RoboCup 2010

RoboCup Rescue Simulation League
Virtual Robots competition
Rules document

Technical Committee; Arnoud Visser, Behzad Tabibian and Stephen Balakirsky

Release Candidate version 1: June 15, 2010

Abstract

The purpose of the competition is to provide a common benchmark to demonstrate scientific progress in robotics in the field of Urban Search and Rescue. The rules of this competition are inspired by the rules of the RoboCup Rescue Robot League and Agent competition. As in the Robot League, a devastated area has to be explored for victims with a team of robots controlled by an operator. Compared to the Robot League, the focus of the research is more focused on teamwork to accurately explore large areas and less on mobility. As in the Agent competition, the disaster situation is not known before a competition run. Compared to the agent league, the focus is more on the sensory and actuation level and less on planning. This year the Technical Committee is looking forward to see innovative solutions based on the new opportunities and challenges of the latest Unreal Tournament (UT3) environment.

1 Foreword

The design and implementation of a RoboCup Competition is an ongoing process that is possible thanks to many people around the world often volunteering a significant part of their time to this event. Contributions include improvements to the simulation engine, creation of competition worlds, and running the competition itself. The generous work of all volunteers who provided these contributions in the past is warmly acknowledged. This year the contributions of the teams are acknowledged with community points. Those community points will be used during the qualification process. We hope that this acknowledgment helps to create a competition that is sustainable in the long term with very limited man power.

Rules proposed for the 2010 competition strive to demonstrate the progress made on the problem as a whole (the comprehensive mission) and several sub-problems (the elemental tests). The organizers are fully aware that there are many other combinations of tests that are possible to demonstrate scientific progress, but while designing the competition numerous constraints had to be taken into account. As usual, suggestions, constructive feedback and volunteer work are welcome and needed. All teams eventually participating in the 2010 competition agree to obey the final version of the rules that will be finalized after the regional competition in Iran (April 2010).

2 League Objectives & Background

The major goal of this competition is to encourage intuitive operator interfaces, and algorithms that can be used to monitor and control multiple heterogeneous robots in a challenging environment. While significant improvements have been observed over the past years, no single subproblem can be considered completely solved. Certain observations made in the recent past led to this proposal.

1. A scoring metric that evaluates only the final result in terms of victims and maps may fail to recognize optimal solutions to partial sub-problems. At the same time, certain evaluations (e.g. map quality) are still hard to carry out in an automated way with no human in the loop. It is our goal to finally converge to a competition where the scoring is fully automated, thus ensuring ease of competition administration, and full transparency of the scoring.

2. While the Bremen 2006 competition clearly favored fully autonomous teams, successive contests held in Atlanta and Suzhou saw a significant drift towards systems where the role of the human supervisor and teleoperation became dominant. With very few exceptions, the introduction of a wireless server with limited communication range did not lead to teams which are capable of promptly and effectively switching between teleoperation and autonomy. The teams implemented relay schemes to remain fully teleoperated all the time. It is our belief that both competences are needed in real world rescue systems. In Graz 2009 the concept of hands off periods was introduced.

In the light of the above reasons the competition schema introduced in Graz 2009 will be further refined.

1. The competition will be broken down into a set of individual tests during the preliminaries and comprehensive competitions during the finals. Individual tests aim to assess the teams' ability to solve specific tasks relevant to the comprehensive mission. Here we use the term *comprehensive mission* to mean a competition as performed in the past, i.e. a mission where robots are requested to detect and locate victims, produce maps, etc.

2. During the finals, teams will be required to perform two comprehensive missions. During these missions, teams will be allowed to teleoperate their teams for 50% of the time, and will be required to be *hands off* for the remaining 50%. Details about the switching will be clarified later in this article.

