coverings may be light in color.

vii. Some robots may use foam, powder or other substances to attack the candle flame. Our best efforts will be made to clean up after each robot. Unless you are operating in the Uneven Floor mode (see Operating Modes, Section 18 below), the floor will be level (except for the staircase).

viii. The robot will start at the Home Circle location marked by the H in a circle on the arena floor plan. The Home Circle will be a solid white circle (without the H) on the floor. The 30 cm diameter white Home Circle will be roughly centered in the hallway. Robots may also use any placement fixtures if they help the robot initially align itself in the Home Circle. The robot must start within the Home Circle, but once started, it can go in any direction desired.

5. AMBIENT LIGHTING

Contestants will be given time on the contest days to take ambient light level readings to calibrate their robot. Once set on Saturday, the lighting in the contest area will not be changed to suit individual competitors. Part of the challenge of the contest is to make a robot that can operate in real world situations and that includes inconsistent lighting, shadows, glare, etc.

6. ROBOT OPERATION

Once turned on, the robot must be autonomous--self-controlled without any human intervention. That is, they are to be computer controlled and not manually controlled devices.

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. There will not be a penalty for touching a wall, but there is a penalty for moving along the wall while in contact with

it. (See Penalties, section #20) The robot cannot leave anything behind as it travels through the arena. It cannot make any marks on the floor of the arena that aid in navigation as it travels. Any robot that deliberately, in the judges' opinion, damages the contest arena (including the walls) will be disqualified. This does not include any accidental marks or scratches made in moving around.

The robot must, in the opinion of the judges, have found the candle before it attempts to put it out. For example, the robot cannot just flood the arena structure with CO2 thereby putting the candle out by accident.

7. PUTTING OUT THE CANDLE

The robot must not use any destructive or dangerous methods to put out the candle. It may use such substances as water, air, CO2, etc., but any method or material that is dangerous or will damage the arena is prohibited. Halon is not allowed because it is harmful to the environment.

It will be permissible to put out 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 will receive a 15% time reduction.

A penalty is given to robots that touch a lit candle. Such penalty touches can be made by the robot itself or by one or more of the robot's sensors. (See Penalties, section #20)

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

8. ROBOT SIZE

Robot must be able to fit in a box 31 cm long by 31 cm wide by 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. The robot cannot separate into multiple parts and must never extend itself beyond the 31 cm allowed. (Separating robots are allowed in the Expert Division.)

Note that an additional constraint on the robot height is imposed on robots that run in the Standard Level Arena and go up and down the staircase. Since no part of the robot may exceed the height of the wall, the height of these robots is limited by the available vertical space; i.e. the minimal wall height (27 cm) less the peak height of the stairs (6 cm), or 21 cm.

Contestants may add a flag, hat or other purely decorative, non-functional item/s to the robot as long as the item has absolutely no effect on the operation of the robot.

As noted previously, the robots in the Walking Division may be up to 46 cm long.

9. ROBOT WEIGHT

There are no restrictions on the weight of the robot.

10. ROBOT CONSTRUCTION MATERIALS

There are no restrictions on the types of materials used in the construction of the robot.

11. THE CANDLE

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

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

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

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

The candle will be mounted on a small wooden base painted semi-gloss yellow. This base is used to help keep the candle from tipping over easily, but it will be possible to knock the candle over by bumping into it (which you don't want to do - see Penalties, section #20).

12. SENSORS

There is no restriction on the type of sensors that can be used as long as they do not violate any of the other rules or regulations. Robots that use laser-based devices must take measures to prevent eye damage to team members and to observers. If effective safety measures have not been taken, in the opinion of the qualification judges, the robot will not be allowed to qualify for the competition. The judges may require the team to remove the laser device from the robot.

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

Robot builders should be aware that many cameras transmit infrared light as part of their automatic focusing systems. Ambient lighting in the contest room may also be a source 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 may 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. If a robot uses light sensors to find the candle or detect walls or furniture, it is the robot builder's responsibility to design their robot

to prevent these and other 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 candle flame and ignore everything else.

13. ELECTRICITY
The maximum electrical requirements for any system needing electricity at the arena will be 10 amps at 120 VAC, 60 Hz.

14. CABLES
If the robot is connected to an external computer system for instructions and/or power make sure that the cable is long enough for the robot to get to all areas of the arena. If a contestant wants to hold the cable above the walls while the robot runs, they can, but if during the trial, in the opinion of the judges, they use the cable to assist the robot, then that trial will be ended with no score.

15. THE ORDER OF RUNNING
The robots will be assigned numbers to determine the order in which they will compete in the contest. Each robot will make a trial run in the arena in the order in which it is assigned. The robots will compete consecutively and when everyone is done with their first attempt the whole process will repeat for the second and third attempts.

Contestants will have time between their trials to make any adjustments, modifications or repairs to their robot, but once the robot before them has completed its trial, then they will have 1 minute to get their robot in the arena and started on its trial. There will be a special clock at each arena that the judges will start when they call for the next contestants to get ready. The robot must begin its trial before that clock reaches 1 minute. Any robot that is not ready to run after 1 minute will forfeit its chance at that trial. It may still compete in any other trials. Once assigned, the order of running will not be changed. If you are not ready, then you've missed your turn. The time between turns is undetermined and is controlled by how long the other competitors take to complete their trials.

The contestants will show a judge how to start the robot.

Once the robot is ready and the judge knows how to start it, the location of the candle, furniture, clutter and ramps, as appropriate, shall be determined. The judges will then place these objects in proper locations.

The contestants will show a judge how to actuate the robot. The judge will press whatever buttons are necessary to start the robot.

16. TIME LIMITS
In order to achieve the contest objective of building a robot that can find and extinguish a fire in a house, finding the fire within a reasonable period of time is very important. The maximum time limit for a robot to find the candle will be 5 minutes. After 5 minutes the trial will be stopped. The maximum time for the robot to return to the Home Circle in the Return Trip mode will be 2 minutes. If in any trial, a robot gets stuck in a loop and performs the same movement 5 times in a row, that trial will be stopped. Any time the robot does not move at all for 30 seconds, the trial will be stopped. Stopping a trial run for any of the above reasons will have no impact on any of the other two trial runs that the robot has.

17. SCORING

The robot with the lowest Final Score (FS) is the winner. The Final Score is calculated from a number of different factors, which are explained below. The scoring process is not as complicated as it might seem at first. It is intended to make the contest as realistic and as fair as possible. We are sorry if it reminds you of the federal tax code.

18. OPERATING MODES

Note: A Mode Factor (MF) is associated with each of the operating modes described below in parts A and B. The mode factors, the actual run time (AT), the penalty points (PP), and room factors are used to calculate the Operating Score (OS) that we used to rank the robots.

