RoboCupRescue RobotLeague

Rules 2011.2

RoboCupRescue Robot League

http://www.robocuprescue.org/ http://robotarenas.nist.gov/competitions.htm

A League of Teams with One Goal: To Develop and Demonstrate Advanced Robotic Capabilities for Emergency Responders

Using Annual Competitions to Evaluate, and Teaching Camps to Disseminate, Best-in-Class Robotic Solutions

The RoboCupRescue Robot League competition has three main objectives: 1) to increase awareness of the challenges involved in deploying robots for emergency response applications such as urban search and rescue and bomb disposal, 2) to provide objective performance evaluations of mobile robots operating in complex yet repeatable environments, and 3) to promote collaboration between researchers.

Robot teams demonstrate their capabilities in **mobility, sensory perception, localization and mapping, mobile manipulation, practical operator interfaces, and assistive autonomous behaviors to improve operator performance and/or robot survivability.** All missions in the arenas are conducted via remote teleoperation as the robots search for simulated victims in a maze of terrains and challenges based on emerging standard test methods for response robots. Winning teams must reliably perform 7-10 missions of 20-30 minutes each from various start points to find the most victims.

As robots continue to demonstrate successes against the obstacles posed in the arenas, the level of difficulty will continually be increased so the arenas provide a stepping-stone from the

FEMA's Texas Task Force 1 Training Facility

COMPETITION WINNERS AND BEST-IN-CLASS CAPABILITIES take part in Response Robot Exercises organized at emergency responder training facilities with similar robot test methods and practice deployment scenarios.

laboratory to the real world. Meanwhile, the annual competitions provide direct comparison of robotic approaches, objective performance evaluations, and a public proving ground for capable robotic systems that will ultimately be used to save lives.

COMPETITION VISION

When disaster happens, minimize risk to search and rescue personnel while increasing victim survival rates by fielding teams of collaborative mobile robots which enable human rescuers to quickly locate and extract victims. Specific robotic capabilities encouraged in the competition include the following:

- Negotiate compromised and collapsed structures
- Locate victims and ascertain their conditions
- Produce practical sensor maps of the environment
- Establish communications with victims
- Deliver fluids, nourishment, medicines
- Emplace sensors to identify/monitor hazards
- Mark or identify best paths to victims
- Provide structural shoring for responders

These tasks are encouraged through challenges posed in the arena, specific mission tasks, and/or the performance metric. Demonstrations of other enabling robotic capabilities are always welcome.

INTERNATIONAL CHAMPIONSHIPS	REGIONAL OPEN COMPETITIONS
2001 Seattle, USA	**Germany**
2002 Fukuoka, Japan	**Iran**
2003 Padua, Italy	**Japan**
2004 Lisbon, Portugal	**Mexico**
2005 Osaka, Japan	**Thailand**
2006 Bremen, Germany	**USA**
2007 Atlanta, USA	
2008 Suzhou, China	
2009 Graz, Austria	
2010 Singapore, Singapore	

SEARCH SCENARIO

A building has partially collapsed due to earthquake. The Incident Commander in charge of rescue operations at the disaster site, 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 with associated victim data. The section near the building entrance appears relatively intact while the interior of the structure exhibits increasing degrees of collapse. Robots must negotiate and map the lightly damaged areas prior to encountering more challenging obstacles and rubble. The robots are considered expendable in case of difficulty.

A league of teams, competing not against one another, but rather collaborating against the application domain itself to implement viable robotic capabilities.

Innovation is the goal, so the design space is wide open -- just make it work!

A maze of walls, doors, elevated floors and complex terrains provide various tests for robot mobility, manipulation, and mapping capabilities. Sensory obstacles, intended to confuse specific robot sensors and perception algorithms, provide additional challenges while searching for simulated victims. Intuitive operator interfaces and robust sensory fusion algorithms are highly encouraged to reliably negotiate the arenas, locate victims, and map the results.

A common robot mobility platform for the league, the Mesa Element, is $12K USD with serial and USARsim interfaces (www.mesa-robotics.com)

Compact operator interfaces are essential.

Repeatable test method apparatuses that anybody can build and practice!

Draft ASTM Standard Test Methods

The RoboCupRescue arenas constructed to host these competitions consist of emerging standard test methods for emergency response robots developed by the U.S. National Institute of Standards and Technology through the ASTM International Committee on Homeland Security Operations; Operational Equipment; Robots (E54.08.01). The color coded arenas form a continuum of challenges with increasing levels of difficulty for robots and operators.

See http://www.astm.org/COMMIT/SUBCOMMIT/E5408.htm for more information on the standard test methods.

ARENA COLOR CODES	YELLOW	ORANGE	RED	BLUE	YELLOW/ BLACK	BLACK
	Challenge robots with autonomous navigation and victim identification capabilities	Challenge robots with modest mobility capabilities in structured obstacles	Challenge robots with advanced mobility capabilities in complex terrains	Challenge robots with manipulator grasping and precision placement capabilities in complex terrain	Challenge robots with modest mobility to perform autonomous navigation tasks	Challenge robots to perform similar tasks in a realistic scenario

SIMULATED VICTIMS

The objective for each robot in the competition, and the incentive to traverse every corner of the arena, is to find simulated victims. Each simulated victim is either a mannequin part of a baby doll emitting body heat and other signs of life, including motion (shifting, waving), sound (crying or audible numbers to identify), and/or carbon dioxide to simulate breathing. Particular combinations of these sensor signatures imply the victim's state: unconscious, semi-conscious, or aware.

Each victim is placed in a particular rescue situation: surface, trapped, void, or entombed based on the number of access holes and the direction they face, side or upward. Each victim also displays identification tags such as hazmat labels and eye charts that are usually placed in hard to see areas around the victim, requiring advanced robot mobility or directed perception to identify. Once a victim is found, the robot must identify all signs of life, read the tags, determine the victim's location, and then report their findings on a human readable GeoTiff map with a pre-determined format (see mapping section).

VICTIM DISTRIBUTION

4 Yellow Arena (autonomous only)
4 Orange Arena (auto or teleop)
4 Red Arena (auto or teleop)
2 Radio Drop-Out Zone (auto nav.)

SIGNS OF LIFE TO IDENTIFY

Victims are located in directed perception boxes with limited access holes. Every victim box contains

visual acuity challenges and other signs of life:

- Form (doll or mannequin parts)
- Visual (eye charts and hazardous materials labels)
- Thermal (heating pad)
- Motion (waving cloth)
- Sound (random numbers)
- CO_2 (soda or tire cartridges)