Very important this year will be set of robots, sensors and actuators available during the competition. The robots, sensors and actuators used in the previous competitions will not longer be available. Part of this year's challenge is to create an acceptable scheme of introducing, validating and certifying components (robots, sensors, actuators) required for the competition. No new components should be introduced after the finalization of the rules. Bug fixes can be expected until the last moment (even during the preliminaries). The Technical Committee will propose a default configuration the day before the run. Minor configuration changes (e.g. orientation change of a sensor) should be provided to the Technical Committee that same day.

3 Elemental Tests

The following tests will be be performed in the preliminary rounds.

1. **Teleoperation test.** The assigned task is to control of large teams of diverse robots. Teams will be provided n starting locations and n target locations, but no map of the environment. The starting and goal locations will be available with the GETSTARTPOSES command. The goal of the trial is to bring at least one robot to each target location in the allocated time (20 minutes). A point is considered reached it at least one robot is within T meters of it (three-dimensional distance will be computed). The robot should stop and stay at this location (only the final position counts). In case two teams manage to reach an equal number of points the sum of the distances of the target points from the deployment site will be used to rank teams (the farthest wins). In case two or more teams reach exactly the same points, the distance of the robots to those points are used. This test can be performed in

teleoperation. Teams are encouraged to deploy heterogeneous teams because there will be locations only reachable by a certain type of robots. The number of robots from the same type is limited to t. Previous year $t = 2$, this year the actual number will depend on the quantity and quality of robots implemented in UT3. Only robot types listed in appendix B are allowed. This test will be run with the Wireless Communication Server WSS configured with the NoopPropagationModel.

2. **Mapping test** The assigned task is to provide an accurate map of the environment in the allocated time of 20 minutes while reaching as many test points as possible. Teleoperation is allowed during the test. Each team will be allowed to use at most 4 ground-robots at their choice. Only robot types listed in appendix B are allowed. The test environment will contain multiple storeys, areas of sloped flooring (ramps) as well as some discontinuities (single steps). Further, the robots can encounter water and smoke. During this test the sensors will be very noisy. This configuration allows one to evaluate the performance of the mapping algorithm with less accurate motion estimates. At the beginning of this test a number of test locations are provided (available with the GETSTARTPOSES command). At the end of this test teams are required to provide two files. The first file will be a map containing two layers of the GeoTIFF file, the layer pertaining to occupancy information and the victim layer. In this case, the teams will mark their estimated locations of the test points as victims. This occupancy map will be checked on accuracy and usability by planning paths to the predetermined test points. The second file will be a MIF-file, containing the estimation of the paths driven by the robots. These paths will be compared with the ground truth. This test will be run with the WSS configured with the DistanceOnlyPropagationModel.

3. **Deployment test**: The task assigned to a team is to deploy a communication infrastructure. Each team will be provided a georeferenced occupancy grid of the environment and a certain number of starting locations (available with the GETSTARTPOSES command). The goal of the trial is to disperse robots around in the environment in order to provide communication coverage to the largest possible area while ensuring connectivity with a base station whose location is known and fixed. Only the robots' positions at the end of the run will be used for scoring purposes. This test will be run with the WSS configured with the ObstaclePropagationModel. The GETSS functionality of the wireless server will be used to determine if a point is covered by the communication infrastructure or not. A point will be deemed covered by one of the robots if GETSS returns a value above a fixed threshold T (known and communicated to the teams before the test). Teams will be ranked based on the size of the largest connected covered area including the base station location. It is important to observe that a large connected area not covering the location of the base station will not lead to any points, as the goal is to test the ability to deploy a communication infrastructure capable of ensuring communication with the outdoor world via the provided base station. Only points belonging to free space will be considered for scoring. This test needs to be completed autonomously. Each team will be allowed to use at most 8 ground-robots of their choice. Only robot types listed in appendix B are allowed. The test environment will be mainly planar, but will include ramps and some discontinuities. The file with the map will be given just shortly before the run. No GroundTruth information will be available, but the INSSensor will be configured with the default settings (drifting on, small sigma, high precision).