Basic Level Operating Modes

Five Basic Operating Modes apply to Entry Level and Standard Level runs: Standard Mode, Tethered Mode, Sound Activation Mode, Return Trip Mode, and Extinguisher Mode. Each is associated with a mode factor that is used to adjust the Actual Time (AT).

A. Standard Mode

In the Standard Mode there are no wires connecting the robot to anything. The deciding factor in determining this mode is whether or not there is a tether connected to the robot. The Mode Factor for running in the Standard Mode is 1.0 (MF= 1.0)

B. Tethered Mode

In Tethered Mode the robot has a wire connecting it to either an external computer or a power supply. This Mode Factor is actually a penalty and increases the Operating Score. If the robot has its own on-board power supply and is controlled by either an on-board computer or a wireless link to another computer then it will not be in this mode and will not have an increased score. The Mode Factor for running in Tethered Mode is 1.2 (MF = 1.2).

C. Sound Activation Mode.

In Sound Activation Mode the robot activates itself when it detects a sound signal between 3.0 kHz and 4.0 kHz. This action replaces manual pressing of start buttons on the robot or on a keyboard. The sound frequency is commonly used in smoke detectors and is created by piezo-electric devices available at Radio Shack and many other sources. Once turned on, the robot cannot start to move until the sound signal is activated. For example, if the robot starts to move before the sound signal is activated because it mistakenly detected ambient room noise (even the sound of another robot being activated in a different arena), then the trial will still count, but the robot will not get credit for operating in the Sound Mode. If the robot does not start to move in response to the sound signal it will not be given a second chance (i.e. another press of the sound button) to run in the sound mode for that trial. The sound signal device can be held at any distance from the robot that the contestants want and can continue for up to 5 seconds. The time for the trial will begin when the sound signal is created and not when the robot actually starts to move in response to that signal. There will be an official sound signal device at the contest, but contestants can bring and use their own sound devices operating within the proper frequency range. There will be a 5% reduction in

score for a robot operating in this mode. The Operating Mode factor for running in the Sound Activation mode is 0.95 (OM = 0.95).

D. Return Trip Mode
In Return Trip Mode, the robot returns to the Home Circle after extinguishing the flame. It does not have to retrace its path in returning to the Home Circle or even take the most efficient route; it just must get back once it has put out the candle. It must leave that room and return to the Home Circle without entering any other rooms. The robot will be considered to have returned to the Home Circle if the robot stops with any part of the robot within the 30 cm white Home Circle. The robot does not have to be in the same position that it was when it started the run.

If a robot is entered to run in the Return Trip mode and finds and extinguishes the candle, but doesn't return to the Home Circle, the robot will not be disqualified. Instead the robot will receive the Operating Score with no Return Trip mode factor reduction.

The Actual Time (AT) score will include just the time the robot takes to find and extinguish the candle. It will not include the time for the robot's return trip to the Home Circle. Operating in Return Trip Mode will result in a 20% reduction in the score; the Operating Mode factor for running in the Return Trip mode is 0.8 (OM = 0.8).

E. Extinguisher Mode
Extinguishers that fan the flame would not be useful in the real world. Therefore, we assign a 15% decrease in time score (Operating Mode Factor OM = 0.85) to robots that put out the candle without blowing air. Robots that use an air stream of any kind will receive the Operating Mode Factor OM = 1.0).

2005 Standard Level Operating Modes
In addition to the four basic level operating modes, the Standard Level offers three additional modes: Furniture Mode, Uneven Floor Mode, and Clutter Mode.

A. Furniture Mode.
In Furniture Mode there will be one or more pieces of furniture in each room. The robot 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 run.

The furniture will be made of cylinders approximately 11 cm in diameter, painted semi-gloss yellow. The cylinders are approximately 30 cm high and weigh more than 1 kg. The furniture will NOT block a doorway and a robot will be able to come into a room at least halfway before it encounters furniture. The furniture will always be placed so that there is at least one path to the candle that is at least 31 cm wide. The possibility that the furniture may be blocking the robot's view of the candle or that the robot may have to go around the furniture to get to the candle is what makes the Furniture Mode such an interesting and real-world realistic challenge. The robot may have to look around the room from different locations to see if the candle is there. If the candle is indeed behind furniture, the robot may have to determine what is the best way to go around the furniture to get to the candle. Successfully operating

in this mode will result in a 25% reduction in the score. The Operating Mode factor for running in the Furniture mode is 0.75 (OM = 0.75).

B. Uneven Floor Mode

Many robots use a form of dead-reckoning to travel through the arena. That is, once correctly oriented at the start of the arena, they count the distance moved and angle turned and add them to their old position to obtain their new location and orientation. While this is a legitimate method of traveling through the arena in this contest, it is not as practical or useful in the real world where the floors are often uneven and surfaces irregular. So to encourage robots to use more sophisticated methods of determining their position and orientation within the arena, we give a score reduction bonus to robots that do not use a dead-reckoning method. The key to using dead-reckoning is knowing the distance beforehand to the various rooms in the arena. Under normal conditions to aid in dead-reckoning, the floor surface of the arena is made as smooth and uniform as possible. However, if you decide to operate in the Uneven Floor mode, the uniformity of the floor will be taken away by adding ramps that will change the direction of dead-reckoning robots. The judges will choose the orientation of the ramps. Since the robot will not know exactly where a ramp will be placed or which wheel it might affect and by how much, the robot will have to use other methods besides dead reckoning to determine its location and orientation within the arena.

More than one ramp may be present on any run, and the exact placement of ramps will be unknown to the robot before the start of any run. The ramps will be used in hallways and not in rooms. The ramps will not be placed in the hallway directly outside of a doorway, although one could be placed next to a doorway. The number and location of the ramps will be changed from trial to trial, and the ramps will remain in place during the return trip portion of the trial. The maximum height of the ramps will be 5 cm. The ramps are tapered, and there will be as smooth an intersection with the floor as practical. The ramps will not have steps or sharp drops greater than 5 mm, and the average maximum slope will be 15 degrees. The ramps will be painted the same flat black as the floor. Click here for ramp construction information (link to same diagram used in 2003 rules). Successfully operating in this mode will result in a 20% reduction in the score. The Operating Mode factor for running in the Uneven Floor mode is 0.8 (OM = 0.8).

C. Clutter Mode

In Clutter Mode the robot must operate in the presence of small household objects that are randomly placed throughout the arena, both in hallways and rooms. These objects will be scaled relative to the size of the arena, and they may include such items as furniture, pets, sports equipment, and clothing. The largest linear dimension of a clutter object will be approximately 8 cm. A robot operating in Clutter Mode must deal with the clutter in a non-destructive manner.