VICTIM SITUATIONS

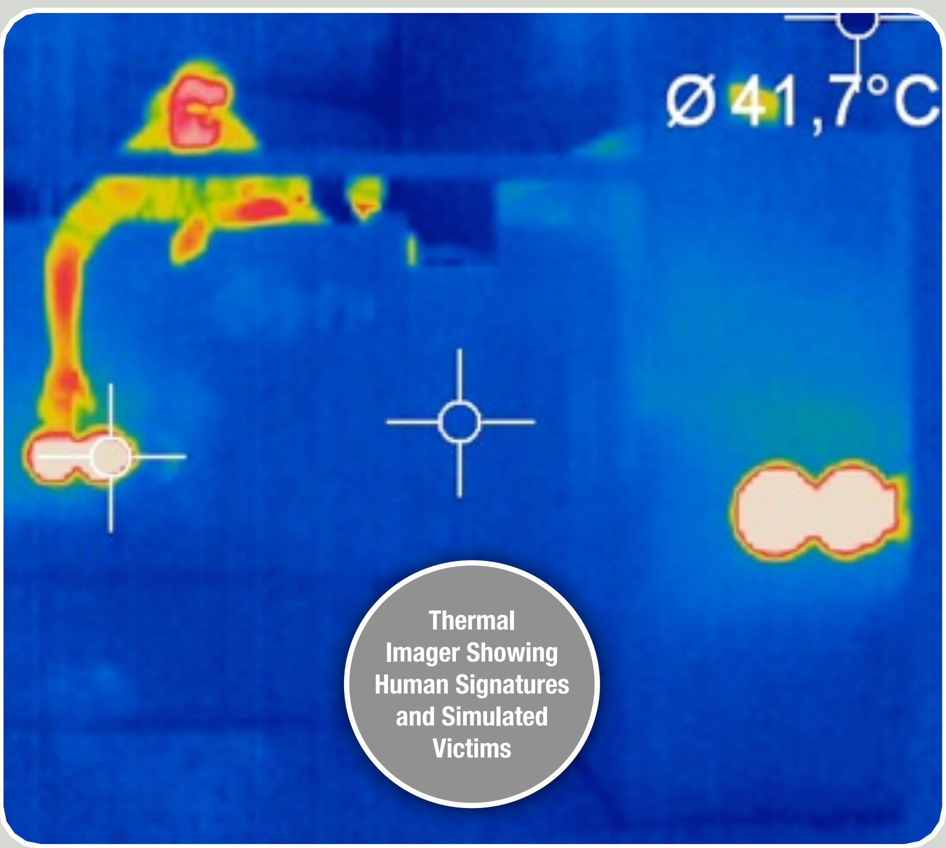
Victims can have either 1, 2, or 3 access holes (15 cm diameter) through which robots must identify the signs of life. Triple access holes will be found in arenas with more difficult tasks to perform such as full autonomy in the Yellow arena and advanced mobility in the Red arena. Orange arena victims will mostly be viewed through single access holes. Situations are represented by viewing directions into the victim boxes. These will also vary. Victim boxes can be located below the robot on the elevated floors.

- "Trapped" victims are in boxes open on top
- "Void" victims are in boxes open to side
- "Entombed" victims are in boxes with single access holes in any direction.

VICTIM ELEVATIONS

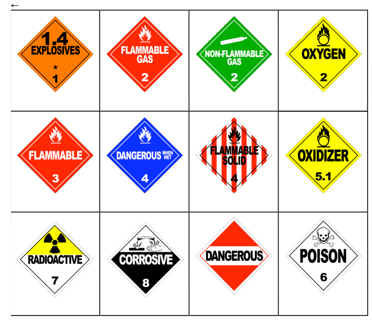
Victims can be placed at any of three levels and will be distributed equally over the course of multiple missions:

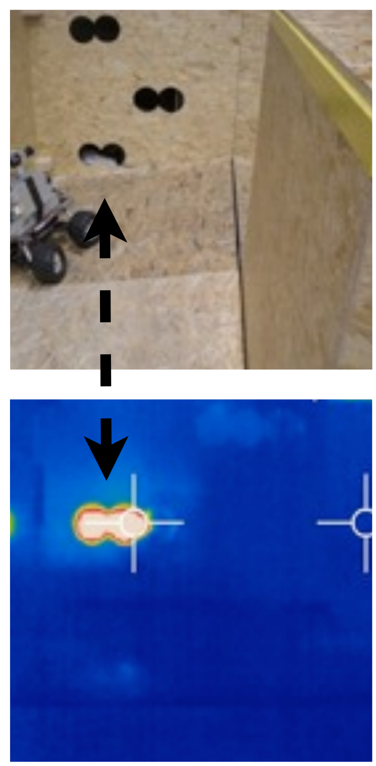
- 0-40 cm
- 40-80 cm
- 80-120 cm
- 120-160 cm



Thermal Imager Showing Human Signatures and Simulated Victims

SIMULATED VICTIMS





YELLOW ARENA

Challenges for robots with autonomous navigation and victim identification

- Random mazes with continuous 15° ramps flooring to challenge localization/mapping
- Openings to harder terrains to encourage terrain classification

Autonomous Navigation and Perception Tasks

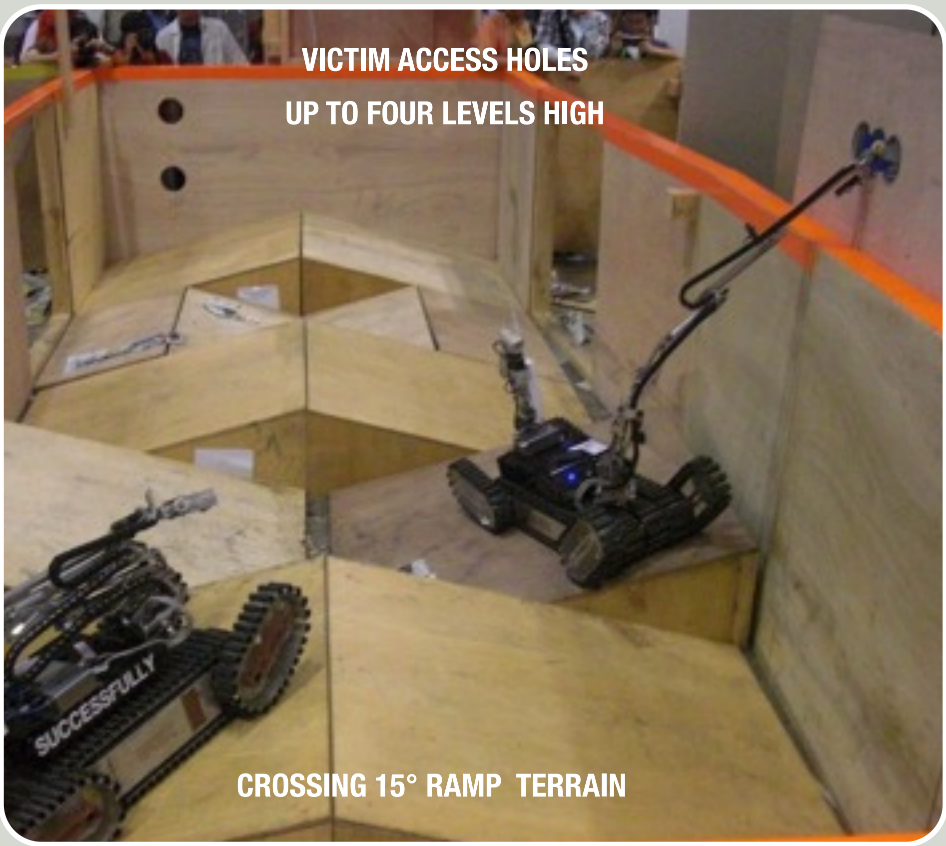
The purpose of the Yellow arena is to encourage fully autonomous robot navigation and sensor fusion capabilities. It consists of random mazes of 1.2 m wide hallways and larger rooms with continuously rolling and pitching 15° ramps throughout to challenge localization and mapping implementations. Paper and debris cover the ramps to thwart odometry sensors and encourage reliable feature based approaches that can transition to realistic environments. Victims in the Yellow arena can only be scored by fully autonomous robots. All other robots must map the Yellow arena then navigate into the other arenas to score victim points. Robots are required to autonomously search the environment until they recognize more than one co-located sign of life associated with a victim. It should use the multiple sensor signatures to guide its approach onto the pallet directly in front of the victim, saturating all its available sensors for confidence and displaying them on the interface before calling the operator to verify. If the robot is more than one pallet away from the victim, or if the robot has identified a single false positive indication (e.g. a lone heating pad in the environment), the robot is penalized 1 minute. If the robot is correctly placed on the pallet in front of the victim, the judge uses all the sensor signatures displayed on the interface to score the victim. The operator is then allowed to map the victim (one keystroke by the operator) and resume the search.