   Scoring for the elemental test will be performed with the scoreRadio program that is located as part of the sourceforge SVN repository. Directions for running the program are located with the source code, as well as the necessary ground truth file for the sample deployment world.

Test worlds for the elemental tests will be posted as part of the SVN release on sourceforge. For example, the deployment test world is called *DeploymentSample2010.ut3* located in the directory *Unpublished\USARSimMaps*. Additional support files are located in the directory

Unpublished\USARSimMapFiles. These files include the *a priori* data for the sample worlds. Directions for downloading files from the repository are available at http://sourceforge.net/projects/usarsim/develop.

Each elemental test yields a certain number of points to the teams, depending on the score of the best team. If the best team receives 50 points with score $\max(s_i)$, the other teams will receive a score $\frac{s_i}{\max(s_i)} * 50$. At the end of the three qualifying days, the teams with the highest cumulative score will advance to the finals.

4 Comprehensive Missions

During the competition, indoor and outdoor urban search and rescue scenarios may be encountered. The day before the run, the teams will be given basic information about the scenario. This basic information will include the origin and location of the disaster (i.e. chemical spill in a large terminal), possible dangers (i.e. a mud slide made part of the area difficult traversable), simple georeferenced maps of the area (not guaranteed to be up to date) and the start locations of the robots on that map. This year, the maps will not include information on difficulty.

In response to this input, teams will be required to submit to the referee the ini file describing each robot that will be used for the mission. Submissions are binding, i.e. no changes to the robots will be allowed. The organizing committee will then review these files to make sure that they meet budgetary constraints as well as include realistic platform-sensor combinations. Teams submitting files that do not pass such inspection will be forced to compete with standard platforms, i.e. those published by the Technical Committee that same day. Only robots validated by NIST will be allowed to be used in the competition. The list of accepted robots and sensors is reported in this document as Appendix B. Note that not every combination is possible. The sensor load will be examined, which can lead to a reduced battery-lifetime of the combination. The referee reserves the right to disallow any unrealistic combination of robots and sensors.

5 Running Missions

During the competition, the organizers will provide two sets of machines (from now on each set will be called *cluster*). USARSim will be run in *client mode* on the cluster. Each team will run its client code on its own machines. A single TCP/IP cable will be provided to the team to connect to the cluster. One of the two clusters will be used by the team currently competing, while the second one will be used by the team setting up for the following competition round. Each team has 20 minutes to setup on the cluster currently not being used. The run starts at the scheduled time. If a team is not ready, time will start anyway. Robots are provided with batteries that will operate for 25-45 minutes (time to be announced before the run). At the prescribed start time, the robots will be instantiated in the world. The robots must wait for a 'start' command to be issued before beginning their exploration. The robots are responsible for monitoring their battery condition. Information not reported and logged before batteries expire will not be counted towards the total score. All robots must be spawned at the same time, though teams can decide to activate them at their convenience. During the mission, the operator will be touched on the shoulder by one of the organizers, to get his/her attention. After 10 seconds, the operator will be told to turn his/her back to the teleoperation station. Before the turn, the operator will be allowed to send one command from their station, after which the robots should be able to handle this *hands off* operation period gracefully.

All communications (operator-robot and robot-robot) will use the Wireless Communication Server WSS[1]. This version is tested with UT3.

[1]The WSS is developed and documented by Max Pfingsthorn. The WSS simulate wireless network links in a disaster setting. In a disaster settings network links are not guaranteed, which forces robot-control developers to deal with the main issues of unreliable wireless links, such as either multi-hop routing to the operator or autonomous behavior of the robots. During the competition, the WSS will operate with the *ObstaclePropagationModel*. The latest version 0.6.1 is available on http://usarsim.cvs.sourceforge.net/viewvc/usarsim/usarsim/Tools/WSS/

All communications via the WSS includes the connection to the image server[2]. This version is also tested with UT3. In this way the operator base station can send commands to a robot and will obtain measurements and video images from a robot only when that robot is in radio contact. The location of the operator base station and the wireless cutoff strength are provided as a-priori data. During the competition all socket communication to the robots is logged. Therefore, we are able to check for TCP-packages that bypass the Wireless Communication Server. Teams that violate this policy are immediately disqualified, and the reason for the disqualification will be posted on the web.

