RoboCup Rescue Robot League

PADUA, ITALY
JULY 2003

CHAIRIED BY:

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National Institute of Standards and Technology, USA

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Kobe University, Japan

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University of Padua, Italy
GENERAL ANNOUNCEMENTS

LEAGUE BACKGROUND
- RoboCup Rescue Robot League Vision
- Search and Rescue Scenario
- Need for Rule Changes

RULES for 2003:
- General Rules
- Negotiating Arenas
- Finding Victims
- Scoring Points
- Performance Metric (Proposed 2003)
GENERAL ANNOUNCEMENTS
PADUA, ITALY 2003
GENERAL NOTES: PRACTICE IN THE ARENAS

To promote development, collaboration among teams, and general research goals, we allow all teams to practice within the arenas during the set-up days and after hours.

Some teams will be asked to demonstrate their robots to the public at certain times (for example opening ceremonies). We’ll try not to burden any team nearing a competitive mission.

Once the competition starts, no teams are allowed in the arenas during daily competitions. Practice may begin again after hours.

Once a team has been disqualified, they are encouraged to practice in the arenas any time accept during competition hours.

We are expected to have activity in the arenas continuously from 1000 - 1900 every day for spectators.
GENERAL NOTES: SCHEDULE OF EVENTS

SETUP AND PRACTICE

THURSDAY (building is open 24 hours)
- 1800: All team meeting BLDG 8A
- ALL DAY: Team setup and practice
- 1800: All team meeting BLDG 8D

FRIDAY (building is open 24 hours)
- ALL DAY: Team setup and practice
- 1800: All team meeting BLDG 8A
- 1900: Welcome reception within the building
PRELIMINARIES

SATURDAY (building is open until 0300)
- 0900: TEAM LEADER MEETING (operator station)
- 1000 - 1900 PRELIMINARIES (13 TEAMS)
- 1900: TEAM LEADER MEETING (operator station)

SUNDAY (building is open until 0300)
- 0900: TEAM LEADER MEETING (operator station)
- 1000 - 1900 PRELIMINARIES (13 TEAMS)
- 1900: TEAM LEADER MEETING (operator station)

MONDAY (building is open until 0300)
- 0900: TEAM LEADER MEETING (operator station)
- 1000 - 1900 PRELIMINARIES (13 TEAMS)
- 1900: TEAM LEADER MEETING (operator station)
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GENERAL NOTES: SCHEDULE OF EVENTS

SEMI-FINALS

TUESDAY (building is open until 0300)

- 0900: TEAM LEADER MEETING (operator station)
- 1000 - 1900 SEMI-FINALS (6 TEAMS):
- 1900: TEAM LEADER MEETING (operator station)
FINALS

WEDNESDAY (building is open until 0300)
- 0900: TEAM LEADER MEETING (operator station)
- 1000 - 1800 FINALS (3 TEAMS)
- 1900: AWARDS CEREMONY
GENERAL NOTES: CURRENT ISSUES

VIDEO TAPING ROBOTS DURING MISSIONS
- GOAL IS TO DOCUMENT WHAT HAPPENS FOR EACH ROBOT
- HELP LEARN FROM SUCCESS AND FAILURES
- HELP PROMOTE SEARCH AND RESCUE APPLICATION AND LEAGUE

- ISSUE: WILL RECONFIGURE BETWEEN ROUNDS SO NO ADVANTAGE SHOULD BE GAINED?
- ISSUE: CAN WE HAVE TEAM-MATES FILMING WITHIN THE ARENA OR SHOULD WE USE OTHER TEAM PERSONNEL?

TEAM POSTERS ON WALLS ARE ENCOURAGED
- GOAL IS TO PROMOTE YOUR RESEARCH COLLABORATE WITH OTHERS TEAMS AND OTHER LEAGUES!

PRINTER AVAILABILITY
- USB COLOR PRINTER WILL BE AVAILABLE AT THE OPERATOR STATION FOR ALL TEAMS TO USE. DON'T WAIT TO SEE IF IT WORKS FOR YOU!

RADIO FREQUENCIES
- OTHER ROBOCUP LEAGUES USE 2.4 GHz (CHANNEL 1, 6, 11)
ROBOCUP RESCUE
ROBOT LEAGUE BACKGROUND
PADUA, ITALY 2003
When disaster happens, minimize risk to search and rescue personnel while increasing victim survival rates by fielding teams of collaborative robots, which can:

- Autonomously negotiate compromised and collapsed structures
- Find victims and ascertain their conditions
- Produce practical maps of their locations
- Deliver sustenance and communications
- Identify hazards
- Provide structural shoring

...allowing human rescuers to quickly locate and extract victims.
A building has partially collapsed due to earthquake.