The purpose of the Orange arena is to encourage robots to negotiate more difficult structured terrains and obstacles. The random maze continues with 1.2 m wide hallways and rooms, but contain crossing 15° degree ramp flooring to increase complexity. A 45° inclined plane provides challenges for motor torque and configuration management to maximize friction. Stairs with 20 cm risers, 40° incline, and rounded wood tread edges provide access to elevated flooring platforms. So-called pipe steps which use 10 cm diameter plastic pipes stacked to form 20 cm and 30 cm high steps encourage variable geometry robots and good operator interfaces to ascend reliably.

ASTM Standard Moderate Mobility Terrain

Confined spaces under the elevated flooring platforms constrict clearance while on ramp flooring to a minimum of 50 cm vertically with complex ceiling features like stalactites made from 10 cm square posts.

Mobile manipulation challenges include negotiating the complex terrains and working on side slopes to reach victim locations that range from 0-40 cm, 40-80 cm, and 80-120 cm elevation. Mobile manipulators must also stow well to ascend the stairs and the inclined plane, and also deploy while under the confined spaces to identify victims.



VICTIM ACCESS HOLES UP TO FOUR LEVELS HIGH

CROSSING 15° RAMP TERRAIN

ORANGE ARENA

Challenges for robots with modest mobility

- Crossing ramps (15°)
- Inclined plane (45°)
- Stairs (40-45°)
- Rolling pipe steps
- Confined spaces
- Manipulator challenges

RED ARENA

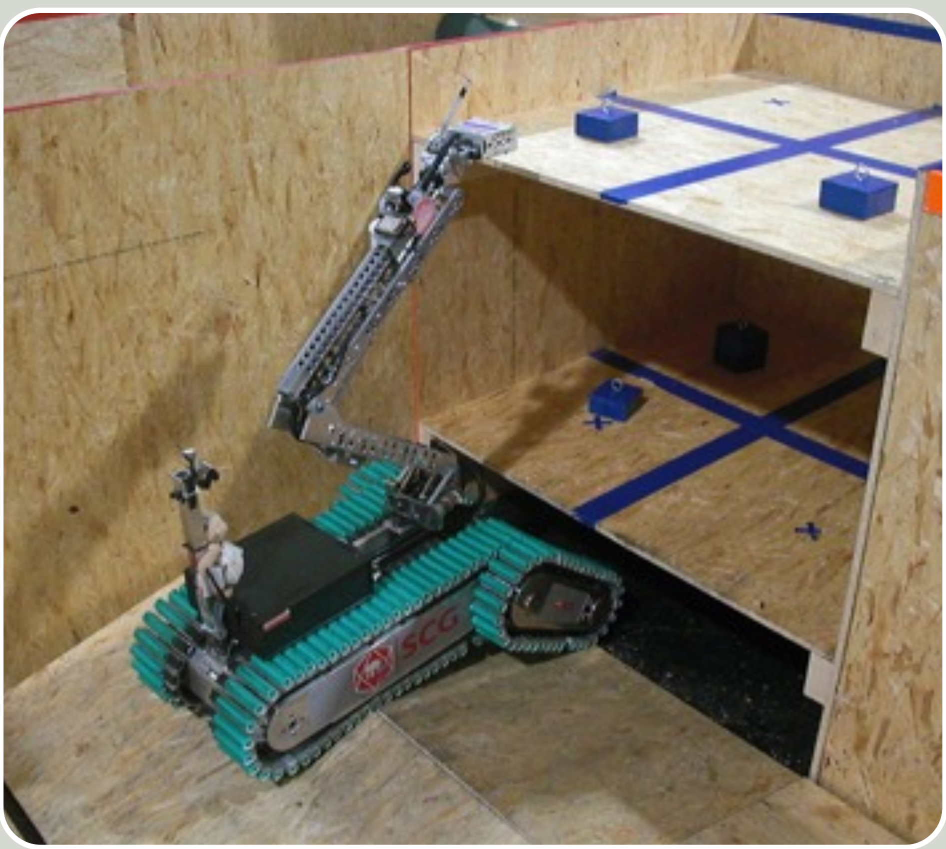
Challenges for robots with advanced mobility and exceptional remote situational awareness to negotiate very complex terrains.

The purpose of the Red arena is to encourage innovative mobility approaches that can reliably maneuver and deploy sensors and/or manipulators in complex terrain. The stepfield terrains provide the describable, repeatable, reproducible terrain for Red arena. Stepfields are made from 10 cm square posts cut to lengths of 10, 20, 30, 40, and 50 cm. Initially all the stepfield terrains in RoboCupRescue were arranged in random topographies which tended toward flat, hills, and diagonal hill pallets. As intended, this produced a very difficult challenge for robot developers both for mobility and for operator awareness during remote teleoperation. However, these random stepfield pallets were not producing repeatable results over many trials, which is a necessity to become a standard test method. So the latest configurations of stepfield terrains are more symmetric rather than random. They appear as similar mobility challenges to the robot either forwards or backwards over the terrain. They are very easy to describe and build, and so should make a good test method apparatus. RoboCupRescue has been, and will continue to be, instrumental in capturing performance data for robots demonstrating advanced mobility, especially in confined spaces. And these new stepfield terrains will be setup as an open room (2.4m wide x 6m long) as shown below, and as hallways with forced turns in the maze configuration.

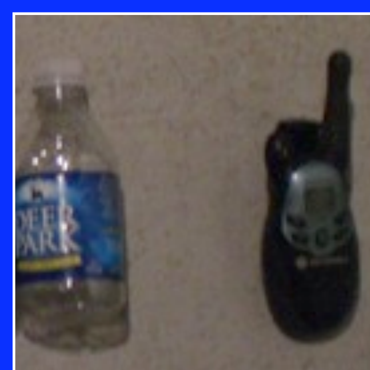
ASTM Standard Advanced Mobility Terrain

The purpose of introducing pick and place tasks in the arena is to encourage development of cartesian controlled mobile manipulators with inverse kinematics that can perform grasping and precision placement of items at different levels (0, 50, 100 cm) and reaches (30, 60 cm) while working in complex terrains (initially 15° ramps). Wood blocks (10 cm cubes covered in duct tape) provide a relatively lightweight object to manipulate. Addition of a singe eye-bolt screwed into one side allows simplified grasping, hooking, or carrying and delivering on a rod. The eye-bolt is roughly 2 cm diameter. This can be considered a sensor, communications repeater, or other useful object that is adapted for easy handling by a robot. There are also full water bottles (500 ml) and small radios that can be grasped and manipulated to encourage more generalized approaches needed to retrieve samples in the field. The goal is to place one of these three objects inside a found victim box to score an additional 20 points - the same incentive as the mapping capability. Three items can be carried in as a payload on the robot from the initial mission start point. But additional items must be retrieved from the Blue arena shelves. Teams may choose which items to have available and in which orientation they will be placed on the shelving targets.