6 Performance metrics

Each team will be judged on the files they will deliver after a competition run. During the elemental tests, less information has to be provided than after the comprehensive missions. The scores of the preliminary rounds are used to determine the teams which proceed into the final rounds. The scores of the teams are reset after the preliminary rounds.

6.1 Teleoperation test

The team does not have to deliver any files. The file `UT3.log`, produced at the Unreal-server, will be used to automatically compute the coverage with the program that will become available at http://usarsim.svn.sourceforge.net/viewvc/usarsim/Tools/ScoreTeleOp/. This program will calculate an absolute test score.

To calculate the absolute test score 50 points are given for each goal point one of the robots reached within T meters (in three dimensions). The distance of the reached points in meters from the deployment site is added as an indication of the difficulty. The distance of the closest robot to a reached point in meters is subtracted from the score. To compute the overall score S, the collected points are divided by H^2, equivalent with the metrics of the Comprehensive mission.

This absolute test score is scaled down to a relative score. One can get up to 50 points for the teleoperation test. The best team will get 50 points. The absolute test score of the best team is used to calculate the relative score of the other teams (linear decrease to 0).

6.2 Mapping test

The team will only deliver a georeferenced map with occupancy and test point information. All information used for scoring should be turned in no later then 15 minutes after the run is completed. Late information will not be accepted for scoring purposes. The georeferenced map has an obligatory color scheme, equivalent with the color scheme in Appendix A, except that only the colors Black, White, Blue, and Red may be used. The mapping quality M will be based on a single criterion:

Utility A map can be used for different applications. In this case the quality of the map is tested for the application 'robot navigation'. The utility of the map for robot navigation will be tested by planning a number of paths to predefined reachable locations (the provided test points). The fraction of correct paths as a function of the possible path is used as the measure. Path planning can fail due to the following map characteristics:

1. no occupancy information is available for the target point (map too small)
2. every possible path is blocked by occupied space, due to observed obstacles that are actually not present in the world

[2]The new image server is developed and documented by Prasanna Velagapudi. With this version you run the UsarSim camera client in higher resolution, and request rectangular regions of the full image for each robot. The latest version of the sourcecode is available on http://usarsim.svn.sourceforge.net/viewvc/usarsim/Tools/ImageServer/

3. a path is found to the target point, but the path is dangerously long due to obstacles observed or gateways that are missed (a detour). This classification will be based on a relative threshold (say 20% longer than the optimal path).
4. a path is found to the target point, but the path is dangerously short due to missed obstacles or observed gateways which are not present in the world (a shortcut). Executing this path would crash a robot. This classification will be based on a relative threshold (say 5% shorter than the optimal path).

It is the intention of the committee to publish a tool to automatically calculating this measure for an occupancy grid. The program will become available at http://usarsim.cvs.sourceforge.net/viewvc/usarsim/usarsim/Tools/MapEvaluator. If this program is not finished and validated on time, the mapping quality M will be manually evaluated, equivalent with the previous years.

This program will give an absolute test score. To compute the overall score S, the collected points are divided by H^2, equivalent with the metrics of the Comprehensive mission. This absolute test score is scaled down to a relative score. One can get up to 50 points for the mapping test. The best team will get 50 points. The absolute test score of the best team is used to calculate the relative score of the other teams (linear decrease to 0).

6.3 Deployment test

The team does not have to deliver any files at the end of the run. The file `UT3.log`, produced at the Unreal-server, will be used to automatically compute the coverage with the program that will become available at http://usarsim.svn.sourceforge.net/viewvc/usarsim/Tools/ScoreRadio/.