The Incident Commander in charge of rescue operations at the disaster scene, fearing secondary collapses from aftershocks, has asked for teams of robots to immediately search the interior of the building for victims.

The mission for the robots and their operators is to find victims, determine their situation, state, and location, and then report back their findings in a map of the building and a victim found data sheet.

The section near the building entrance appears relatively intact while the interior of the structure exhibits increasing degrees of collapse. Robots must negotiate the lightly damaged areas prior to encountering more challenging obstacles and rubble.

The robots are considered expendable in case of difficulty.
NEED FOR RULE CHANGES

Deter parallel teleoperation in separate arenas
- Solution: Force robots to traverse arenas sequentially

Deter sequential teleoperation in separate arenas
- Solution: Remove “Number of Robots” in scoring formula

Deter false victim identifications
- Solution: Add penalties for errors in scoring formula

Promote use of multiple sensors
- Solution: Add incentives for multiple sensor identifications
- Solution: Add incentives for correctly identifying victim
  “Situation” (surface/trapped/void/entombed)
  “State” (unconscious/semi-conscious/communicative)

Promote limited use of radio communication channels
- Not addressed
GENERAL RULES
PADUA, ITALY 2003
To promote multiple search missions for each team, demonstrate maximum capabilities, require modest stamina and ease of operation, and allow some chance of failure without consequence, the competition will follow the following format:

- There will be (3) rounds of competition
  - Preliminaries (13 teams)
  - Semis (6 teams)
  - Finals (3 teams)
- Each round will consist of (3) missions in the arenas
- Each mission will last 20 minutes
- The best (2) of (3) mission scores will be added to record a final score for the round
- The (#) best scores for each round advance to the next round of competition
- Each round of competition is administered similarly
- Teams start each round with no score
To test mapping and planning capabilities while allowing robots better access to their intended arenas, all robots must begin the first mission of every round negotiating the Yellow arena (from the Yellow/Orange start point). Later missions allow some arena start preferences.

**YELLOW / ORANGE START POINT:**

- Located between the Yellow and Orange arenas
- Available as start point for all three missions of a round

**ORANGE / RED START POINT:**

- Located between the Orange and Red arenas
- Available as a start point for third mission of a round
GENERAL RULES: ADVANCING & RETREATING

To promote collaboration between robots, and deter parallel teleoperation in separate arenas the following rules apply:

ADVANCING TO MORE DIFFICULT ARENAS

- To advance to a more difficult arena, any given robot must leave the simpler arena through the exit
- Robots may advance without the entire team of robots

RETREATING TO SIMPLER ARENAS

- Robots are always free to retreat to a simpler arena successfully negotiated during the current mission
- Retreating back to an arena not successfully negotiated during the current mission must be done as a team (all robots gather at the mission start point before entering the simpler arena). Teams may use “RESETs” to get all the robots there. Once restarted, robots may retreat as far as they can without the entire team of robots.
GENERAL RULES: TEAM SETUP FOR MISSIONS

SPECTATOR AREA

YELLOW ARENA

ORANGE ARENA

RED ARENA

EXIT

ENTRANCE

START

OPERATOR

ROBOT STAGING AREAS

INSIDE BUILDING

OUTSIDE BUILDING

ROBOT TRANSFER BEFORE/AFTER RUNS

HOT ZONE
GENERAL RULES: TEAM SETUP FOR MISSIONS

To maintain an ambitious schedule of missions, team setup for each mission must be timely and efficient. Failure to be ready for any scheduled mission means scores (0) for that mission. Teams may trade time slots with other teams if mutually beneficial - but both team leaders must notify the chair at least one mission prior to the negotiated mission start time:

- Teams and robots must leave the Team Preparation area via the exterior doors in the hallway between rooms (2) and (3) [not near the Red arena or the toilets]
- Teams must transfer their robots outside the building to the exterior doors located near the operator station.
- Teams should have robots inside the staging area near the operator station 15 minutes before mission start.
- Teams will have 10 minutes to move into position at the operator station (while the previous team exits)
- Teams must demonstrate all sensing and localization capabilities to the Judge prior to the start of their mission
Since the arenas are small compared to a building, and we want spectators to enjoy a nice view of your robots, there are several ways to thwart the intention of the arena design. These rules address those issues:

- Robots must enter arena “rooms” to identify victims:
  - No victim identifications allowed over maze walls, through glass walls, through mesh walls or netting (this will not generate a penalty - just keep searching)
  - Looking over obstacles or through access holes is encouraged
  - Knowing a victim is there does not mean you have identified that victim (you must complete a VICTIM DATA SHEET)

- Robots must surmount elevated level to identify victims on that level, unless the robot is looking up/down through access holes.
  - Orange: Elevated Floor
  - Red: Multiple levels (some collapsible)

- Robots must pass under crossbars and orange netting when traveling through arenas
GENERAL RULES: SIMULATED VICTIMS

- Reflective tape
- Voice
- Locator strobe
- Clothing: dust covered or colorful
- Locator alarm
- Victim tag
- Human form
- Body heat
- CO2 emissions
- Waving arms
- Moving fingers
- Tapping
- CO2 emissions
- Voice
GENERAL RULES: SIMULATED VICTIMS

Operator must SHOW all perceived signs of life

- Judges (with the operator) note the validity of the call based on the information shown in the operator interface
- Referees (with the robot) note the order that the victims are found

A victim may not be counted twice for scoring, even when found by a different robot

SIGN OF LIFE:

- Form: Shape, color, ...
- Motion: Moving appendages, ...
- Heat: Body heat (heating blankets)
- Audible: Voice, beacons, tapping
- Chemical: CO2 emissions

VICTIM STATES

- Aware
- Semi-conscious
- Unconscious

VICTIM SITUATIONS

- Surface
- Trapped
- Void
- Entombed
The intent of the performance metric for this competition is to encourage certain robot capabilities while discouraging certain team strategies. In general the performance metric has the following components.

There are 50 points available for each victim found:

- 20 points for Mapping are available to reward map QUALITY and accurate LOCATION of victims and features

- +/- 15 points for Mobility are available to reward capabilities required to identify the victim SITUATION and for advanced mobility required to read the VICTIM TAG.

- +/- 15 points for Sensing are available to reward individual sensor capabilities and for correctly identifying the victim STATE

NOTE: Points may be deducted for errant identifications in both Mobility and Sensing capabilities. So be sure before you report a victim found.

50 POINTS POSSIBLE PER VICTIM FOUND

PENALTIES PER EVENT

\[
\begin{align*}
\text{ARENA WEIGHTING} & = \left( \frac{\text{MAP QUALITY} + \text{VICTIM LOCATION} + \text{VICTIM STATE} + \text{VICTIM SITUATION} + \text{VICTIM TAG}}{- \text{ARENA BUMPING} - \text{VICTIM BUMPING}} \right)^2 \\
& \times \left( 1 + \text{NUMBER OF OPERATORS} \right)
\end{align*}
\]

YELLOW 0.50

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<th>10 PTS</th>
<th>10 PTS</th>
<th>+/- 15 PTS POSSIBLE</th>
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<th>+/-10 PTS</th>
<th>-20 PTS</th>
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<td>RED 1.00</td>
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<td>+/- 3 PTS</td>
<td>+/- 5 PTS</td>
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STATE +/- 5 PTS
(any 3 correctly interpreted)
SCORING POINTS: VICTIM STATE

VICTIM STATE (+/- 10 of 50 pts per victim)

Requires interpreting signs of life to determine a victim’s capabilities. Use any three signs of life to determine a VICTIM STATE.

- **FORM** (+/- 1 POINT)
- **MOTION** (+/- 1 POINT)
- **HEAT** (+/- 3 POINTS)
- **SOUND** (+/- 2 POINTS)
- **CO₂** (+/- 3 POINTS)

- **AWARE**: Fully conscious and moving (arm waving and/or yelling)
- **SEMI-CONSCIOUS**: Not aware but may be moving (finger moving or moaning)
- **UNCONCIOUS**: No motion, no sound (has heat and may have alarm and CO₂)
- **UNKNOWN**
VICTIM SITUATION (± 5 of 50 pts per victim)

Requires understanding of a victim’s rescue needs by discerning one of the following situations

- SURFACE: Entirely visible (head/torso and legs)
- TRAPPED: Partially visible under light rubble (head/torso or legs)
- VOID: Minimally visible in void under collapse (arm)
- ENTOMBED: Not visible without probing (use sound, heat, CO₂)
- UNKNOWN
VICTIM TAG (+/- 10 of 50 pts per victim)

These identification tags are placed throughout the arenas as likely locations to search for victims (analogous to a rescue dog handler’s pointing motion). All victims have VICTIM TAGS prominently displayed, but may not be easily visible. This may be an extreme test in mobility. The key is for the robot to attain the proper viewing position, read the tag along with gathering other victim readings, and score +10 points. Be careful not to be too quick to identify VICTIM TAGS from a distance, because reporting a VICTIM TAG that is not associated with a victim will score -10 points. So be sure you identify other signs of life in addition to the VICTIM TAG.