The number of objects will vary from run to run, but there will be at least five and no more than ten objects on any run. Successfully operating in this mode will result in a 20% reduction in the score. The Operating Mode factor for running in Clutter Mode is 0.8 (OM = 0.8).

19. STARTING AND OPERATING THE ROBOT

A. STARTING THE ROBOT MANUALLY

If the robot is not being run in the Sound Mode then it must be started manually by a contest official.

B. EXTERNAL COMPUTER

If the robot is using a tether connecting it to an external computer then the only key that can be pressed to start the robot is the "Enter" or "Return" key on the computer keyboard. A contest official will press the key. Any program that needs to be run must be loaded and ready to go before the robot is put in the arena. Once the robot is in place and the candle put into position, only the "Enter" or "Return" key can be pressed to start the robot. If for any reason the robot does not start, then that trial is over.

C. ON-BOARD COMPUTER

If the robot is using an internal computer, then there can be one and only one button that can be pressed to start the robot. This button must be positioned some place easy to see and get to on the robot and must be labeled as such, i.e., "START". "RUN", "GO", etc.

D. PROGRAM DOWNLOADING

Any program necessary must be downloaded to the robot before it is put into the arena. Once that is done then the specific "start button" and only that "start button" can be pressed to start the robot. If for any reason the robot does not start, that trial is over.

20. PENALTIES

The goal of this contest is to be as realistic as possible. Continuous contact of the robot with a wall for the purposes of navigation, or touching the candle, are not illegal but they are not good operating procedures for the real world (see A. and B. below). Penalty Points (PP) will be added to the Actual Time (AT) of any robot that exhibits these behaviors. Don't let these penalties scare you too much. These penalties are generally a small price to pay for a robot that manages to accomplish the task.

A. Continuous Contact With a Wall

Any robot that slides along a wall will have an additional penalty point 1 point (1 second) added to its time score for each 2 cm of wall it touches as it slides along. A robot may still touch a wall to orient itself. There are no penalties counted for hitting the wall on the return trip to the Home Circle.

B. Touching the candle

Any robot that touches the candle or its base with any part of its body or feeler, either deliberately or accidentally while the candle is lit, will have 50 penalty points (seconds) added to its Actual Time score. If the touch occurs as part of the actual extinguishing process (i.e. smothering the flame with a wet sponge) or after the candle is extinguished, there is no penalty. This touching refers only to a part of the robot's body and does not include any water, air or other material that the robot might use to extinguish the candle. (PP = 50)

21. ROOM FACTOR

In order to make the contest realistic and to encourage the creation of smart robots, we have deliberately added uncertainty into the contest. The robot does not know in which of the 4 rooms the candle has been placed. Sometimes a robot gets lucky and the candle is in the first room it searches and sometimes the candle is in the 4th room

searched. The unfairness of this is that finding the candle in the 4th room you look in is a lot harder and takes longer than finding it in the 1st room you search. To reduce the impact of "luck" and give some credit to the more sophisticated robots that can search multiple rooms successfully, there will be a Room Factor involved in the scoring that will be multiplied by the Time Score to get the Operating Score. The more rooms a robot has to search before it finds the candle, the lower the Room Factor and thus the better the Operating Score.

If the candle is in the 1st room searched, the Room Factor will be 1.0

If the candle is in the 2nd room searched, the Room Factor will be 0.85

If the candle is in the 3rd room searched, the Room Factor will be 0.50

If the candle is in the 4th room searched, the Room Factor will be 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.

After searching a room with a lit candle in it, there is no further reduction of room factor. This is true whether or not the robot extinguishes the candle. No matter how many more rooms the robot searches, there will be no effect on room factor.

Some robots have extremely sensitive sensors and can tell if the candle is in the room by merely looking in the doorway as it passes by. The robot does not have to enter a room to be considered to have searched it. Any robot going past a doorway that it has not gone past before will be considered to have searched that room. 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.

22. SCORING PROCEDURES

For any run the judges measure the Actual Time (AT) of the run and they record the operating modes and penalties. The AT for each run is adjusted by adding the time penalties first to get the Time Score (TS) and by multiplying the TS by the mode factors.

Multiply the Operating Modes together to get the Mode Factor (MF). The Operating Mode factors are: Tethered=1.2, Sound = 0.95, Return=0.8, Extinguisher Mode (1.0 for robots that use air to blow out the candle, 0.85 otherwise), Furniture=0.75, Uneven Floor=0.8, Clutter = 0.8.

A. If none of the Operating Modes are used and the robot is running in the Standard Operation then MF=1.0

B. Record the Actual Time (AT) in seconds needed to put out the candle

C. Add all the Penalty Points (PP) together
Sliding along wall = 1 point per 2 cm
Touching the candle or base while the candle is lit = 50 points

D. Record the Room Factor (RF)
1st room = 1.0, 2nd room = 0.85, 3rd room = 0.50, 4th room = 0.35

E. Add the Actual Time to the Penalty Points to get the Time Score (TS)
TS = AT + PP

F. Multiply the Time Score, Room Factor and Mode Factor together to get the Operating Score (OS) for that trial.
OS = TS x RF x MF

G. The method for determining the winner in the Expert Division is given below in Section 25. First, second and third prizes in each division will be determined as follows. To receive a cash prize a robot must have at least two successful runs.

i. Robots with three successful runs (candle extinguished) will form the highest group. The top three robots in that group will be ranked according to the sums of their three OS scores as determined in A-F above.

ii. If there are fewer than three robots in any division with three successful runs, the remainder of the top three prizes will be determined by ranking, according to finishing times, the robots that complete two successful runs.

23. SCORING EXAMPLES

A. Entry Level Scoring Example

1st Trial: The robot runs its first trial in the Standard, Sound, and Return modes, takes 1 minute and 23 seconds to extinguish the candle in the 2nd room and slides along the wall a total of 42 cm. The robot puts out the flame with a fan. Its Operating Score for that trial is computed as follows:

i. Multiply the Operating Modes together to get the Mode Factor (MF) (Standard=1.0, Sound = 0.95, Return=0.8, Extinguisher = 1.0)
MF = Std x Snd x Rtn x Ext = 1.0 x 0.95 x 0.8 x 1.0 = 0.76

ii. Record the Actual Time (AT) in seconds needed to put out the candle
AT = 83

iii. Add the Penalty Points (PP) together (1 penalty point per 2 cm of sliding along the wall PP = 42/2 = 21.

iv. Record the Room Factor (RF) (2nd room = 0.85)
RF = 0.85

v. Add the Actual Time to the Penalty Points to get the Time Score (TS)
TS = AT + PP = 83 + 21 = 104

vi. Multiply the Time Score, Room Factor and Mode Factor together to get the Operating Score (OS)
OS = TS x RF x MF = 104 x 0.85 x 0.76 = 67.184