Robot names will be used to retrieve their positions from the log files for scoring. Teams are therefore required, before the run, to provide a text file with the name of their robots (one name per line).

This program will give an absolute test score. This absolute test score is scaled down to a relative score. One can get up to 50 points for the deployment test. The best team will get 50 points. The absolute test score of the best team is used to calculate the relative score of the other teams (linear decrease to 0). Directions for running the scoring program are provided in the readme located in the directory. A sample ground truth file for the deployment test map is also provided.

6.4 Comprehensive mission

A map and a victim file has to be delivered after a comprehensive mission. The map has to be georeferenced in the GeoTiff format[3]. This allows one to compare the maps against the ground truth. The map may contain multiple overlays, indicating the information gathered from the environment. One overlay of the map will be a GeoTIFF with a fixed color scheme, equivalent with the 2007 rules, to allow automatic processing of the exploration measure. A second overlay will be in MIF format and will contain a vector diagram, with a symbolic drawing indicating important locations on the map. Although this overlay should also be georeferenced, this overlay will only be judged on skeleton quality, and not on metric quality. The other overlays have a free format and can be used to provide additional information collected from the environment. The value of the additional information will be manually evaluated by the jury and can result in a bonus. The formula of the score S, as indicated in equation 1, has three components:

1. One can get up to 50 points for the exploration efforts E
2. One can get up to 50 points for the mapping quality M

[3]See for more information http://www.robocuprescue.org/wiki/index.php?title=VRCompetitions#Map_Format_and_A_priori_Information.

3. One can get up to 50 points for the victims found V

To compute the overall score S, the collected points are divided by H^2, where H is the number of human operators. For scoring purposes a team member is counted as a *human operator* as soon as a human:

- Starts a robot, enters initial points, or perform any operation needed for the successful start of the rescue mission
- Actively drives a robot around
- Stops a robot before the run is over (for example, to prevent it from bumping into victims)
- Is involved in any way in the victim recognition process

According to the above definition, each team will be charged at least one human operator for the robot setup, which means that $H \geq 1$ is guaranteed.

$$S = \frac{E * 50 + M * 50 + V * 50}{(H)^2} \tag{1}$$

- The exploration effort E is automatically determined based on the area indicated as Cleared on the map (i.e. green in the overlay with the fixed color scheme). Teams that have cleared more then a certain number of square meters of the environment (the number is environment dependent and will be fixed by the referees) will be awarded the entire 50 points. For lower percentages, the number of points will linearly decrease to 0. Note that a penalty will be given for each unreported victim that exists in an area reported as Cleared (see the issue about missed victims in the victim points section). Bumping into walls or other features during exploration carries no penalty, however some structures may be unstable and could collapse.
- The mapping quality M is calculated based on the following criteria:

  Skeleton quality A map skeleton is a vector product that reduces a complex map into a set of connected locations. For example, when representing a hallway with numerous doorways, a skeleton may have a line for the hallway and symbols along that line that represent the doors. A map may be inaccurate in terms of metric measurements (a hallway may be shown to be 20 m long instead of 15 m long), but may still present an accurate skeleton (there are three doors before the room with the victim). The category allows the judges to award 20 points based on how accurately a map skeleton is represented. The accuracy is determined by following the skeleton. False positives (gateways that do not exist) and false negatives (gateways which are obscured by non-existing obstacles) will be penalized (indication: one point per severe error). The skeleton will be delivered as a ".mif" formatted vector file.

  Metric quality The accuracy of the map file when compared to ground truth. 20 Points will be granted based on this measure. When available, the tool in section 6.2 will be used to calculate this score automatically. Otherwise, the provided georeferenced map will be overlaid with the ground truth. Inaccuracies will be penalized (indication: one point for 0.5 meter shift of large sections of the map).