For this competition, VICTIM TAGS will display numbers.
SCORING POINTS: VICTIM LOCATION

VICTIM LOCATION (+10 of 50 pts per victim)
Maps should locate any part of a given victim to within a 1 cubic meter. The arena grid coincides with arena walls, floor sections, and other prominent features noted on the map.

SCORING
- (10 points) Locating a victim to within 1 cubic meter from entrance to arena.
- (5 points) Adjacent grid is called, but cannot propagate beyond wall
- (1 points) Any other grid is called
SCORING POINTS: MAP QUALITY

MAP QUALITY (+10 of 50 pts per victim)

Refers to the paper-based map of the arenas submitted to the Incident Commander (Judge) within two minutes after the end of your mission time expires. All maps should indicate the following:

- Victim LOCATIONs
- References to each victim’s DATA SHEET (may be hand written)
- Other pertinent features (doors, windows, stairs, collapses, etc.)
- Hand corrections of sensory generated maps are allowed, but may be discounted by the Judge if considered influenced by operator knowledge of the arena layout
- DO NOT start with a line denoting the perimeter of the arena

SCORING

- (10 Points) Robot sensor generated, easily readable map of arena interiors automatically showing victim LOCATIONs.
- (5 Points) Computer generated map showing victim LOCATIONs.
- (1 Points) Hand drawn map of the arenas or topological directional information to the the victim.
SCORING POINTS: PENALTIES

ARENA PENALTIES
- Uncontrolled Bumping (-10 points per incident)
  Undesirable contact with environment that does not result in damage
- Heavy Damage (-20 points per incident)
  Undesirable shifting or damage to environment

VICTIM PENALTIES
- Bumping Victim (-10 points per incident)
  Any contact with a victim
- Harming Victim (-20 points per incident)
  Any contact that repositions or “harms” a victim

Penalties May Compound
- Example: Causing ‘Heavy Damage’ (-20 points) to arena which results in ‘Harming’ a victim (-20 points) = 40 point deduction
Victims are found by following all the steps below in order:

Determine:

1) VICTIM STATE (sensors: aware, semi-conscious, unconscious)
2) VICTIM SITUATION (sensors: surface, trapped, void, entombed)
3) VICTIM TAG (operator)
4) VICTIM LOCATION (sensors and/or operator)

Then:

5) Map the VICTIM LOCATION
6) Complete the VICTIM FOUND DATA SHEET
7) Notify the Incident Commander you have found a victim (identify the victim using the VICTIM TAG)
8) Show the Incident Commander a view of the TAG, SITUATION, all sensor readings leading to a STATE, and how you determined your LOCATION
Teams submit all VICTIM DATA SHEETS:
(maps must be produced two minutes after mission has ended)

- VICTIM TAG/SITUATION /STATE
- VICTIM LOCATION
- ARENA FEATURES/HAZARDS

Points are deducted for penalties such as:

- ARENA BUMPING or HEAVY DAMAGE
- VICTIMS BUMPING or HARMING
**VICTIM DATA**

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<tr>
<th>VICTIM (±/ - 10 of 50 pts per victim)</th>
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**STATE (±/ - 15 of 50 pts per victim)**

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<td>SOUND</td>
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<tr>
<td>CO₂</td>
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- **AWARE:**
  - Fully conscious and moving (arm waving and/or yelling)
- **SEMI:**
  - Not aware but may be moving (finger moving or moaning)
- **UNCONSCIOUS:**
  - No motion, no sound (has heat, may have alarm and CO₂)
- **UNKNOWN:**

**VICTIM STATE (±/ - 5 points)**

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**SITUATION (±/ - 5 of 50 pts per victim)**

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<th>SCORE</th>
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<td>VOID</td>
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<tr>
<td>UNKNOWN</td>
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- **SURFACE:**
  - Entirely visible (head/torso and legs)
- **TRAPPED:**
  - Partially visible under rubble (head/torso)
- **VOID:**
  - Minimally visible in void (legs)
- **ENTOMBED:**
  - Visible only with probing (arm, sound, heat, CO₂)
- **UNKNOWN:**