2nd Trial: The robot runs its second trial in the Standard, and Sound modes but fails to return to the home position. The robot takes 1 minute and 41 seconds to blow out the candle in the fourth room searched while accidentally bumping into the candle one time. The Operating Score for that trial is calculated as follows:

i. Multiply the Operating Modes together to get the Mode Factor (MF)
(Standard=1.0, Sound = 0.95, Extinguisher = 1.0)
MF = Std x Snd x Ext = 1.0 x 0.95 x 1.0 = 0.95

ii. Record the Actual Time (AT) in seconds needed to put out the candle
AT = 101

iii. Add all the Penalty Points (PP) together (hitting candle = 50 points)
PP = 50

iv. Record the Room Factor (RF) (4th room = 0.35)
RF = 0.35

v. Add the Actual Time to the Penalty Points to get the Time Score (TS)
TS = AT + PP = 101 + 50 = 151

vi. Multiply the Time Score, Room Factor and Mode Factor together to get the Operating Score (OS)
OS = TS x RF x MF = 151 x 0.35 x 0.95 = 50.2075

3rd Trial: In the third trial the robot tried to run in the Sound, and Return modes. The audio start circuitry failed to operate and it was necessary to push a button to start the robot. The robot blew out the candle in the first room in 1 minute and 10 seconds, but it did not make it back to the Home Circle.

i. Multiply the Operating Modes together to get the Mode Factor (MF). The robot lost the deductions for sound activitation and return mode. The operating mode factors are Standard=1.0, and Extinguisher = 1.0.
MF = Std x Ext = 1.0 x 1.0 = 1.0

ii. Record the Actual Time (AT) in seconds needed to put out the candle
AT = 70

iii. Add all the Penalty Points (PP) together
PP = 0

iv. Record the Room Factor (RF) (1st room = 1.0)
RF = 1.0

v. Add the Actual Time to the Penalty Points to get the Time Score (TS)
TS = AT + PP = 70 + 0 = 70

vi. Multiply the Time Score, Room Factor and Mode Factor together to get the Operating Score (OS)
OS = TS x RF x MF = 70 x 1.0 x 1.0 = 70.0

vii. Final Calculations: The robot completed three runs successfully and is placed in the highest category of finishers.

The three OS scores are added together to get the total OS score (TOS) for the robot:
TOS = 67.184 + 50.2075 + 70.0 = 187.3915

Note: The robot can choose different modes during each of its three trials. The candle and any furniture, if necessary, will be moved to different locations for each trial.

B. Standard Level Scoring Example

1st Trial: Robot runs in Standard, Sound, Return, and Clutter modes and takes 2 minutes and 17 seconds to extinguish the candle, in the second room visited, using a Carbon Dioxide device. It incurs no penalties on this run. The Operating Score for this trial is computed as follows:

i. Multiply the Operating Modes together to get the Mode Factor (MF) (Standard=1.0, Sound = 0.95 and Return=0.8, Clutter = 0.8, Extinguisher = 0.85)
MF = Std x Snd x Rtn x Clu x Ext = 1.0 x 0.95 x 0.8 x 0.8 x 0.85 = 0.5168

ii. Record the Actual Time (AT) in seconds needed to put out the candle
AT = 137

iii. Add all the Penalty Points (PP) together (PP = 0)

iv. Record the Room Factor (RF) (2nd room = 0.85)
RF = 0.85

v. Add the Actual Time to the Penalty Points to get the Time Score (TS)
TS = AT + PP = 137 + 0 = 137

vi. Multiply the Time Score, Room Factor and Mode Factor together to get the Operating Score (OS)
OS = TS x RF x MF = 137 x 0.85 x 0.5168 = 60.18136

2nd Trial: On its second trial the robot operates in the Standard, Sound, Return and Uneven Floor modes, takes 1 minute and 41 seconds to extinguish the candle, using a CO2 system, in the fourth room searched and accidentally bumps into the candle. It fails to return to start. Its Operating Score for that trial would be:

i. Multiply the Operating Modes together to get the Mode Factor (MF)
(Standard=1.0, Sound = 0.95, Return=1.0 and Uneven Floor=0.8, Extinguisher = 0.85)
MF = Std x Snd x Rtn x UnF x Ext = 1.0 x 0.95 x 1.0 x 0.8 x 0.85 = 0.646

ii. Record the Actual Time (AT) in seconds needed to put out the candle
AT = 101

iii. Add all the Penalty Points (PP) together (hitting candle = 50 points)
PP = 50

iv. Record the Room Factor (RF) (4th room = 0.35)
RF = 0.35

v. Add the Actual Time to the Penalty Points to get the Time Score (TS)
TS = AT + PP = 101 + 50 = 151

vi. Multiply the Time Score, Room Factor and Mode Factor together to get the Operating Score (OS)
OS = TS x RF x MF = 151 x 0.35 x 0.646 = 34.1411

3rd Trial: In the third trial the robot ran in Sound, Return, Clutter and Furniture modes. It extinguished the candle (with CO2) in the first room in 1 minute and 10 seconds, and did not make it back to the Home Circle.

i. Multiply the Operating Modes together to get the Mode Factor (MF) . The robot did not make it back to the Home Circle so it loses the Return mode reduction.
(Standard=1.0, Sound = 0.95, Clutter = 0.8, Extinguisher = 0.85, and Furniture = 0.75)
MF = Std x Snd x Clu x Frn x Ext = 1.0 x 0.95 x 0.8 x 0.85 x 0.75 = 0.4845

ii. Record the Actual Time (AT) in seconds needed to put out the candle
AT = 70

iii. Add all the Penalty Points (PP) together
PP = 0

iv. Record the Room Factor (RF) (1st room = 1.0)
RF = 1.0

v. Add the Actual Time to the Penalty Points to get the Time Score (TS)
TS = AT + PP = 70 + 0 = 70

vi. Multiply the Time Score, Room Factor and Mode Factor together to get the Operating Score (OS)
OS = TS x RF x MF = 70 x 1.0 x 0.4845 = 33.915

vii. Final Calculations: The robot had three successful runs and is placed in the highest finishing group. The three OS scores are added together to get the total OS score (TOS) for the robot: TOS = 60.18136 + 34.1411 + 33.915 = 128.23746

Note: The robot can choose different modes during each of its three trials. The candle and any furniture and/or clutter will be moved to different locations for each trial.

C. Scoring Example—Two successful runs, Standard Level
In this example the robot has the same first two (successful) trials as the robot in scoring example B above, but the robot fails to extinguish the candle on the third trial.