ASTM Standard Mobile Manipulation Apparatus



BLUE ARENA



Challenges for mobile manipulators with coordinated controlled arms, automatic tool changing, object grasping, and/or payload carrying and precision placement capabilities.

RADIO DROPOUT

Challenges for robots with modest mobility <u>and</u> autonomous navigation capabilities (e.g. wall following behaviors)

The purpose of the radio drop-out zone (clearly marked with black/yellow hazard tape) is to encourage autonomous behaviors on reasonably mobile robots. Bounded autonomous navigation behaviors such as wall following or centering between obstacles should suffice for this challenge. The operator can remotely teleoperate the robot through the Orange arena to the beginning pallet of the radio drop-out zone . Once the robot is in position on the initial pallet of the zone, the operator can initiate an autonomous behavior to try to navigate the marked hallway. It will initially consist of a few turns but will get more complex toward the final missions. The floor will be continuous 15° degree ramps just like the Yellow arena. A bonus victim will be placed on the far side of the radio drop-out zone so that once the robot is through, when radio communications can resume, the victim can be found via remote teleoperation. The same victim <u>will count again</u> if the robot can return through the radio drop-out zone to the initial start point at the beginning of the zone. So there are 2 extra victims worth of points to find, depending on the robot's onboard autonomous behaviors and mobility. Resets go back to the radio drop-out zone entrance.

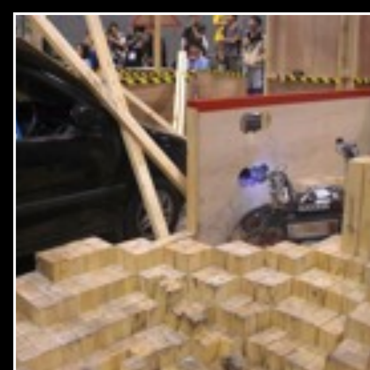
Autonomous navigation in complex terrain

Entrance located past the Orange Arena

The purpose of introducing a mini emergency response scenario into the arenas is to begin to correlate performance seen in the arena features with tasks in more unstructured environments. One or more vehicles will be placed within the arena and called the Black arena. The vehicles will have assorted rubble surrounding them as if they were involved in an earthquake collapse of an overpass, tunnel, or parking garage. Victims will likely be inside, since at the time of the accident the vehicle was being driven on a roadway. One side of the accident will have more complex terrain associated with a possible collapse. This will be accessible from the Red arena stepfield terrain. The other side of the vehicles may be more relatively clear as if it were a hazardous materials event rather than a collapse. This side will be accessible from the Yellow, Orange, or Radio Drop-Out Zone. Directed perception tasks to look into the windows to identify victims, and into the trunk and other areas for potential hazards will be required. Finding victims and hazards will score points just like in the rest of the arenas.

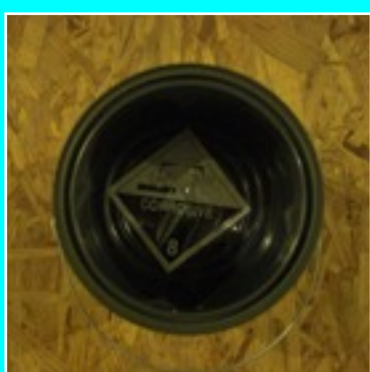
Parking garage or tunnel collapse scenario

BLACK ARENA



Mini emergency response scenario incorporated into the RoboCupRescue arenas.

AERIAL ARENA



Challenges for micro/mini aerial vehicles with autonomous stand-off and station-keeping capabilities

The purpose of the Aerial arena is to encourage autonomous behaviors on small unmanned aerial systems (sUAS). Specifically, this event is focused on vertical take-off and landing aerials, typically quad-rotor aerials, that are under 2 kg total weight. The tasks to be demonstrated will encourage vertical and horizontal station-keeping with automatic standoff and centering on windows. There will also be victim boxes with targets hanging in free-space over the ground arenas. The aerial victim boxes may be hanging nearby each other to add complexity. Line following tasks may also be included. Wind effects generated by fans will add environmental complexity in later missions. This will extend the same basic tasks from the ground arenas into the aerial domain. So all the aerial targets will contain similar signs of life such as form, heat, and sound to challenge the aerial's ability to deploy sensors both for station-keeping and for target identification. Best-In-Class aerials in the finals missions will provide overflight imagery, maps, and other helpful information to all ground robots in the finals missions (not in real time) to encourage collaboration opportunities for ground/aerial operations.

Small Unmanned Aerial Systems (<2 kg)

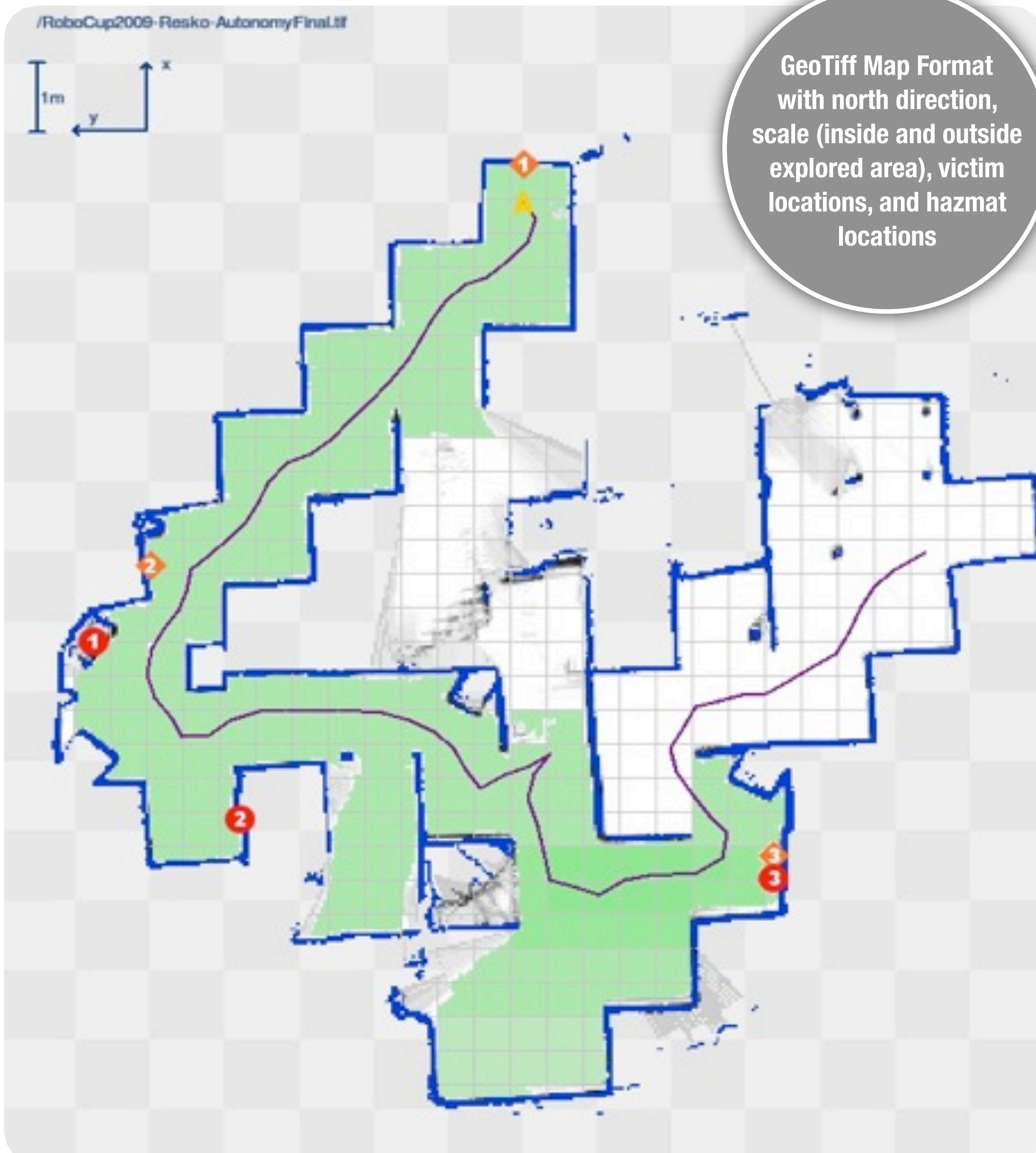
Fake windows of various shapes hang in arrays along one or two walls and have flush and recessed targets to identify