  Attribution One of the reasons to generate a map is to convey information. Important information for emergency responders is related with information on the location of victims, the location of obstacles, and the paths that the individual robots took. This information is often represented as attributes on the map. Up to 10 Points will be awarded for including vector information. The areas of attribution that are eligible for points are described in appendix A. Missing standard attributes (for example no robot paths) will be penalized (indication: one point per missing attribute). The points for innovative attributes will be distributed by making a relative comparison of the innovations on how useful they will be for emergency responders.

- The search and localization of victims is the primary task of the Virtual Robot team. For each victim found, the following information should be provided:

  Location The estimated center of the victim in the same georeferenced coordinates as used for the map. Based on the difference between the estimated location and the ground truth up to 5 points will be awarded. The precise form of the reward function can be adjusted in between competition rounds to reflect t he accuracy that can be attained by the best team (indication: one point per 0.5 meter).

  Identification Each victim correctly reported is rewarded with +5 points. When no information about a victim is provided and a victim is present in the Cleared area, a −5 penalty is given (false negative). When victim information is provided too far from any actual victim location (no localization points could be given), the victim is judged as incorrectly reported, and a −5 penalty is given (false positive).

  Note that the same victim may be seen from multiple locations with multiple sensors. This often results in multiple nearby observations of body parts, which should be grouped to single report. Care should be ta ken that this grouping is performed carefully, to prevent the classification of nearby victims as one. When multiple victim reports are provided for a single victim, the report with the shortest distance to the t rue victim is taken into account to calculate the reward. All other reports are taken into account as false positives. In this special case the −5 penalty is scaled linearly with the localization error. False positives so far from the actual position that no location points could have been given, get the full −5 penalty.

  Attribution One of the reasons to search and localize is to convey information. Points will be awarded for including information on the observed body parts, pictures of the victim, movement of the victim and status of the victim. Up to 10 points per correctly reported victim can be granted by the judges that reflected their feelings on the utility of this information.

  Uncertainty The team could provide a probabilistic estimate P_i with its victim report. This estimate P_i indicates of the chance there is really a victim at that location, and is used to reduce penalties for false reports. On the other hand, it also reduces all the rewards gained. When no estimate is given, an estimate of $P_i = 1$ is assumed.

  Uncontrolled bumping Each victim touched by a robot will incur a penalty of 5 points. If victim Jane is touched by robot A, the team will be penalized 5 points. If the same robot touches the same victim multiple times, no additional penalties will be counted. However, it later on robot A bumps into victim Mark, an additional 5 penalty points are charged. The same applies if victim Jane is touched by robot B. Bumping into victims is automatically detected and logged by the server.

  Per victim V_i 20 points can be earned. The total score for a team V_t can be calculated by the sum $\sum_1^n V_i * 20$. This score is normalized against the team which receives the maximum score $\max(V_t)$. The best team receives a score V of 50 points, the other teams a score V proportional to that.

All information used for scoring should be turned in no later then 15 minutes after the competition run is completed. Late information will not be accepted for scoring purposes.

IMPORTANT: even if a team runs with 10 robots, in the end only a single file can be submitted. The operator that started the robots must prepare this file. Any other person that manipulates robot result files will count as an additional operator for scoring purposes. It is up to the team to decide whether a comprehensive merged file or the best among the individual files should be submitted. Multiple layers of information are allowed and even encouraged, as long as they are georeferenced, and the two obligatory overlays are present.

7 Open source policy

The winning teams are required to provide a fully functioning copy of their software to the organizers before the final ceremony. Failure to do so will result in team disqualification. All other teams are also requested to provide their code, though not before the awards event. The software will be posted on (or linked from) http://www.robocuprescue.org/ giving proper credit to the authors. Source code for previous competitions is available at the aforementioned web page.

All data logs collected during the competition can be made available on the web for public use, including, but not limited to, scholarly work devoted to performance evaluation and benchmarking.