First trial: OS = 60.18136

Second Trial: OS = 34.1411

Third Trial: OS = 600 (score assigned for unsuccessful runs).

The robot is placed in the group with two successful runs, and the overall score is
OS = 60.18136 + 34.1411 + 600 = 694.32246

24. EXPERT DIVISION

The Expert Division was established in 2001 to challenge the most experienced firefighting robot designers and to clearly identify the best robots in the contest. Each year the Expert Division has presented new and more challenging tasks. In 2001 and 2002 Expert Division robots were required to operate within the standard arena using all of the deductions (audio start, arbitrary start, furniture, etc.) In 2003 the contest added a new challenge, a two-story arena whose configuration changed from run to run. In 2004 we increased the challenge by including both firefighting and search-and-rescue tasks. The 2004 Expert Division robots attempted to carry out the tasks of

a fire department scout robot that searches for a baby in a two-story house, marks the baby's location and puts out fires. In 2005 we keep this basic outline of the Expert Division task and open the competition to robot swarms.

The simulated house consists of a 3m x 3m arena that's linked to a 2m x 2m second floor by a ramp. Click here for a diagram of the Expert Division arena.

There are two bedrooms on the second floor. A doll placed in one of these bedrooms must be found and marked (so that a fire department rescue robot can save the baby). In addition two candles must be extinguished. The candles may be located in any room on either floor.

ROBOT SWARMS

Starting in 2005, single robots or robot swarms (multiple communicating robots) may enter the Expert Division. A single robot designed for this competition would be able to perform all of the tasks below while a robot swarm could consist of two or more specialist robots, each able to perform a specific task.

THE EXPERT DIVISION TASKS

The goal is to complete the four tasks below. The tasks can be completed in any order.

1. Put out candle 1;
2. Put out candle 2;
3. Find and mark the baby by placing an audible beeper (see specifications below) within 20 cm of the baby;
4. Go up and down the ramp at least once. This must be accomplished in a controlled fashion.

RULES FOR THE 2004 EXPERT DIVISION

The penalties for the Expert division will be the same as for the other divisions. Differences between the Expert division and the other divisions are listed below.

A. The First Floor

- i. The first floor will measure 3 meters by 3 meters square.
- ii. The outer walls will be fixed, but the inner walls that define the hallways and rooms will be moveable and will, in fact, be moved between each trial.
- iii. Wall height will be at least 27 cm and no more than 34 cm.
- iv. On any trial there will be 2 to 5 rooms on the first floor, and their position, size and doorway location will change from one trial to another. Note: A room will have at least a 2 by 2 grid area, where 1 grid length is approximately 50 cm. A room does not have to be rectangular and it may have alcoves and bends. The door to a room will not be smaller than 1 grid, but it could be wider. Everything else is a hallway.
- v. A room will only have one doorway and that doorway will be connected to the hallway and not to another room.
- vi. Hallways may lead to dead ends.
- vii. The hallways and doorways will be approximately 48 cm wide.

B. Second floor

- i. The second floor will measure approximately 2 meters by 2 meters square.
- ii. Wall height will be at least 27 cm but no more than 34 cm.

iii. The outer walls will be stationary, but the inner walls that define the hallways and rooms may be moveable and may be moved from run to run
iv. There will be 2 bedrooms on the second floor with connecting hallway (s).
v. A room will only have one doorway and that doorway will be connected to the hallway and not to another room.
vi. Hallways may lead to dead ends.
vii. The hallways and doorways will be approximately 48 cm wide.

C. Staircase (ramp)

i. A straight ramp will connect the first and second floors.
ii. The ramp will start and end on the edges of the floors.
iii. The ramp will meet the lower and upper floors at 90-degree angles.
iv. The ramp will not necessarily be centered on grid lines.
v. The entrance to the ramp is not marked in any way.
vi. The ramp angle will not exceed 15 degrees.
vii. The width of the ramp will be approximately 48 cm.
viii. The ramp will have walls that are similar, in height and style, to the walls of the arena.
ix. The length of the ramp is not specified exactly, but it will be between 150 and 300 cm.
x. The floor of the ramp will be covered with an adhesive backed non-slip surface similar to the type used on boat decks.

The Expert Division arena diagrams show only a few of the possible configurations. The Expert Division is trying to encourage development of fantastic state-of-the-art robots that can operate in a truly real-world environment where nothing is precisely known.

D. Baby

i. The baby is a toy doll made of soft fabric material. The baby is approximately 28 cm. in length.
ii. Through a belt on the baby, the baby emits infrared signals that simulate body heat. The nominal IR wavelength will be 880 nm.
iii. The IR emitted by the belt is modulated so standard remote control receiver modules can detect it. The carrier frequency is 36.7 kHz ± 5%. This carrier is modulated by a 300 Hz ± 5% rectangular wave with a duty cycle of 20%. Click here to see the waveform (link to Baby_Waveform±5%.jpg). A printed circuit board for this circuit will be made available at a nominal cost through our Robot Store.
iv. The belt contains multiple IR emitter diodes and a diffuser to achieve a wide radiation pattern. However, we do not specify or guarantee any radiation pattern.
v. The baby's IR emitter can be turned off during any run at the request of the competing team. The request must be made before any robot is placed in the arena and the emitter will remain off through the entire run.
vi. Robots may employ a non-destructive probe to verify the baby's position. Robots will be disqualified if the baby is injured.
vii. The baby will be in a wooden bed. The height of the bed will be in proportion to the room size and the size of the baby. A drawing of the bed is shown here. Two bright white LED emitters will shine outward from the bed.

E. Beeper

i. The beeper dropped by the robot must emit a 1 kHz tone pulsed twice per second.

ii. The beeper must operate for at least one minute and be loud enough to be heard by the judges at a distance of at least 3 meters.
iii. Participants must provide their own beepers.

F. The robots in this division must be untethered and using either on-board computers or an external desktop computer with an RF link. There may not be any wires from the external computer to the robot.

G. The Standard Mode in the Expert Division includes Sound, Uneven Floor, Furniture and Clutter modes. There is no Return Mode in the Expert Division.

H. These standard modes are mandatory and failure to operate successfully within them on any trial will nullify the trial resulting in this tally and time: zero tasks, 6 minutes adjusted time—see Scoring below.

I. There will NOT be a white line in the doorway to a room.

J. Even though some part of the robot must still come within 30 cm of a candle before it attempts to extinguish the candle, there will NOT be a candle circle to indicate that the robot is within the correct distance. Thus the robot will somehow have to make sure it is close enough to the candle before it starts the extinguishing process.

K. The floor in the rooms may not be uniformly black or even smoothly flat. Some rooms may contain more real-world type floors made of such materials as linoleum, tile or even thin rugs (less than 5 mm).