Cubes with targets on four sides seen through different size openings hang in free space over the victim boxes in the ground arenas

Examples of Quad-Rotor Aerial Vehicles (< 2 kg)

AERIAL ARENA

Challenges for micro/mini aerial vehicles with autonomous stand-off and station-keeping capabilities



GeoTiff Map Format with north direction, scale (inside and outside explored area), victim locations, and hazmat locations

GEOTIFF MAPPING

Introduction of a mandatory GeoTiff map format solves two problems: 1) it provides for a standard map format that can be used to compare maps both to ground truth arena designs and to other maps across missions and teams. 2) it also allows us to develop algorithmic scoring metrics to automatically evaluate the location accuracy of victims initially, and ultimately map quality more generally. As a starting point, here is a source to investigate from the RoboCupRescue Virtual robot competition: http://www.robocuprescue.org/wiki/index.php?title=VRCompetitions#Map_Format_and_A_priori_Information

The map color scheme should highlight the important features without distraction. The goal is to have certain key information be immediately identifiable to make the map useful as a printed page while beginning to explore all the potential of a graphical viewer that allows interacting with the map (potential printing in black and white is also a secondary consideration).

So below is a proposed description of a 2009 GeoTIFF map format fo the RoboCupRescue Robot League competitions. The colors for each element are unique so that algorithmic scoring methods can be used without confusion. The values for gray have not exactly the same value for R, G and B to indicate that this particular pixel was modified. This makes it easy to reconstruct the original value when needed.

FILENAME:
DARK BLUE (RGB: 0, 44, 207) TEXT
For example, “RoboCup2009-TeamName-Mission1.tiff” displayed in the upper left corner to identify the map, make it sort properly in a directory, and findable on a computer.

MAP SCALE:
DARK BLUE (RGB: 0, 50, 140) TEXT AND EXACTLY 1 METER LONG LINE
Display this in the upper right corner to indicate the scale of the map.

MAP ORIENTATION:
DARK BLUE (RGB: 0, 50, 140) TEXT (“X” AND “Y”) AND ABOUT 50 cm LONG ARROWS
Display this next to the map scale. It gives the orientation for the victim location in the victim file. Must be a right-handed coordinate system: X points upwards, Y to the left.

UNEXPLORED AREA GRID:
LIGHT/DARK GREY (RGB: 226, 226, 227/RGB: 237, 237, 238) CHECKERBOARD WITH 100CM SQAURES
This solid checkerboard pattern should show the unexplored area and provide scale on all sides of the mapped area. It should also print in black and white without ambiguity with other areas potentially turned grey in the process.

EXPLORED AREA GRID:
BLACK (RGB: 190,190,191) GRID WITH 50CM GRID AND ABOUT 1 CM THICK LINES (use a one pixel line in the map)
This grid should only appear in the explored area, behind any walls, victim locations, or other information. The grid should be aligned with the checkerboard pattern of the unexplored area, but twice as fine to allow visual inspection of wall alignments.

INITIAL ROBOT POSITION:
YELLOW (RGB: 255, 200, 0) ARROW
This should mark the initial position of the robot and always be pointed toward the top of the map.

WALLS AND OBSTACLES:
DARK BLUE (RGB: 0, 40, 120) FEATURES
This should indicate the walls and other obstacles in the environment. The color should make the walls stand out from everything else.

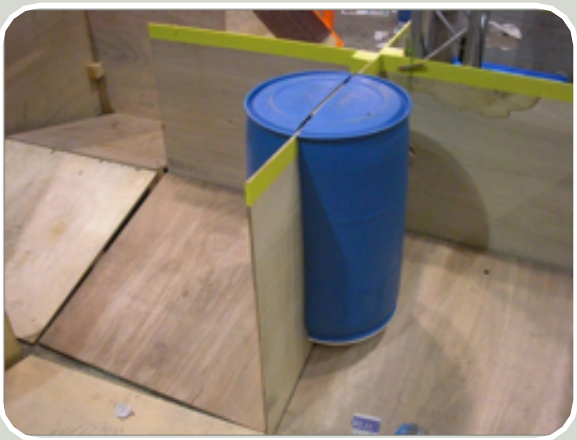
SEARCHED AREA:
WHITE CONFIDENCE GRADIENT (RGB: 128, 128, 128 to RGB: 255, 255, 255)
This should be based on the confidence that the area is really free. It should produce a clean white when seen as free by all measurements and nearly untouched when undecided, that is, nearly equally seen as occupied as free, to produce a dither effect.

CLEARED AREA:
LIGHT GREEN CONFIDENCE GRADIENT (RGB: 180, 230, 180 to RGB: 130, 230, 130)
This should be based on a history of 1-50 scans to show the area cleared of victims with confidence. This should also factor in the actual field of view and range of onboard victim sensors – noting that victim sensors don’t typically see through walls!

VICTIM LOCATION:
SOLID RED (RGB: 240, 10, 10) CIRCLE WITH ABOUT 35CM DIAM CONTAINING WHITE (RGB) TEXT “#”
This should show the locations of victims with a victim identification number such as “1” in the order they were found. Additional information about this victim should be in the victim file noted below.

HAZARD LOCATION:
SOLID ORANGE (RGB: 255, 100, 30) DIAMOND WITH ABOUT 30CM SIDES CONTAINING WHITE (RGB) TEXT “#”
This should show the locations of hazards with an identification number such as “1” in the order they were found. Additional information about this hazard should be in the hazard file noted below.

ROBOT PATH:
MAGENTA (RGB: 120, 0, 140) LINE ABOUT 2CM THICK
This should show the robot path.