**MAPPING (±20 of 50 pts per victim)**

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FIELD OF PLAY: HOT ZONE

- Yellow Arena
  - 2-D maze with no flooring issues
  - Arena weighting = 0.5

- Orange Arena
  - 3-D maze with variable household/office flooring
  - Arena weighting = 0.75

- Red Arena
  - Totally unstructured and unstable
  - Arena weighting = 1.0

NOTE:
- No operators or team members allowed in the field of play once competition starts!
FIELD OF PLAY: WARM ZONE

- Operator station
  - Faces away from “Hot Zone”
  - Only essential team operators should be present during a mission
  - Everybody who enters the warm zone during a mission will count as an operator during that mission

- Starting Point
  - All team members may place and initialize the robot prior to the mission

NOTE:
- Any member of a team found in the “Warm Zone” during another team’s mission will be penalized at the discretion of the Chairs.
FIELD OF PLAY: COLD ZONE

- Contains TEAM PREPARATION ROOMS and STAGING AREA.
- All team members must stay in this area during the competition or be counted as an operator.
Intent of this rule is to encourage an increase in the ratio of robots to operators by demonstrating bounded autonomy and high level management of multiple robots.

- Any person present in the “Warm Zone” during a mission
- Any person who touches, interacts with, or controls the robot during a mission
PERSONNEL : JUDGE

- An organizing committee member

- Responsibilities during each mission
  - starts the official time
  - only official allowed to interact with the operator(s)
  - relays to the referees that a potential victim has been found

- Responsibilities after each mission
  - interprets the map to seek each victim
  - determines the victim location and map quality
  - calculates the score

- Has final authority over any disputes
Either organizing officials or non-competing team members

Responsibilities
- tracks the robot through the mission
- notes victim identifications
- assigns penalties (arena damage and victim harm)

One referee per robot

Must observe in an non-interference manner
Either a team member, another team member, or an administrative agent (chosen by the chair) will be equipped with a camcorder and properly labeled tape to capture continuous video of the robot performance.

- Must capture video in an non-interference manner

- All such video will be archived and used to further research and marketing goals

- Each team’s robot performance will be distributed to that team after the competition.
OTHER: START

- Operator(s) will place their robot at the “Starting Point” in the Warm Zone during the preparation time

- Judge will indicate when official mission time has started
OTHER: RESET

Operator can call 'RESET'
- Judge returns robot to starting point
- Time continues to mission
- Penalty: add one operator in score

Self-Reset
- Robot can return to starting zone by itself for operator repair.
- Penalty: none
- Operator can continue setup during mission time

'Out of Bounds RESET'
- Occurs when a robot leaves both the 'HOT' and 'WARM' zones
- Imposed at the discretion of the judge
- Penalty: add one operator in score
OTHER: AWARDS

Place Awards
- 1st, 2nd, and 3rd place awarded based upon the teams’ quantitative performance scores

Minimum Score
- Required for place award
- To be determined by the Co-Chairs after the preliminaries

Qualitative Awards
- For inspired hardware
- For inspired software/sensing
OTHER: TEAM REPORTS

Team Report

- All teams that receive either a place or qualitative award must provide a document outlining the hardware and software specifications of their robots within 30 days of the last day of competition.
- Any team that has signed a non-disclosure agreement with a third party regarding their robot’s hardware or software must inform the Co-Chairs prior to competition.

Protests and Rule Changes

- All protests must be filed with the Co-Chairs before the start of the following mission.
- Rule changes may be proposed by any team captain at the end of day meeting. Co-Chairs will consider such changes and make decisions before the next day.
Questions ??
RobotRescueScore = 

\[
\text{VictimsPoints} \times \left(\frac{\text{NumberOfRobots}}{1+\text{NumberOfOperators}}\right)^3 \times \text{AverageAccuracy}
\]

VictimsPoints = (YellowVictimsFound - YellowPenalties) \times (YellowVictimWeighting) + (OrangeVictimsFound - OrangePenalties) \times (OrangeVictimWeighting) + (RedVictimsFound - RedPenalties) \times (RedVictimWeighting)

[YellowVictimWeighting = 0.50]
[OrangeVictimWeighting = 0.75]
[RedVictimWeighting = 1.00]

NumberOfRobots = Number of robots that find a unique victim
NumberOfOperators = Number of operators having touched the robot or are in the hot zone
AverageAccuracy = \frac{\text{positional accuracy + map quality}}{\text{Total victims found}}