8 Résumé

The intention of the competition is to stimulate research in robotics that allows for autonomous and safe exploration of significant parts of the environment providing high quality maps and demonstrating the capability to actively search and localize victims (or clear environments) using robot models consistent with the state of the art. The organizing committee has the obligation to make the competition a challenging but fair challenge. NIST personnel neither involved nor affiliated with any of the participating teams and institutions are part of the organizing committee. In case of protests or objections, after having consulted the relevant parties, the final word is up to them.

9 Acknowledgments

Special thanks to Stefano Carpin who was co-author of the rules of the previous years.

Appendix A: File Formats

Start locations

Start locations will no longer be provided. Instead, teams have to retrieve this information directly from USARSim using the GETSTARTPOSES command.

A priori maps

For the deployment test, a binary map will be provided that shows the locations of large obstacles (walls). Small obstacles will not be represented and the map is not guaranteed to be perfectly accurate. The map will be in GetTiff format with the Red channel being used for mobility. Values of 255 will be used to represent an obstacle.

Obligatory color scheme

Each team should provide a single file with a map in GeoTiff format with one overlay with the following colors (RGB coordinates are provided assuming color components are coded in a single byte):

- Non traversable - Black RGB(0,0,0)
- Cleared (=traversable, and victim free) - Green RGB(0,255,0)
- Uncleared (=traversable but not necessarily victim free) - White RGB(255,255,255)
- Unexplored - Blue RGB(0,0,255)
- Victim location - Red RGB(255,0,0)

This overlay will be used to automatically determine the explored area.

Other georeferenced overlays in the file can be used to convey additional information (for instance the probabilistic occupancy grids) in private color schemes.

Victim file

The teams should provide a single text file containing the discovered victims (victim file from now on). The victim file should contain the locations of each discovered victim (x,y,z) in a reference frame consistent with the map file (see previous section) and the given start locations. The victim file format is as follows: each line of the text file should contain (in sequence) a victim id (assigned by the team) and the position (in meters), a specification of how the victim was discovered (VISUAL, because in 2010 the victim sensor is not longer used) and the probability that there is a victim at that location (normalized between 0 and 1). The last line of the file should contain the string END. An example of valid victim file which reports two possible locations of victims, one location where enough confidence is build to classify it as victim, another location that is classified with a low probability. Additional information about those victim locations, as for instance pictures, should be starting with victim id as provided in the Victim file. Georeferencing those additional information is encouraged.

```
Victim1, 2.3, 5.6, 0.0, VISUAL, 0.7
Victim2, 7.0, 4.4, 0.0, VISUAL, 0.4
END
```

Vector Attribute File

The skeleton map and map attribution should be provided as a vector file. Two MIF formatted files may be delivered that include vector information. The first file contains the standard attributes, such as:

- Connected locations
- Paths of individual robots
- Hazards
- Obstacles (i.e. outlines of walls)
- Location of victims
- Representation of best path to reach victim

The second file includes vector attributes that the judges have not yet thought of, but your team has. If these features are deemed to be useful to emergency responders, then points will be available for their inclusion. Any additional features that are awarded points will be announced at the daily team meeting.

Appendix B: Allowed robots and sensors

Teams can use combinations of the following robots:

- P3AT
- Kenaf

Teams can use combinations of the following sensors:

- AcousticArraySensor
- Tachometer
- Odometry
- INS Sensor
- Encoder
- Camera
- Sick
- Hokuyo URG04LX
- Battery
- Sonar
- GPS

Sensor load will be examined. The functionality of the Battery sensor has improved this year and reduced battery-lifetime can be simulated by additional discharges. The Technical Committee reserves the right to disallow any unrealistic combination of robots and sensors. Prior to the competition, the technical committee will publish a number of logical configurations that can be used during the competition. Additionally, when during the competition unrealistic behavior is detected for a robot or sensor, this device can be excluded for further usage during the rest of the competition.