L. The walls in the Expert division may not be uniformly white or even smoothly flat. There could be pictures or other materials hung on the walls, which change the color, texture or reflectivity. In any case, nothing will extend more than 5 mm from the wall surface. Hanging objects represent a component of the Clutter Mode, and robots that knock hanging objects off of the walls will have failed to operate successfully in Clutter Mode (see Section H. above for scoring in this case).

M. Eligibility for cash prize: In order to win a cash prize in the Expert mode, a robot must complete at least three tasks during three runs.

N. Qualification: To qualify for the final competition, a robot must complete at least two tasks in one run within six minutes.

O. Starting Position. All starting positions will be in hallways. Robots will be placed in arbitrary starting locations and orientations by the arena judges. The order of placement (but not location or orientation) of the robots in a swarm may be specified by the team. At the start adjacent swarm robots will be separated by no more than 20 cm.

P. All arena intersections will be at right angles. There will NOT be any diagonal hallways or walls.

Q. All rooms will be at least 2x2 grids in size (a grid is approximately 48 cm on a side). Rooms do not have to be square or even rectangular.

R. Other considerations
i. A candle will NOT be place in a hallway.

ii. There may be more than one Furniture item in a room.

The Room Factor discount (Section # 21) will NOT be applied to the Expert division.

NO penalty is given when two members of a swarm touch each other.

S. Each swarm robot must conform to the size requirements in section 8.

T. Before each round starts all robots and associated remote computers will be impounded before the arena walls are installed.

EXPERT DIVISION SCORING

Note: There is no special bonus for reliability in the Expert Division since all three runs are used in determining scores.

The scoring method (see example below) counts completed tasks. It uses time as a differentiator among robots with the same number of completed tasks.

A. Each robot or swarm is allowed three runs.

B. The maximum run time for each run is 6 minutes. This time will be recorded for runs that are not fully completed.

C. For each run, judges count the number of tasks completed and measure the raw time and penalties.

D. An adjusted time is computed by adding penalty time to raw time.

E. The score is then taken as follows:

i. Sum the number of completed tasks for the three runs;
ii. Add the total adjusted run times for the three runs;

Finishing rank is computed by the total number of tasks completed using time as the tiebreaker.

EXPERT DIVISION SCORING EXAMPLE

The example below applies to single robots and to swarms.

Team A:

Run 1: Finds a candle on the first floor and puts it out. Goes up the ramp. Finds and marks the baby. Fails to go down ramp (does not return to first floor in controlled fashion).

Two tasks completed.

Raw time = 6 minutes (did not complete four tasks)

Run 2: Failed run. Zero tasks, 6:00

Run 3: Completes all four tasks, 2:56.

Team A score: 6 tasks, total time = 14:56

Team B has following runs:

Run 1: Extinguishes one candle, 6 minutes.

Run 2: Extinguishes two candles (both on first floor), 6 minutes.

Run 3: Completes all four tasks in 5:24.

Score: 7 tasks, total time = 17:24.

Robot B's final ranking is higher. It completed more tasks even though its total run time is higher.

25. DIVISION DECISIONS

Each division will have its own set of winners and prizes (see section #30 - Prizes). Anyone who meets the criteria for a particular division may, at their option, decide to run in a higher division. Contestants will not be able to run in a lower division than that which they should be in. This means that an 8th grader could decide to run in the High School (or even Expert) division if they want to try to win more money, fame and glory.

When registering for the contest, contestants will be asked to select a division to run in. Division entry fees will not be refunded after registration so if you choose to change divisions after registration you will need to re-register your robot in the correct division. If that division is full your robot will be placed on a waiting list.

No single robot can be entered in two different divisions. If contestants want to operate in two divisions (with two different robots) then they must register in each division. (See the rule on Multiple Entries - section #31)

26. CHALLENGES OF JUDGES' RULINGS

The Chief Judge is the FINAL AND ABSOLUTE authority on the interpretation of all rules and decisions. Any contestant who wishes to challenge any ruling or scoring of the arena judges to the Chief Judge must do so BEFORE they leave the arena area. If a contestant has a problem or question about any decision the Arena Judges have made, they simply have to say that they wish to appeal this to the Chief Judge. The Chief Judge will then be called in to arbitrate the matter. Once the contestants have left the arena they may not appeal any decision or scoring of the Arena Judges.

27. HELP FROM ADULTS

The division structure was created to make the event more fun for students, but at the same time we realize that we are opening another entire area of possible conflict and problems. The problem occurs with a robot submitted by a group consisting of people both in and out of school.

An easy case might be one in which a microprocessor controlled stepper motor driven robot using modulated IR sensing with the programming written in C++ is submitted by a 2nd grader whose parent just happens to work for NASA. This robot would probably end up in the Senior division.

In general, a robot created by a group of 6th and 7th grade students with an adult teacher advisor would probably be entered into the Junior division since it is our experience that the students really do build and program the robots themselves. We aren't concerned about adults who helps a team of college students since they will be in the Senior division which is open to anyone. However, the robot entries in the Junior and High School divisions are supposed to be actually created by the students themselves. This does not mean that the students have to do everything, i.e., mechanics, hardware, electronics, software completely on their own. But on the other hand, we would not like to see a teacher spending hours upon hours writing and debugging a student's software. Adults helping are OK; adults taking over is not.

As far as the students are concerned, the goal of the contest should be education and not necessarily winning. We know that the students desperately want to win, but the adults should let them compete (win or lose) on their own. This contest is pretty much on the honor system, but we expect that the student contestants are primarily responsible for the creation of their robots. If we find any case to the contrary, they will be assigned to a more appropriate division. We will try to be very fair, and as in everything else, the decision of the Chief Judge is final.

28. PRIZES

There will be cash prizes for the top robots in each division that compete at least one successful run. The exact value of the cash prizes will be listed on the contest website. There will also be additional prizes donated by our contest sponsors and other interested supporters. All robot entries, which participate in the contest, will receive a Certificate of Achievement and an official contest T-shirt.

29. MULTIPLE ENTRIES

The guiding principle of the Trinity College Fire-Fighting Home Robot Contest and its regional contests is that every robot entered is to be an original and unique design.

Thus an individual, team or school cannot enter multiple identical robots, except in the Expert Division where the identical robots comprise a single swarm. A team may enter more than one robot, but they must be significantly different from each other in at least some aspects of electronics, software and mechanics. The challenge of this contest is for every contestant or team to complete a unique robot of his or her own design.