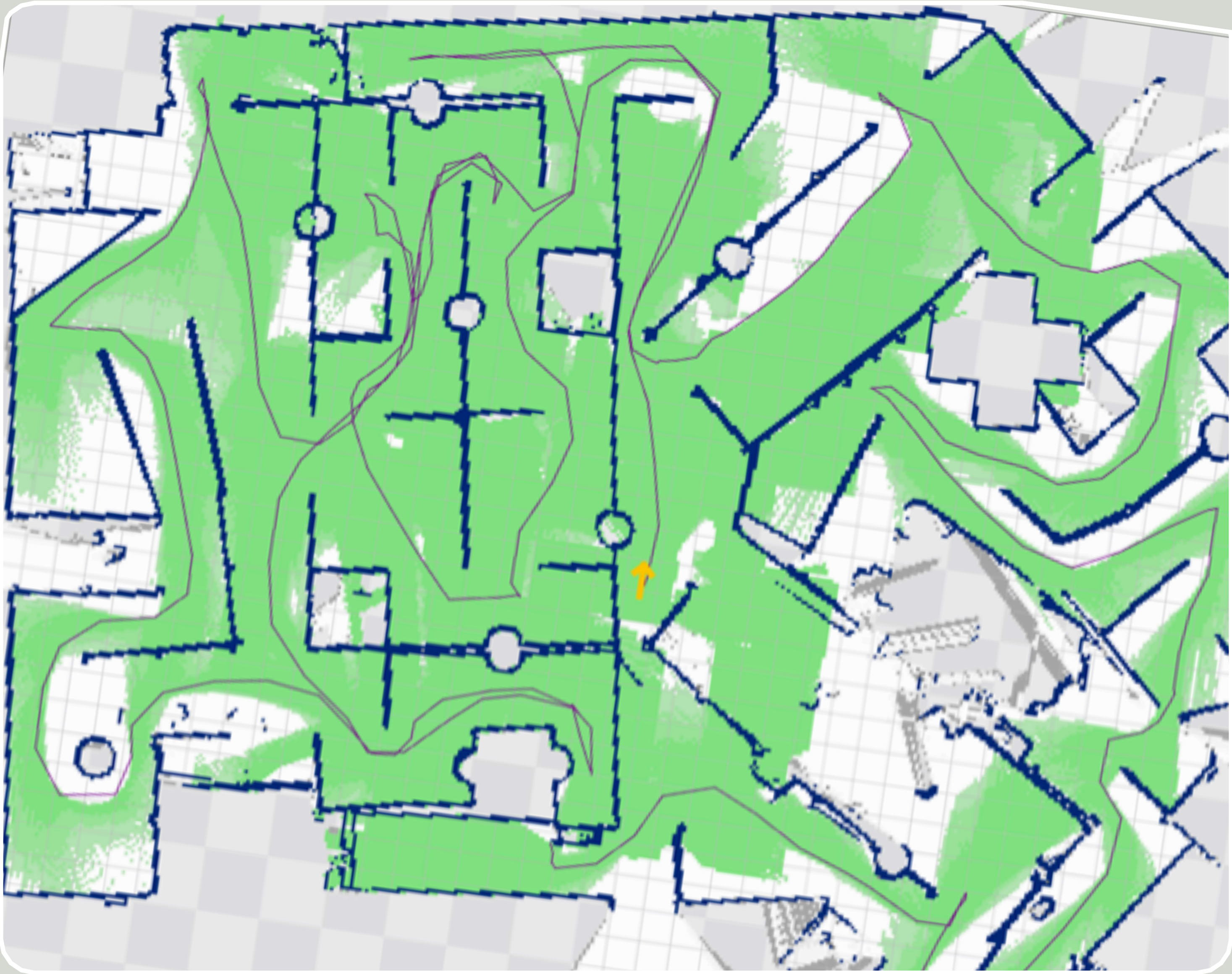


DEVELOPMENT OF NEW ROBOT PERFORMANCE METRICS

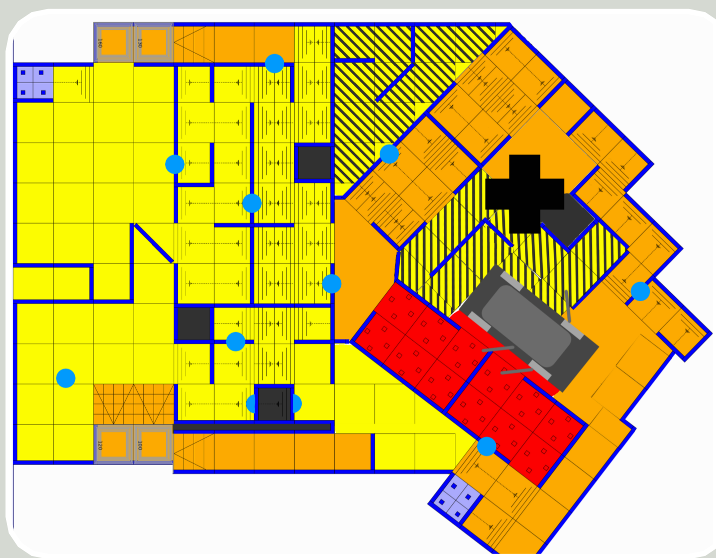
The RoboCupRescue Robot League supports research agendas beyond the robotic capabilities on display. The robotics community is already benefiting from common test methods, but also need agreed upon measures of performance to guide their research. Robotic mapping is one area where the league is implementing innovative measurement techniques to provide developers with clear reproducible metrics they can use to measure their progress and then compare to others. For example, this competition features new map fiducials as markers in the laser scanner data sets typically used to generate maps. They provided easy measures for general coverage of the environment, consistency of fiducials across multiple scans, along with local and global accuracy of fiducial locations. There is somewhat more to the idea not described here, but it is essentially a low cost way to populate any environment in which mapping is to take place enabling a ground-truth assessment of the mapping system performance.

As shown to the left: A) freestanding barrels work well as mapping fiducials to analyze the coverage of rooms in the maze. B) Two half barrels make up one single mapping fiducial on either side of maze walls, adding occlusions to prevent single scans from capturing the complete fiducial. Some barrels span adjacent hallways, requiring extensive mobility between scans to completely map. C) Barrels are placed throughout the maze independent of terrain type to encourage mapping on more complex terrains. D) The barrels are relatively inexpensive to purchase and easy to cut so can be placed throughout the environment.

In the resulting map, shown to the right, when the barrel fiducials are well formed they are extremely easy to locate and score, which essentially provides the “coverage” metric giving one point for each half barrel mapped. The difficulty factor can be set and maintained for different random maze configurations by counting how many flooring pallets are traversed between contact with both halves of a mapping fiducial. When the mapped fiducials visually separate in the map due to errors in the robot’s pose estimate, the “consistency” metric quantified how much the fiducials degraded in terms of barrel diameters to provide a course but obvious measure of performance.



Note: the map shown above was generated for the as-built configuration of the arena for a Finals mission. It does not exactly reflect the arena design shown below which was for a Preliminary mission with two concurrent arenas.



RoboCupRescue Scoring

The purpose of the scoring metric is to encourage development of complete and reliable robotic systems while emphasizing certain best-in-class capabilities and integration of critical sub-components. The scoring approach centers around finding simulated victims distributed roughly uniformly throughout the arenas. There are essentially the same amount of points available on every victim. So robots with more capabilities, such as autonomous navigation and victim identification, have more victims available to find. Similarly, robots with advanced mobility capable of negotiating the Red arena stepfields have access to more victims. Robots with manipulators that can reach and search victim boxes on the highest elevation (80-120 cm), have access to modestly more victims if they can also deploy their manipulator under the elevated flooring platforms to find the confined space victims.