30. QUALIFICATION TRIALS

In order to run in the final competition on Sunday each robot must demonstrate that it can function in the arena as intended (see the exception in Section D below). The Saturday qualification period begins at 10 a.m. and ends promptly at 9 p.m. Robots may qualify at any time during that period. During the qualification period each robot will have a maximum of three chances to find and extinguish the candle, subject to the following rules:

A. The 3 qualification trials do not have to be run consecutively. A robot can come back after adjustments to try again.

B. Once a robot has successfully qualified by finding and extinguishing the candle, it does not have to complete any further trials. A robot only has to find the candle once to be qualified for the contest on Sunday.

C. If the robot cannot find and extinguish the candle once during its 3 qualification trials, then it has not qualified for the contest on Sunday.

D. First, Second and Third place winners of Official Regional Contests do not have to qualify, but the head of those Regional Contests must notify the Event Coordinator, Juliet Manalan (juliet.manalan@trincoll.edu) of their names by March 28th.

E. The candle will be placed in a room chosen by the contestant. The qualification judge will place the candle in a randomly chosen position in that room.

F. There is a five-minute limit on each qualification run. Any run that exceeds five minutes WILL BE RECORDED AS UNSUCCESSFUL AND will be counted as one of the three allowed runs.

G. The rules concerning not moving for 30 seconds or repeating the same movement 5 times will apply.

H. When you are ready to make a qualification trial, you will notify the qualification judges and they will give you a trial position. (For example: "There are 3 robots ahead of you in line and when they are done then you go.")

I. When it is your time to make your qualification trial you will have 1 minute to get set up and begin your run. If you can't begin within the 1 minute setup time, this particular qualification trial is over and it is counted as one of the three runs.

J. The qualification period will end at 9 pm sharp on Saturday. Any robots that have not qualified by that time FOR ANY REASON will not be qualified for the contest on Sunday. It is your responsibility to qualify before the qualification period ends.

K. The qualification trials will only take place on Saturday. There will be a short practice session on Sunday, but there will NOT be any qualification trials on Sunday.

L. Robots do not have to qualify in the same operating modes that they will run in on Sunday except that robots competing in the Expert Division will have to qualify in the special Expert Division arena and will be subject to the Expert Division rules.

31. PRACTICE TIME

The robot should be built, programmed and ready to run on arrival at the contest site. Practice time in the arenas will be limited due to the number of participants and because some of the arenas will be used all day Saturday for Qualification Trials. Practice time is intended to be used for calibrating sensors to the conditions in the gym and trouble shooting last minute problems. Don't expect to be able to do extensive code development and testing.

32. ASSIGNED ARENAS

There will be arenas set aside for the Qualification Trials on Saturday. The other arenas will be available for practice. However on Sunday morning before the contest, the qualifying competitors will be told which arenas they will actually compete in for which trial. They will have some limited time before the actual start of the contest on Sunday in which to make any final adjustments to their robots in this arena. It is very likely that robots in the High School and Senior divisions will run each trial in a different arena. We will strive to make the lighting and other factors the same for each arena, but there will be some variations. Your robot should be able to handle them.

The robots should be prepared to run in any arena for any trial. The robots in the Expert, Walking and Junior divisions will only run in their single assigned arena and will not switch arenas.

33. SAFETY
The contest judges may stop any robot at any time if they feel that it is performing, or is about to perform, any action that is dangerous or hazardous to people or equipment. No robot is allowed to use any flammable or combustible processes.

34. "SPIRIT OF AN INVENTOR" PRIZE
In 1999 a walking robot was entered in the contest. It was an incredible device that could actually walk on 2 legs and find and extinguish the candle. Even though it had absolutely no chance of winning the contest because it was so slow, the inventor entered it anyway because it was such a good idea. We were so impressed with this attitude that there will be a special prize for the most unique robot that does not win the contest, but shows the greatest creativity, ingenuity and a true "Spirit of an Inventor." A robot does not have to conform to all the rules in order to be eligible for this prize.

35. "COST-EFFECTIVE" PRIZE
Robotics does not have to be expensive. Spending money does not guarantee success, in fact, some of the very best robots have been some of the least costly to build. To award financial efficiency there will be a special prize for the best performing robot built with the lowest amount of money in material cost. If you put in $50,000 in labor and destroyed $5,000 in parts finally getting it to work, but your final robot has less than $200 in actual parts in it, then it is a good contender for this prize. It does not matter what you paid for the parts, but only what they are worth. A motor that originally cost $50, but is now for sale in a surplus catalog for $5 is now a $5 motor. However, if you got a $50 motor for free from a friend, then it's still a $50 motor regardless of the fact that you got it for free. If, on the other hand 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:

A. 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).

B. Participating teams will prepare an inventory for their robot that lists all parts and their prices. Use guidelines above.

C. To qualify for the CEP, robots must qualify for the competition on Saturday.

D. Following the qualification run, two judges will inspect the robot and verify the inventory.

E. Each robot will be put into a cost category (CC): (1) CC1: under $100 U.S.; (2) CC2: $100-$150 U.S

F. Robots will be ranked as follows:
- Best two runs will be used to compute a total operating score (TOS).
- CC1 robots will be identified and winner determined according to TOS.

- If there are no successful CC1 robots, judges will determine winner from CC2 group using TOS for two runs as above.

36. PRESENTATION PRIZE
A section of the contest floor will be reserved for the display of posters, presentations and exhibits dealing with topics of interest and there will be some great prizes for the winners. The poster, display, presentation and/or exhibit can be any shape or size and deal with any sort of robotics related topic. This could include anything such as: school programs, software algorithms, historical information or trivia, basic descriptions of research, educational curriculum or strategies, mechanical construction techniques, descriptions of technology used or proposed, write-up and descriptions of robots running in the contest, explanations and descriptions of any other robots that might be in progress, or any topic or subject that might be of any interest or value to anyone at the contest This prize is open to anyone of any age or affiliation, whether they are competing with a robot or not. There is no registration or fee to enter the poster session. Simply show up and set up your presentation. Judging will take place on Sunday after 12 noon on the basis of interest, presentation and informative value. Winner will be announced at the final awards ceremony on Sunday. All materials will be returned to their creators at the end of the contest.

37. INTERPRETING THE RULES
In all matters of interpreting these rules before and during the contest and in any issues not covered by these rules, the decisions of the Contest Judging Committee will be final.

38. WHO MAY ENTER
There are no restrictions as to who can enter a robot. There is no limit on team size. Only one prize will be given to each winning robot entry.

39. ENTERING A ROBOT
A non-refundable registration fee is required for each robot entered into the contest. Any individual or group can enter more than one robot, but a registration fee must accompany each entry. The same physical robot cannot be entered twice even if two entry fees are paid. If you want to enter two robots, then you must build two robots.