In this way, the league doesn't assign specific points associated with different capabilities, for example autonomy vs. remote teleoperation. The total victims available for different robotic implementations will be well known by teams, as will the situations in which they will be located. Victims will be moved around the arena and placed at different elevations each round to ensure that the winning robots have reliably negotiated the entirety of the arenas across multiple missions. Victim locations may also get harder, search times may get shorter, or arena sizes may get larger as the competition progresses toward the Finals to ensure that the best robots are appropriately challenged. But in the end, ***this is a league of teams not competing against one another, but rather collaborating against the application domain***. As such, we are interested in robots demonstrating world-class capabilities in the arenas so that the rest of the league may appreciate, learn, and ultimately leverage new and exciting approaches.

MISSION SCORING

Robots must be within 1 meter directly in front of found victims to score points. Several key capabilities are specifically rewarded in the scoring metric. Since victims are distributed across all arenas, more capable robots have access to more victims.

VICTIMS PER ARENA

- 4 Yellow
- 4 Orange
- 4 Red
- 2 Radio Drop-Out Zone

POINTS PER VICTIM

VISUAL IDENTIFICATIONS (10 pts)

- (5 pts) Hazmat labels
- (5 pts) Eye charts

OTHER DETECTIONS (20 pts)

- (5 pts) Motion sensors
- (5 pts) Thermal sensors
- (5 pts) CO_2 sensors
- (5 pts) Audio: victim ---> operator
- (5 pts) Audio: operator ---> victim

ARENA MAPPING (20 pts)

- (10 pts) Quality of geotiff map
- (10 pts) Accuracy of victims

PAYLOAD DELIVERY (20 pts)

- (20 pts) Placing of payloads blocks or bottles into found victim boxes.

PENALTIES (-10 pts per event)

- Assessed when arena elements need to be replaced

ROBOT LEAGUE MISSION FORM (v2010.2)

COUNTRY	TEAM NAME	ROUND/MISSION	START/END

BOT #	ROBOT NAME	TELE	AUTO	CAMERA VIDEO	THERMAL DETECTION	MOTION DETECTION	AUDIO LISTEN / TALK	CO_2 DETECTION

START POINT

PENALTIES 10 10 10 10 10

RADIO DROP ZONE (DEAD END TRAVERSE)
START/END

RESET	BOT#	ARENA	ID	HOLES	TAGS		SIGNS OF LIFE					PLACE	MAP	SCORE	NOTES
					5	5	5	5	5	5	5	20	20		
V1					E	E_E	T	M	A_L	A_T	C_{O2}				
V2					E	E_E	T	M	A_L	A_T	C_{O2}				
V3					E	E_E	T	M	A_L	A_T	C_{O2}				
V4					E	E_E	T	M	A_L	A_T	C_{O2}				
V5					E	E_E	T	M	A_L	A_T	C_{O2}				
V6					E	E_E	T	M	A_L	A_T	C_{O2}				
V7					E	E_E	T	M	A_L	A_T	C_{O2}				
V8					E	E_E	T	M	A_L	A_T	C_{O2}				
V9					E	E_E	T	M	A_L	A_T	C_{O2}				
V10					E	E_E	T	M	A_L	A_T	C_{O2}				
V11					E	E_E	T	M	A_L	A_T	C_{O2}				
V12					E	E_E	T	M	A_L	A_T	C_{O2}				
V13					E	E_E	T	M	A_L	A_T	C_{O2}				

NOTE: IF RADIO DROP ZONE IS A DEAD END, COUNT TELEOP VICTIM SCORE TWICE AFTER SUCCESSFUL AUTONOMOUS RETURN.

PENALTIES	POINTS		TOTAL
		=	

JUDGE NAME	REFFEREE NAME

Schedule of Missions

Preliminary Round

Typically 20+ teams perform 4 preliminary missions resulting in a total of 80+ missions over the first two days. Given the number of teams, preliminary missions are performed in half size arenas to facilitate concurrent operations. Each mission lasts 15 minutes including setup of the robots in the arena and the operator station in the operator blind. Mission start times are every 20 minutes. The half size arenas include all color-coded elements but could not be considered exactly similar, so teams are provided an equal number of missions in each arena. The order of teams scheduled to perform missions are initially random and are maintained across missions for the entire day to allow for battery charging. The team order is reversed each subsequent day to allow teams to watch each other. Teams can drop one preliminary mission score so three of four missions are summed as the preliminary round total. The number of victims found is the only scoring metric used in the preliminary round, ignoring the sensor, mapping, and manipulation points, to ease the scoring burden on administrators and allow teams time to better understand the deliverables expected and improve their deployment procedures. Roughly half the teams advance to the semi-final round based on a scoring gap above a minimum threshold of performance that average two or more victims found per mission depending on the success of the teams overall.

Semi-Final Round

Typically 10 teams perform 2 semi-final missions in the full size arena resulting in a total of 20 more missions in approximately 10 hours. Each mission lasts 25 minutes including setup of the robots in the arena and the operator station in the operator blind. Mission start times are every 30 minutes. Preliminary round scores do not transfer into the semi-final round, however the order of teams in the semi-final round is based on the scores in the preliminary round with the lowest scoring team going first and the highest scoring team going last. The order of teams is maintained for the entire day to allow for battery charging. Typically only 3 teams advance into the final round, however the number of teams that advance can vary depending on the appearance of a scoring gap in team performance.

Final Round

Typically 3 teams perform 1 final round mission in the full size arena resulting in a total of 3 more missions in approximately 1.5 hours. Each mission lasts 25 minutes including setup of the robots and the operator station. Mission start times are every 30 minutes. The order of teams in the final round is based on the scores in the semi-final round with the lowest scoring team going first and the highest scoring team going last. Semi-final round scores are maintained and summed with the final round score to determine the awardees.

Best-In-Class Missions

All teams are eligible to participate in the Best-In-Class missions if they scored at least one victim in the associated color-coded arena elements during the preliminary missions in which all teams participated. The number of victims found or tasks achieved in each color-coded arena are summed as one point each and counted as 50% of a given robot's Best-In-Class score. The other 50% of the Best-In-Class score are determined in one final mission with an equal number of points available as the combined preliminary missions (3 victims per color-coded arena over 4 preliminary missions = 12 possible points). The Best-In-Class mission tasks are as follows:

Autonomy (Yellow & Radio Drop-Out Zone):

The number of Yellow arena victims found autonomously combined with the number of Radio Drop Zone victims navigated to autonomously in the preliminary round are added to a final autonomous mapping mission throughout the entire arena. The mapping mission has 12 possible points using 6 mapping fiducials (barrels) placed throughout the arena providing 1 point for coverage and 1 point for accuracy. The start point is the same for all teams. All doors to more difficult arenas are left open to require terrain classification to circumnavigate the entire arena. The mission duration is 30 minutes. Reset of the robot back to the start point is allowed in case of failure of any kind but accumulated points are lost and time keeps running.

Mobility (Orange & Red Arena):

The number of Red arena victims found in the preliminary round is added to one final mobility mission totaling 12 possible points with no attention to victims. The final mission counts 1 point per obstacles traversed in each direction on each of the following:

- up/down the 45° stairs with steering occlusions
- up/down the 45° inclined plane on a diagonal path
- up/down the 30 cm pipe step
- 3 figure-8 laps in the Red Arena stepfields, 2 points per lap.