40. ONLINE REGISTRATION PROCESS
A. Go to the secure registration web site and fill in ALL of the information. If you don't have all the required information then wait until you do have all the information before you fill out the form. A pre-registration sheet will be available for download on the website to help you prepare.

B. Fill in the required fields on the website.

C. Confirmation of your successful registration will be emailed within three days to the contact person provided on the form.

41. REGISTRATION DEADLINE
The sole purpose of requiring advanced registration is to help us plan the event.

If you do not register by March 15, 2005, your robot will not be in the contest. There are NO EXCEPTIONS. Registration fees are non-refundable.
You have spent hundreds of hours and dollars on your robot. PLEASE REGISTER EARLY!

42. LOCATION, DATE & SCHEDULE

The contest will be held at Trinity College in Hartford, Connecticut on Saturday & Sunday, April 9 & 10, 2005. A final schedule for the contest weekend will be posted on the website.

43. REGIONAL CONTEST EVENTS

In order to enable people from all over to participate in this scientific, educational and fun event, we are working with local groups around the world to establish regional contests that will occur before the main Trinity contest. The rules and regulations in the regional contests will be approximately the same as those used in the main Trinity contest. (However they may not be exactly the same so check with the organizer of the regional contest to find out any differences.) It is NOT mandatory for a robot entered in the main Trinity contest to have first competed in an regional event, but if you want to compete in both, you certainly can. Any robot that has come in 1st, 2nd or 3rd in a regional event does NOT have to qualify for the main Trinity contest, but THEY STILL DO HAVE TO REGISTER and pay the appropriate registration fee. When they arrive at the main Trinity contest they should also be sure that the Qualification Master is aware that they had previously won a regional event and thus do not have to complete preliminary qualification. Check the contest website for a list, schedule and contact information for all of the regional contests. If your organization is interested in sponsoring a regional contest in your area next year, contact the Contest Director for more information (dahlgren@trincoll.edu).

44. UPDATED INFORMATION

As updated information is developed it will be posted on the website so check it often for the latest information.

45. CONSTRUCTION SCHEDULE

Contestants are supposed to have built their robots at home and then merely bring them to the contest to run. This is NOT a construction contest where the devices are built at the event. Trinity will try to help out by providing some time and space for last minute changes, adjustments and improvements, but the robots are supposed to be completed (or at least nearly so), by the time they get here. Contestants should also bring any and all materials and equipment that they might need.

46. CONCEPT ARENA TRIALS

Joe Jones designed the Concept Arena as a means to promote innovation, preserve continuity of the contest, and improve spectator friendliness. The Concept Arena may suggest new directions for future Trinity contests.

A. The Concept Arena

This Concept Arena attempts to preserve the advantages of the current arena while offering the potential for radically different approaches to the fire-fighting robotics task. The outside dimensions of the alternate arena are the same as the current one but the passageways are narrower and the wall height is relaxed (at least 20 cm but no more than 34 cm). In the diagram of the Concept Arena, lines indicate walls and furniture. The dashed lines define a portion of the platform's perimeter where no wall is present. Interior walls are not uniformly white but may include patterns or colors (this provides potential vision systems with something to look at). The green-hatched region indicates surfaces covered with carpet, Astroturf, or some other material that does not support accurate dead reckoning. The arena incorporates a door held shut with a magnetic latch, a tiny hole in one wall, and sets of ascending and descending stairs. These three features provide shortcuts to the goal.

There are only two positions where a candle will be found (both equidistant from the start). An easily overturned object (a "vase") occupies the alternate candle spot. Contestants whose fire extinguishing method knocks over the vase are penalized.

The Concept Arena supports at least six different methods for accomplishing the task. In order of descending start-to-goal path-length they are:

1. Use dead reckoning. A smooth (but long) path suitable for dead reckoning exists from start to goal. This approach may appeal to repeat contestants whose strategy incorporates accurate, high-speed dead reckoning.
2. Follow the wall. It is possible for a robot to follow the left wall from the start to a position where the flame from the candle is detectable. This is also a relatively long path but it provides a low complexity entry point for novice competitors.
3. Traverse the region of poor dead reckoning. A robot equipped with a vision system or some other sensor able to correct for drift can traverse the next shorter path by crossing the region of poor dead reckoning.
4. Open the door. A robot possessing a simple mechanism able to pull open the door can take advantage of the next shorter route.
5. Climb the stairs. This strategy offers a much shorter route, one that might also rely on wall following but the robot must be agile enough to climb the stairs and compact enough to fit under the (transparent) ceiling above the stairs.
6. Crawl through the hole. The shortest route to the fire is through a small hole near the starting point. But only a tiny robot can take advantage of this route.

Beyond enabling novel solutions the Concept Arena offers several other advantages. Competitors from all contest divisions could compete in the same arena and experience the same environment—an environment that offers the possibility of simple (but slow) solutions like wall following as well as sophisticated (and hopefully faster) solutions like door-opening and vision.

B. Physical Characteristics of the Concept Arena

The Concept Arena (click here) is built on an 8'x8' base just like the standard arena and the walls are centered on the 8'x8' grid. The walls are made from 10"x1" boards (actual dimensions, 9.25" by 0.75") so the width of the corridors is about 11". The stairs are formed by stacking up 2x4s. The home circle is approximately 11 inches in diameter. As shown in the 3-D view (click here) the blue braces at the top of the wall serve to make the structure more ridged and to discourage over-tall robots. Any number of braces may be used. The door is secured by a magnetic catch of the sort used to keep kitchen cabinet doors closed. The door opens outward only.

C. Concept Arena Rules

i. Teams wishing to enter the Concept Arena Trials must register for one of the five regular contest Divisions (Junior, Walking, High School, Senior, Expert) and complete the qualification for that Division (see qualification, Section 30 above).
ii. There is no additional charge for entering the Concept Arena Trials.
iii. Robots in the alternate arena robots must obey the same safety rules as in the standard arena (Section 33 above).
iv. Contestants may not attach anything to the arena and the robots mustn't damage the arena.
v. Climbing or peeking over the top of walls is not allowed.

vi. Swarm robots may be used as long as all members of the swarm fit together on the home circle at the start. Robots that unfold to a larger size are permitted.
vii. A robot is disqualified it displaces a lit candle.
viii. Robots may use touch sensors for any purpose, and there is no penalty for sliding along a wall

D. Scoring
The score is simply the time it takes to put out the candle.

E. Prize
The fastest robot in the Concept Arena Trials will receive a Roomba vacuum cleaning robot donated by iRobot, Inc.

48. QUESTIONS ABOUT THE RULES
should be directed to the contest Director, Dave Ahlgren (Dahlgren@trincoll.edu) or to the Chief Judge, Chris Wynschenk (Christopher.wynschenk@trincoll.edu).