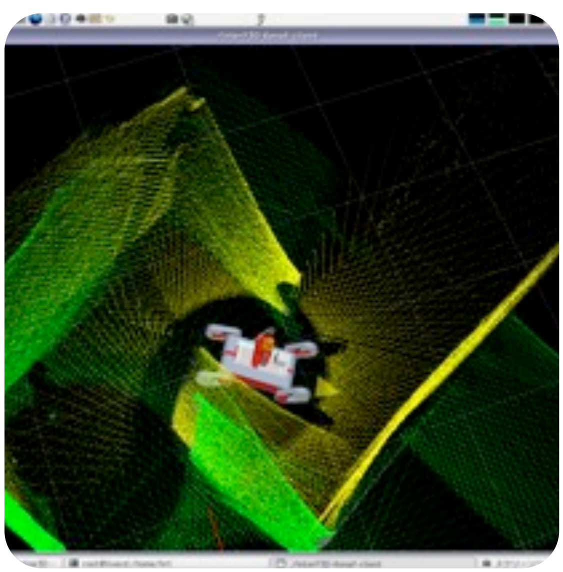
If 10 figure-8 laps can be achieved, an ASTM standard test method form will be filled out and provided to the team to show reliable performance of advanced mobility. Resets of the robot back to the start point is allowed in case of failure of any kind but accumulated points are lost and time keeps running.

Manipulation (Blue Arena):

The number of objects successfully placed into victim boxes during the preliminary missions are added to one final manipulation mission requiring pick, carry, and place tasks. Blocks, half-blocks, and/or full water bottles are placed on the four marked locations of a Blue Arena shelf at 50cm elevation for teams to pick. The teams chose which objects they prefer in each of the four marked locations. Blocks and full water bottles are worth 1 point per task to pick, carry, and place. Half-blocks are worth ½ point per task because of their reduced weight. The robot has to pick the object from the shelf, carry the object to a nearby victim location across complex terrain, and place the object into the associated victim access hole at the four different elevations used throughout the competition. Only one object can be placed in any given hole. The holes nearest the pick task are three complex terrain pallets away, but are single access holes requiring more precise placement. An additional set of victim holes are twice as far away over complex terrain but have double access holes at each elevation making for a longer carry but a relatively easier placement task. The total number of pick, carry, and placement points are equal to the number of objects allowed to be carried in from the start of the preliminary missions, which was three objects in each of four missions for a total of 12 possible points. Reset of the robot back to the start point is allowed in case of failure of any kind but accumulated points are lost and time keeps running.

RoboCupRescueAwards

RoboCupRescue Winners and Best-In-Class Awardees get to participate in Response Robot Evaluation Exercises in Responder training facilities



Championship Awards

1st, 2nd, 3rd place awards will be given to teams with the highest cumulative scores from 7-10 missions.

Best-In-Class Awards

Best-In-Class awards will be given to individual robots that do the following:

Best-In-Class Autonomy:

- 50%: Find the most Yellow arena and Radio Drop-Out Zone victims during regular missions.
- 50%: Produce the best map during a Best-In-Class mission to map the entire arena with no attention to victims.

Best-In-Class Mobility:

- 50%: Find the most Red arena victims during regular missions.
- 50%: Traverse the most Red and Orange arena obstacles in a Best-In-Class mission with no attention to victims. Score 1 point per obstacle, per direction of traverse (i.e. forward/up and backward/down scores two points) on each of the following: stairs, inclined plane, pipe-step, and stepfield figure-8 laps.

Best-In-Class Mobile Manipulation:

- 50%: Place the most payload items into victim boxes during regular missions.
- 50%: Pick the most items from the Blue arena shelves during the Best-In-Class mission to quantify manipulator reach in two shelf conditions: open and covered by a shelf above.

Championship awardees get trophies. Best-In-Class awardees get trophies or certificates and an opportunity to teach their implementation at the next camp.

Best-In-Class Small Unmanned Aerial System:

- 50%: Compulsory tasks such as station-keeping in front of window targets, line following, and lost-link behaviors.
- 50%: Search task over ground arenas

RoboCupRescue Robot League

RULES-AT-A-GLANCE (2011.2)

RECENT ADDITIONS

- A radio drop-out zone with crossing pitch/roll ramp flooring to encourage mobile robots to demonstrate autonomous navigation capabilities in complex terrains.
- Payload delivery to encourage mobile manipulators using inverse kinematics to perform automatic payload grasping, tool changing, object retrieval, and precision placement tasks on complex terrains. Three items can be carried as payloads from the start, additional items can be grasped in the arena.
- Two-way communications tests to establish victim identification by a remote operator (and judge) using randomly spoken numbers played as audio files within victim boxes.

MISSION OVERVIEW

- Teams should queue at the paddock entry with their robot(s) and operator interface(s) prior to their scheduled start time.
- 15-30 minute missions include robot placement at the start point and operator station setup. Each team is responsible for making sure victims in the arenas are functional (heat, batteries, tags) prior to mission start.
- The operator station will be limited to a 120 cm wide x 60 cm deep desk with walls. Teams are allowed only one operator in the operator station at any time during missions. Teams may switch operators whenever necessary.
- All robot start points will be in or around the Yellow arena and facing the same direction (marked as "north" on your map). The initial direction may be facing a wall. Teams with multiple robots will be co-located at the start point (as near as possible) and facing the same direction.
- Victim placements will be known to the operators and audience prior to missions, and changed each round to ensure complete arena coverage over multiple missions.
- All teams should map the Yellow arena, but robots must perform autonomous navigation and victim identification to score Yellow arena victims. Operators may remotely teleoperate the robot at any time to navigate into the Orange and Red arenas but must return to the start point to resume autonomous searches to find Yellow arena victims.
- Teleoperative robots can only score Orange or Red arena victims, which are likely placed on both sides of the Yellow arena to encourage complete mapping of all arenas.
- An operator (or team leader) may request a "ROBOT RESET" to fix a robot during a mission, but suffers loss of accumulated victim points, maps, and elapsed time. The robot must re-start the mission from the initial mission start point and work for the remaining time available. The robot can be teleoperated to the start point to fix with no loss of points.
- GeoTiff maps are required and will be compared to ground truth for accuracy. Map quality will be based on Technical Committee review.
- Bumping penalties will be assessed if the administrator must replace or fix arena elements prior to next mission.
- The league will assign 802.11A channels for practice and missions. All league SSID's must be "RRL-TEAMNAME". No other radios using either 2.4 GHz or 5 GHz radio frequencies are allowed.

MISSION SCORING

Robots must be within 1 meter directly in front of found victims to score points. Several key capabilities are specifically rewarded in the scoring metric. Since victims are distributed across all arenas, more capable robots have access to more victims. In general, up to 70 points are available per victim found:

VICTIMS PER ARENA

- 4 Yellow (auto nav. & ID only)
- 4 Orange (auto or teleop)
- 4 Red (auto or teleop)
- 2 Radio Drop-Out Zone (auto nav.)

POINTS PER VICTIM

VISUAL IDENTIFICATIONS (10 pts)

- (5 pts) Hazmat labels
- (5 pts) Eye charts

OTHER DETECTIONS (20 pts)

- (5 pts) Motion sensors
- (5 pts) Thermal sensors
- (5 pts) CO_2 sensors
- (5 pts) Audio: victim ---> operator
- (5 pts) Audio: operator ---> victim

ARENA MAPPING (20 pts)

- (10 pts) Quality of geotiff map
- (10 pts) Accuracy of victims

PAYLOAD DELIVERY (20 pts)

- (20 pts) Placing of payloads blocks or bottles into found victim boxes.

PENALTIES (-10 pts per event)

- Assessed when arena elements need to be replaced